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Peri-cene Framework

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framework 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 each complex, contingent and often controversial.

To manage a large mass of information 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 complex problems but those of 'deeper complexity'.

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

- a) The '**Peri-Urban-Climate Model**' follows a mainly linear frame or model of cause and effect, between four main factors in the peri-urban climate/environment challenge.
- b) The '**Synergistic Model**' addresses wider systems with deeper complexity and collective intelligence, and a process model for exploring both problems and opportunities.

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

The *Peri-Urban-Climate Model* contains four main themes with a functional framing of cause-effect:

- peri-urban development and spatial systems
- climate change direct hazard and risk
- climate vulnerability and sensitivity
- adaptive capacity and governance

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

- looking beyond the direct effects, to **wider** system boundaries with **deeper** layers of value and meaning
- exploring **synergistic / adaptive** pathways, for the emergence collective intelligence and the systems based on it
- working with a process model, the '*synergistic toolkit*', for collaborative co-design and co-production of adaptive pathways.

This report then explores the applications of the Framework to each part of the Peri-cene project:

- (WP1) Overall conceptual structure for peri-urban / climate-environment interactions and adaptive pathways
- (WP2) Structure for spatial analysis and visualization
- (WP3) Structure for international comparisons and online template

- (WP4) Structure for case study knowledge management and consultations
- (WP5) Structure for exploring governance and adaptive pathways
- The Annex contains further details and working templates for fieldwork.

2 Introduction

2.1.1 Scope & structure of this report

This report is an outline of the Peri-cene Framework, a structure for managing knowledge on peri-urban / climate-environment interactions. Generally the project works with 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 and key to all other deliverables in the project.

This report includes:

- Introduction to the scope and background
- Outline of the Framework, a combination of a 'peri-urban-climate' model and 'synergistic model'
- Further notes on the 'peri-urban-climate' model and 'synergistic model'
- Applications of the framework through the various project work packages
- Annex with further details and working templates.

2.1.2 Recap from the project proposal

The Peri-cene Framework follows directly from the proposal aims and objectives, so these are re-stated here for reference:

Key research objectives & hypotheses

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 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 then addresses some very practical questions, at the appropriate level:

- What are the effects of peri-urbanisation on climate risk?
- What are the effects of climate risk on the 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?

2.1.3 Structure of this report

The Framework provides a structure for responses to the above over-arching questions and challenges. It has various roles and applications to each Work Package, as discussed in section 5:

- (WP1) Overall conceptual structure for peri-urban / climate-environment interactions and adaptive pathways
- (WP2) Structure for spatial analysis and visualization
- (WP3) Structure for international comparisons and online template
- (WP4) Structure for case study knowledge management and consultations
- (WP5) Structure for exploring governance and adaptive pathways

3 Peri-cene framework: outline

This combined framework contains two main 'models' or components:

- The '**peri-urban-climate model**': this is 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 / governance. This has limits, but is a practical way to gather data and 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). However it can be more challenging to gather the data for this kind of model, and it involves not only analysis but a creative synthesis. So this synergistic model is not only a conceptual structure but a dynamic process for collaborative (co)-design of adaptive / synergistic pathways. (see section 5 below).

Each of these is based on the literature, as in D1-1:

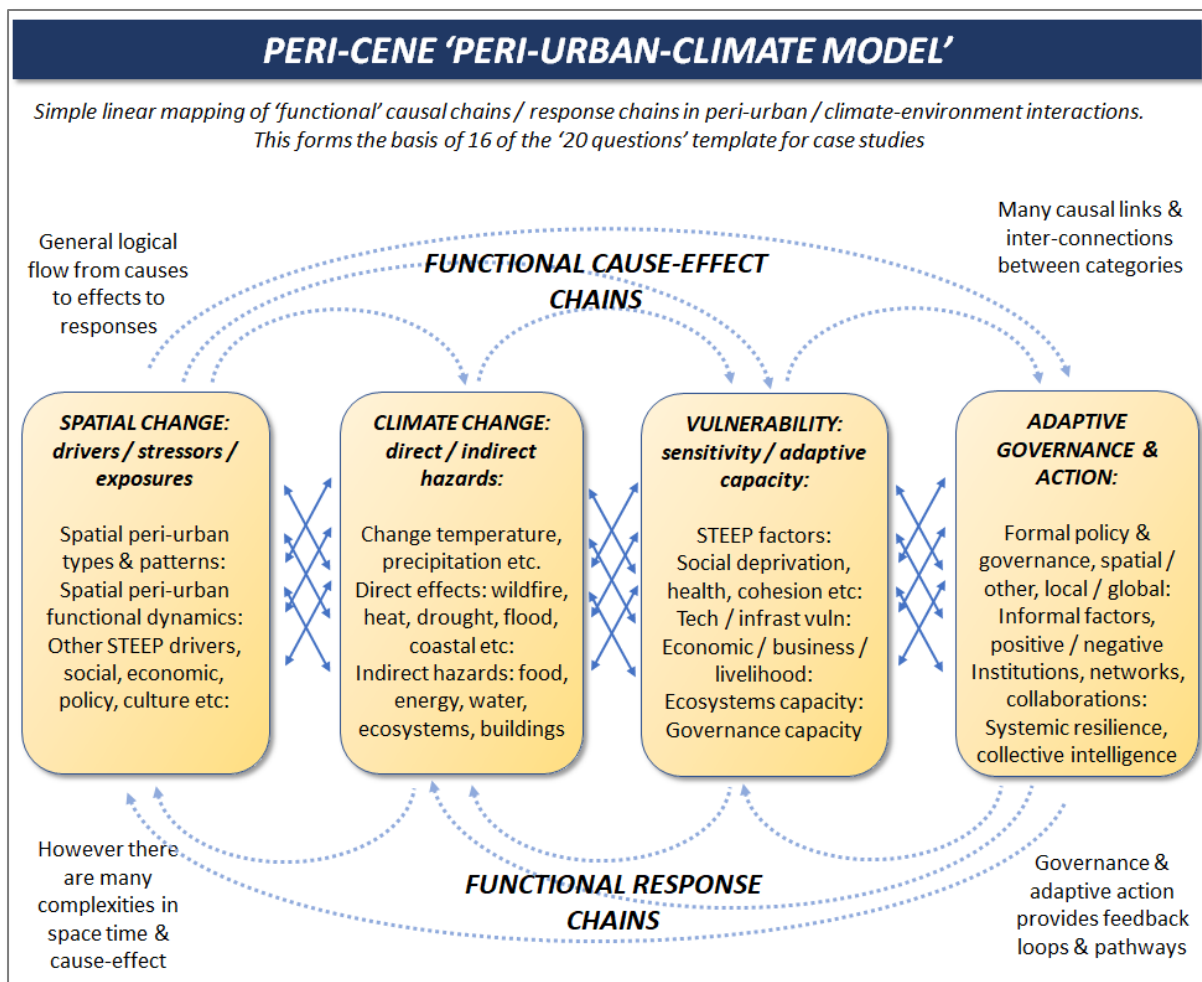
The '**peri-urban-climate model**' draws on studies on both peri-urbanization and climate risk. The first is mainly the work of the EU project PLUREL (Ravetz et al 2013; Piorr et al 2013), and follow-on urban foresight studies (REGIO 2011; Ravetz 2015). For the second issue of climate risk, this builds 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**' address systems of multiple or deeper complexity. It provides methods of mapping such systems, and designing responses, pathways and policies. It also provides a process toolkit for stakeholder dialogue and co-creation. This 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).

3.1 'Peri-urban-climate model' outline

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

Figure 1: 'Peri-urban-climate' model



This provides a structure for exploring and mapping what is often 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: spatial peri-urban functional dynamics: other 'STEPC' drivers, (social, technical, economic, policy, culture etc):
- **CLIMATE CHANGE: direct / indirect hazards:** Change in temperature, precipitation etc: direct effects of wildfire, heat, drought, flood, coastal etc: Indirect hazards of food, energy, water, ecosystems, buildings.
- **VULNERABILITY: sensitivity / adaptive capacity:** physical and biological capacity: social deprivation, health, cohesion etc: technology / infrastructure vulnerability: economic / business / livelihood:

- **ADAPTIVE PATHWAYS & GOVERNANCE:** Formal policy & governance, spatial / other: adaptive institutions, networks, collaborations: Informal factors both positive / negative: Systemic qualities of resilience, collective intelligence.

A summary version is shown in Figure 1:

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 responses: however there are many causal links & inter-connections between the themes. The lower part of the picture shows how adaptive governance and adaptive pathways provide feedback loops and responses to the problem. Again this is a huge simplification of a complex reality.

(Example: in the peri-urban uplands north of Manchester there are post-industrial settlements in the river valleys, which suffer increasing flood risk due to climate change, combined with land cover change and decline of farming, and the flood events then affect the most deprived and least abled populations, exacerbated by the fragmentation and under-funding of local government. A 'functional' response focuses on building flood walls and retention basins).

Each of the 4 main themes in this model is identified in a template with 4 questions per theme, as in the 'templates' in the Annex.

3.2 Synergistic model

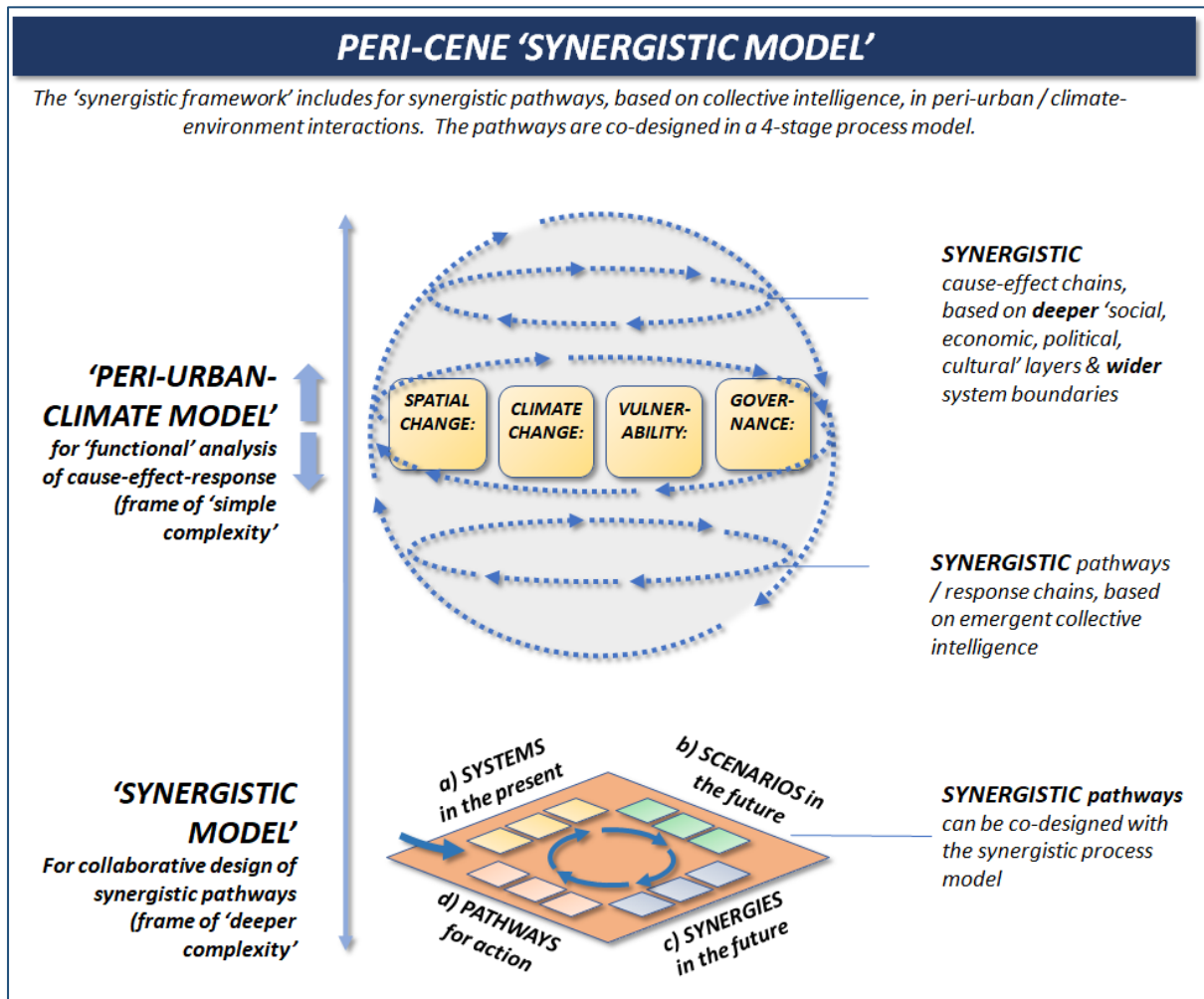
The above functional model is a practical starting point, but it has limits with dynamic complex systems, or those where human intelligence or creative thinking is a dominant factor. To turn this static analysis into a dynamic exploration and co-design process, we use the 'synergistic model'. This helps to explore problems of deeper complexity, and to co-design opportunities or 'adaptive pathways' with insights from collective intelligence.

The synergistic model builds on the basic 'peri-urban-climate' model, in three main dimensions

- a) looking beyond the scope of the basic model, towards **wider** system boundaries with **deeper** complexity,
- b) exploring adaptive pathways for **co-evolution** or emergence of collective intelligence in human systems: this uses a scheme of 'Mode-I, Mode-II and Mode-III' to identify system types.
- c) this calls for a dynamic creative process, using a '**synergistic toolkit**' for collaborative co-design and co-production of adaptive pathways. The synergistic toolkit has a 4-stage structure:
 - systems mapping for problems and challenges
 - scenario mapping for the future
 - synergy mapping for ideas, visions, opportunities
 - strategy mapping for practical pathways, plans and programs.

In Figure 2 below the simple 'peri-urban-climate' model is now one layer in the larger scheme of the synergistic model.

Figure 2: Peri-cene Synergistic Model



4 Applications of the framework

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

4.1 Peri-urban-climate model: notes & applications

4.1.1 Peri-urban-climate model background:

The framework adapts the IPCC's (2014) climate risk conceptual framework: this 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-urban case studies with a focus on adaptive governance approaches, connect to the adaptive capacity dimension of the risk framework.

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

4.1.2 Peri-urban-climate template:

Each of the 4 main themes in this model is identified in a template, each with 4 questions, and a further 4 questions on the synergistic model makes 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:

- 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

4.1.3 Peri-urban-climate model: common types & causal chains

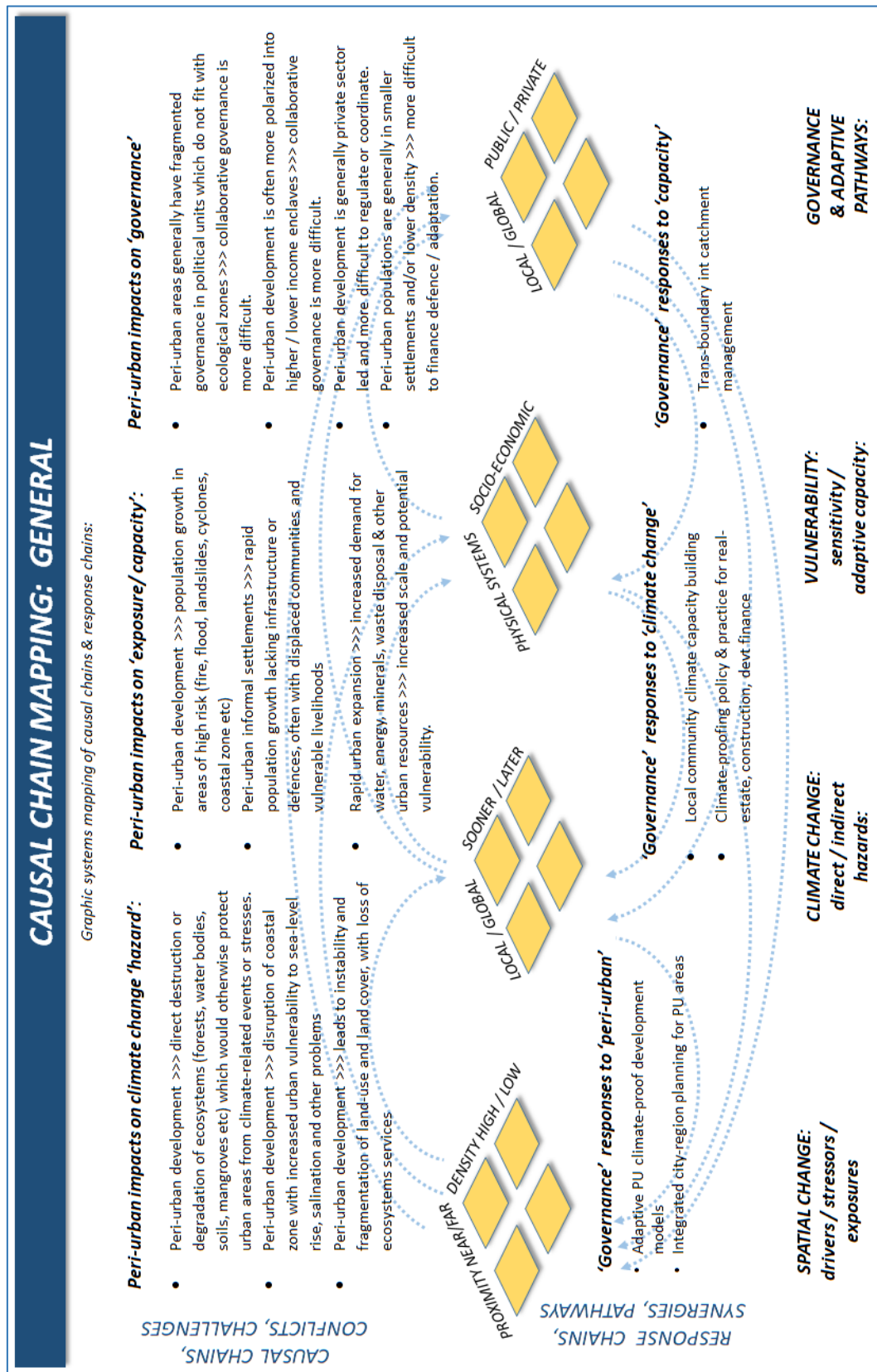
Each of the four main themes of the model are now each shown with typical variations, as a set of common types, in Figure 3. This aims at a simple and generic description of the likely range:

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

4.1.4 Exploring the causal chains of peri-urban-climate:

Here we focus on the key aspects of peri-urban development, which are most relevant to 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 per Connelly et al 2018). Each of these can (in principle) be traced on the Peri-urban-climate model in Figure 3. This is not to replace more detailed and complex causal chains or systems diagrams, but to provide a common basis for summary and comparison.

Figure 3 : Peri-urban-climate : causal chain mapping



This is the summary of the above typical critical causal chains, (i.e. the text from the diagram at 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).

A more analytic matrix 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.

4.2 Synergistic model - applications

This section provides further notes on the theory and practical applications of this model: (for more see the practical guidance on www.urban3.net and Ravetz 2015, 2016, 2020)

4.2.1 Context

Clearly the peri-urban is hugely complex: climate change risk and adaptation is also complex, and the interactions between are even more so. The Peri-cene project cannot analyse every possible interaction in cities around the world, but it can aim to see the overview, the 'wood for the trees', and to compare between different cases. It can also enable the inter-connections and dialogue between different methods for different framings of problems and opportunities.

Synergistic mapping and design provides a conceptual foundation for understanding and managing systems of 'deeper complexity'. These are multiple arrays of complex systems, as per the 'STEEPC' menu (social, technical, economic, environmental, political, cultural etc), which cannot be reduced to one analytic theory or concept.

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 governance. For example 'Resilience' is a topical title for cities around the world, but critical questions arise – resilience to what, for whom, where and when? For the UN Sendai Framework, resilience is: "*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.*"¹ 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 flood risk zone, with more resources and influence, would aim to channel the floodwaters downstream to other lower value areas, and so risk / resilience is not only a functional 'engineering question' but a socio-political question.²

4.2.2 Framing problems and responses

The above all depends on the 'frame' of problems and responses: whether a flood risk is seen only as an issue of water levels and flood walls, or more about the human systems of governance, investment, information and skills, cultural learning and so on. The Synergistic Model helps to see this kind of bigger picture, by systematically looking '**wider-deeper-further**':

¹ Sendai Framework, UNSDR 2011: Sendai Framework for Disaster Risk Reduction 2015 – 2030. NY, UNSDR

² Beilin, R, & Wilkinson, C, (2015) Introduction: Governing for urban resilience. Urban Studies, Vol. 52(7) 1205–1217

- **‘Wider’** synergies between the **actors** of the system, (stakeholders, organizations, institutions, etc): this starts with an **actor mapping** 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 peri-urban-climate model above is basically a **‘factor mapping’** of the problem.

Then we can explore different levels of synergy and systems change, which highlight which kind of resilience we are talking about. These can also be framed as **‘clever, smart or wise’**: or otherwise, **“Mode I, II or III”** type operating systems:

- **‘Mode-I’ (1.0): linear, functional**: here the synergy works as a ‘functional system’: it follows direct instructions and responds to short term pressures. A linear-type ‘Resilience-I’ strategy would build higher walls in response to flood risk.
- **‘Mode-II’ (2.0): evolutionary**: here the synergy works as a ‘complex adaptive system’, evolving by self-selection and self-organization. Evolutionary type ‘Resilience-II’ looks for interactions between flood risk, property and infrastructure, with innovations and markets: but these can easily reinforce inequality and exclusion.
- **‘Mode-III’ (3.0): co-evolutionary**: here the synergy works with co-learning, co-innovation and co-creation. A co-evolutionary ‘Resilience-III’ works on the cognitive level, and promotes shared learning and collective intelligence of all stakeholders. It aims beyond direct functional flood defence, towards a ‘wiser’ co-evolution or transformation of urban systems together with their climate systems.

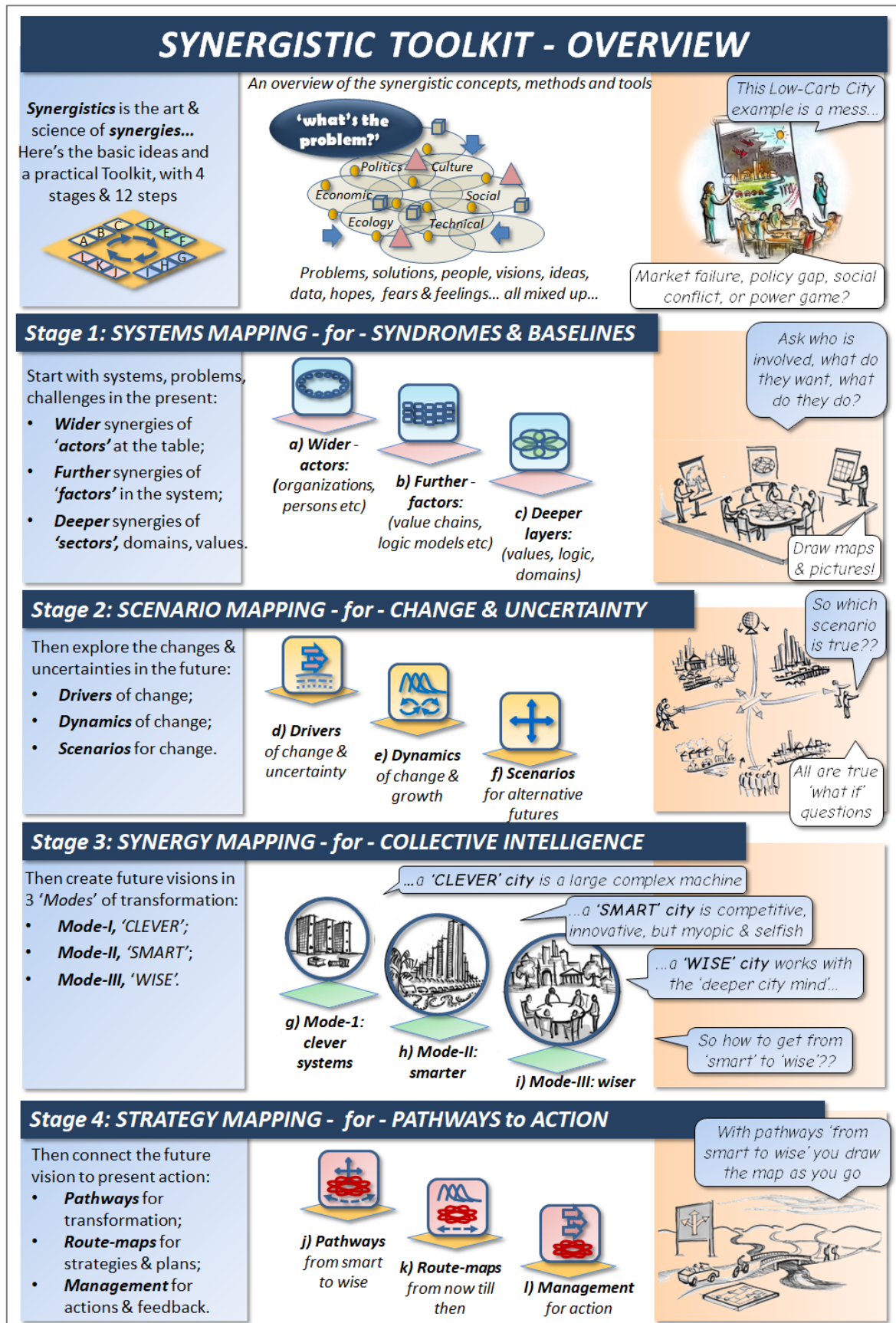
(For example the Kachipedu project in peri-urban Chennai works with local unemployed and disaffected youth, to restore the local water bodies and their ecosystems. This helps build resilience to drought, flood and future climate change, together with combined social, economic, political and cultural co-benefits).

4.2.3 Synergistic toolkit & process

‘Synergistics’ – the science and art of working with synergies – has been developed not only for mapping and analysis, but also for design and practical action. The Synergistic Toolkit helps to explore and enable ‘collective intelligence’ and 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, is more about a dynamic process of creative thinking, and collaborative co-design / co-production. For this we use the Synergistic Toolkit, a flexible set of techniques, with 4 stages and 12 steps (Figure 4):

Figure 4: Synergistic toolkit - overview



- a) **System mapping:** the baseline syndromes, issues or challenges on the table: includes the 'wider-deeper-further' boundaries above.
- b) **Scenario mapping:** the drivers of change & alternative futures, (using mainstream methods):
- c) **Synergy mapping:** design of opportunities, synergies, innovations: includes the Mode-I, Mode-II and Mode-III co-evolutionary in the scheme above.
- d) **Strategy mapping:** design of practical pathways, road-maps, policies & projects, (using mainstream methods).

Visual thinking is at the centre of the synergistic methods and tools. The Toolkit Guide (online) provides a series of visual templates and typical questions for debate, for each of the 4 stages and 12 steps. 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, with responses based on collective intelligence).

4.2.4 Synergistic / causal combined matrix

The synergistic summary matrix at *Table 2* shows the synergistic framework combined with the basic 'peri-urban-climate-risk' framework, set out by the '20 questions' template. This can help with mapping of problems or responses, and as a tool for enquiry and deliberation. For stakeholder discussion, we could start with a blank matrix (i.e. the format can be sketched on a flip chart and used for discussion). This also forms the basis of the 'governance template' in section 5 below.

Table 2: combined peri-urban climate risk / resilience model / synergistic model

	Non-adaptive 'solutions'	'Mal-adaptive innovations'	'Adaptive / synergistic pathways'
SYNERGISTIC MODE>>	Mode-I Linear	Mode-II Evolutionary	Mode-III Co-evolutionary
URBAN / SPATIAL CHANGE			
Peri-urban patterns	Linear urban expansion	Extended post-metropolis	Synergistic city-region
Functional dynamics	Functional territories	Competitive territories	Collaborative territories
Socio-economic dynamics	Direct socio-econ change	Evolutionary change	Co-evolutionary change
Global inter-dependencies	Branch-plant dynamic	Entrepreneurial hubs	Local-global synergies
CLIMATE CHANGE			
Climate direct impact	Direct impact	Bio-geo-physical adaption	Socio-ecological integration
Climate indirect hazard	Flood / drought defence	Flood/ drought market	Eco-Urban transformation
nexus effects / adaptation	Food/ energy impacts	Food/ energy innovation	Integrated nexus thinking
Climate loops	Unplanned side-effects	Evolutionary change	Integrated systems
VULNERABILITY / CAPACITY			
Physical-ecosystems	Farming as production	Commodity speculation	Farming as livelihood
Economic & infrastructure	Mono-functional	Multi-functional	Integrated livelihood
Social & community	Social units / settlements	Social networks	Social collective intelligence
Governance capacity	Technical systems	Market systems	Socio-technical systems
GOVERNANCE / PATHWAYS			
Formal governance (<i>'Deliberative / multi-level'</i>)	Regulation green-belt etc	Peri-market / competition	Integrated 'eco-urban-belt'
Adaptive governance (<i>'Associative, co-production'</i>)	Command / control	Entrepreneurial structures	Collaborative structures
Informal governance (<i>'collaborative, creative'</i>)	Fixed hierarchies	Extractive incentives	Recirculatory exchanges
Synergistic governance (<i>'transformative, emergent'</i>)	Technical 'knowledge'	Smart 'know-how'	Transformative 'collective intelligence'

The table can be used in a practical way, to identify different components in the case studies, or the criteria for 'adaptive' or synergistic, in contrast to functional or 'mal-adaptive' pathways.

5 Applications of the framework

This section charts out the likely 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 of causal interactions (Figure 3), and puts into a more systematic matrix of interactions. This can show both the problems or impact chains (shaded cells): and also the pathways, policies and 'response chains' (white cells).

Table xxx: peri-urban-climate interaction matrix

	<i>Peri-urban change</i>	<i>Climate change</i>	<i>Vulnerability / capacity</i>	<i>Governance & pathways</i>
<i>Peri-urban change</i>				
<i>Climate change</i>				
<i>Vulnerability / capacity</i>				
<i>Governance & pathways</i>				

5.2 WP2: spatial analysis

The likely spatial mapping themes for most parts of the full 20 questions template, are shown in the Annex.

5.2.1 Synergistic model of peri-urban change

The first theme in the Framework is that of the peri-urban, the spatial layers of urban-regional systems. This can be described with both linear, evolutionary and co-evolutionary systems concepts, as explored in the PLUREL project:

- '*Mode-I*' systems, with direct combinations of economic growth, population growth and space per GDP and per person, cause urban expansion and the lowering of urban densities in the peri-urban zones.
- '*Mode-II*' systems focus on the role of markets, incentives and innovations, in an evolutionary type of system. This may see new kinds of spatial pattern evolve and emerge to replace the previous.
- '*Mode-III*' systems focus on *deeper* layers of interaction, with *wider* communities of actors, with *further* factors of cause-effect. These effects are focused on intentional transformations for synergistic (adaptive) pathways: for instance where sustainability policy aims to bring together public sector regulation / private sector enterprise / civic grassroots innovation and mutual aid.

Only the *Mode-I* system levels are directly visible in spatial mapping and modelling, although the effects of both markets and of synergistic policies can be simulated in some ways.

A similar approach works for the climate change themes (section 4 on the Synergistic Model), and the governance themes (see below).

5.2.2 Peri-urban / climate typology

The spatial analysis can help to disaggregate the peri-urban types, and their possible interactions with likely climate problems and governance opportunities for each type of location. These types include:

- High proximity to urban gravity fields / high population density
- High proximity to urban gravity fields / low population density
- Low proximity to urban gravity fields / high population density
- Low proximity to urban gravity fields / low population density

Work in progress includes: (with Manchester examples)

Table xxx: peri-urban typology with climate / governance interactions

	P.U. HIGHER DENSITY	P.U. LOWER DENSITY
HIGH REGIONAL PROXIMITY (near to large urban gravity)	Urban / suburban fringes with urban heat island	Metropolitan open land for flood plains
Typical climate issues / challenges	Metropolitan populated fringes needed for localized biodiversity, cooling, flood alleviation etc: mixed suburban amenities & activities	Peri-metropolitan protected areas (green belt etc), provide containment, biodiversity, cooling, FRM etc: social amenity, health etc
Typical governance issues / challenges	Strategic management of conurbation open space: competing levels of government: competing demands from private ownership / public goods	governance of open / semi-rural land, with high amenity and/or high industrial pollution etc.
LOW REGIONAL PROXIMITY (further hinterland)	Urban / suburban extended sprawl & urbanization with typical climate risk & vulnerability	Open upland & peat bog fire risk: land management affects river headwaters and downstream flooding.
Typical climate issues / challenges	Local urban fringes: suburban food & ecosystems & eco-resources: visitor economy & semi-urban activities. Desakota type combinations	Further hinterland: urban-rural exchange of regional food & eco resources: visitor economy & semi-rural activities.
Typical governance issues/ challenges	Management of diffused urban sprawl in outer hinterland (ex-urban settlements and/or former industrial settlements)	Transboundary policy links: governance of open / semi-rural land, with marginal farming / high amenity / high pollution etc.

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
<i>Spatial framework: (drivers / exposure)</i>	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.
<i>Climate-environment (causes / hazards):</i>	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
<i>Social-economic drivers / sensitivities ('STEEP')</i>	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
<i>Adaptive – collaborative governance</i>	Growth in education, digital, open democracy	(N&E) fragmented & shrinking governance (S&W) pressures of affluence & polarized society	Strong state under shrinkage & polarization
<i>Synergistic model:</i>	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"> Spatial patterns, urban form & design, settlement types 	Under-used land, small settlements, former industrial towns, steep valley sides, barren uplands.
MAPS / INDICATORS		
CLIMATE HAZARD / RISK	<ul style="list-style-type: none"> Flood, storm, drought, heat, fire, sea level, etc: 	Pluvial / SW flooding: upland fires: decline of local farming
MAPS / INDICATORS		
VULNERABILITY / CAPACITY	<ul style="list-style-type: none"> exclusion, inequality, social change : infrastructure, ecosystems 	Rebuilding soil & ecosystems resilience: community cohesion: links to local economic devt
MAPS / INDICATORS		
ADAPTIVE GOVERNANCE	<ul style="list-style-type: none"> Regulation / planning / fiscal policy: collaborative / deliberative / social learning governance 	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.
MAPS / INDICATORS		
PRACTICAL ISSUES	<ul style="list-style-type: none"> Program time, cost, location, people, outcomes etc. 	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' 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	'mal-adaptive' Mode-I & II (Linear / Evolutionary)	'adaptive' Mode-III (Co-evolutionary)	LEADING QUESTIONS
			From KTH
Who is involved?			
Where: spatial area / relationships?			
How: methods of policy & delivery?			
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

Associative 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 then reflects the synergistic model: it contrasts the 'mal-adaptive' type of governance (*Mode I & II* column), with an 'adaptive' / synergistic (*Mode-III*) column, i.e. emergent, learning, transformative etc.

Note that the previous 'adaptive governance' category is renamed as 'associative governance', i.e. partnerships, networks, forums etc, which connects the 'formal' and 'informal'.

In reality most governance examples (policies / projects / institutions etc) will be a combination at various levels & for various actors (reality is complex)

Table xxx: governance theme & synergistic model analysis

	'MAL-ADAPTIVE' (<i>Mode-I & II: Linear / Evolutionary</i>)	'ADAPTIVE' / 'SYNERGISTIC' (<i>Mode-III: Co-evolutionary</i>)	LEADING QUESTIONS
		EMERGENT, TRANSFORMATIVE, SYNERGISTIC:	<i>Does the policy / project lead towards transformative action?</i>
FORMAL GOVERNANCE: <i>'Deeper' policy & agenda formation</i>	<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: <i>'vertical' multi-level integration</i>	<i>Command & control / power & conflict.</i>	MULTI-LEVEL	<i>top down VS bottom up: conflict or synergy? responsive to local needs & opportunities?</i>
ASSOCIATIVE GOVERNANCE: <i>'horizontal' integration of stakeholders</i>	<i>Command & control / power & conflict.</i>	ASSOCIATIVE / INCLUSIVE	<i>Stakeholder conflict management? Stakeholder synergies formed & maintained?</i>
ASSOCIATIVE GOVERNANCE: <i>'Further' integration of policy & services</i>	<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?</i>

6 Annex

6.1 Synergistic visual mapping

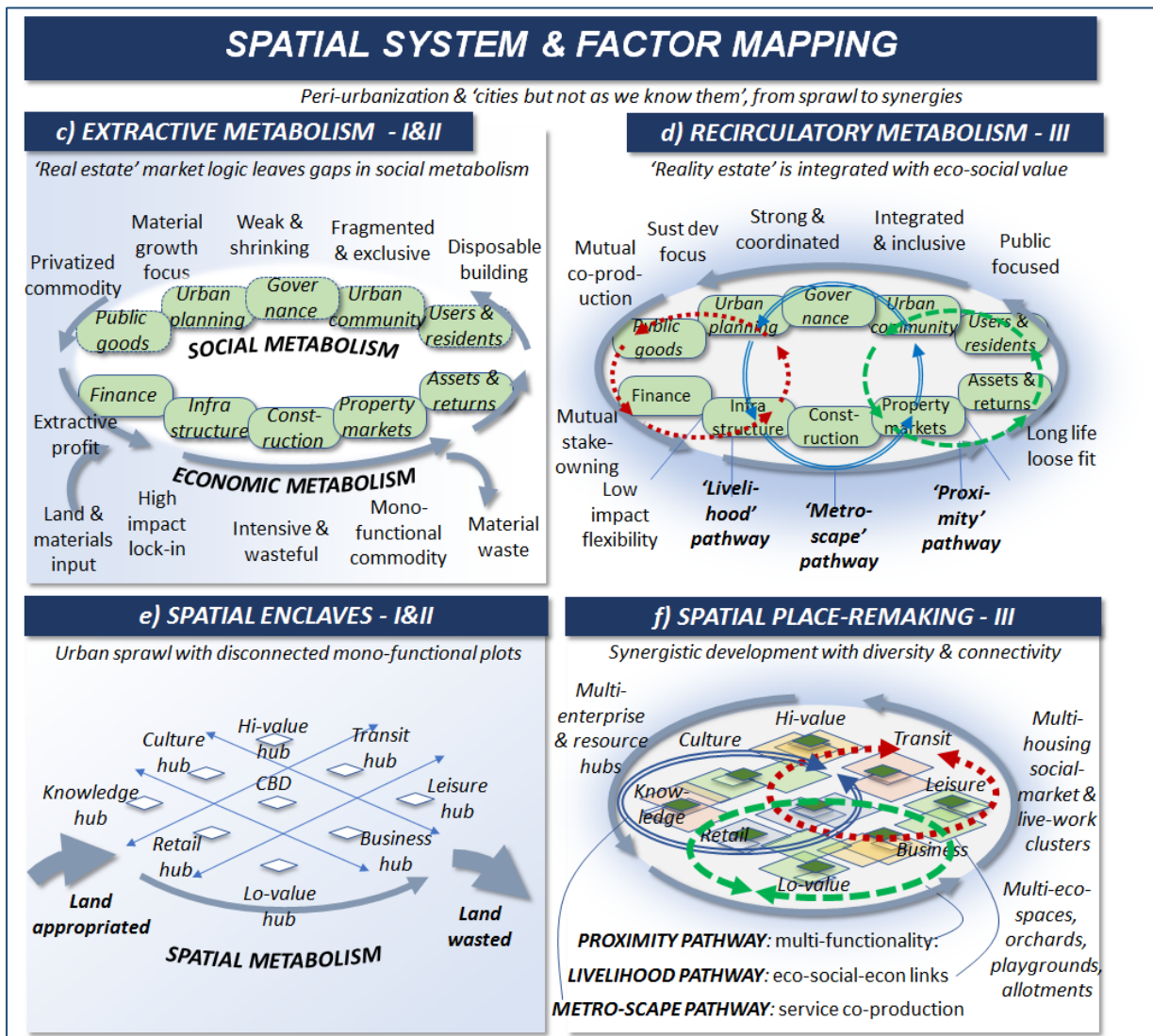
Visual mapping is possibly the best way to work with the synergistic model, as shown in the ‘12-step synergistic toolkit’ in section 4. The guidance on such visual thinking shows a common format, where Mode-I and Mode-II systems are shown on the left of the page, and Mode-III synergistic / adaptive systems 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
- Climate hazard and adaptation: framed (on the left) as a dysfunctional linear mindset – with pathways towards a synergistic model of joined up thinking
- Multi-level governance: framed (on the left) as a typical ineffective and unresponsive top-down system – with pathways towards a more synergistic type of ‘co-governance’.

6.1.1 Peri-urbanization: synergistic mapping

Another 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, with its many 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.



6.1.2 Climate adaptation: synergistic mapping

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

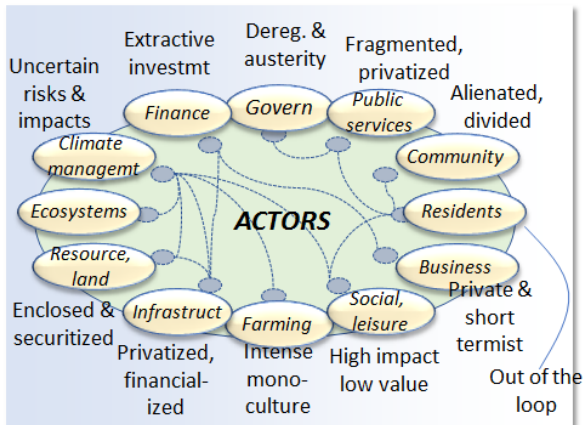
- The upper diagrams show a policy 'cognitive cycle': i.e. how does policy learn about the problem and generate solutions
- The diagrams in the centre show a typical set of actors: on the left with dysfunctional relations and conflicts, and on the right, with new synergies and collaborations,
- The lower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

COGNITIVE CYCLE & ACTOR MAPPING

c) ADAPTATION as RECOVERY

POLICY CYCLE - SINGLE LOOP LEARNING

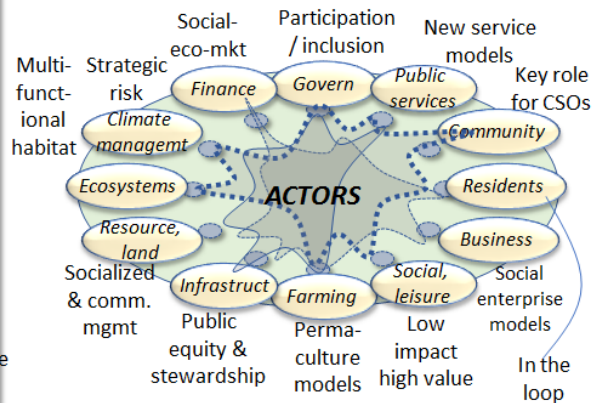
Input: climate risks & costs
 Problem: climate impacts
 Options: short term
 Actions: hard defences



d) ADAPTATION as TRANSFORMATION

POLICY CYCLE - MULTI-LOOP LEARNING

Input: climate / urban change
 Problem: linking urban & climate change
 Potentials: urban / climate transformation
 Actions: co-evolution



e) PATHWAYS

Socio-cultural gaps: degraded public realm, myopic materialism

Socio-economic gaps: myopic business models: corporate capture

Urban-political gaps: govt is fragmented, under-funded, distrusted

Residents / media / public services

Insurers / residents / infrastructure

Governance / public / infrastructure

Adaptation community: mutual aid via eco-education, health, urban farming

Adaptation livelihood: pro-active insurance on long term assets / risks

Adaptation metropolitan: integrated territorial governance for catchments

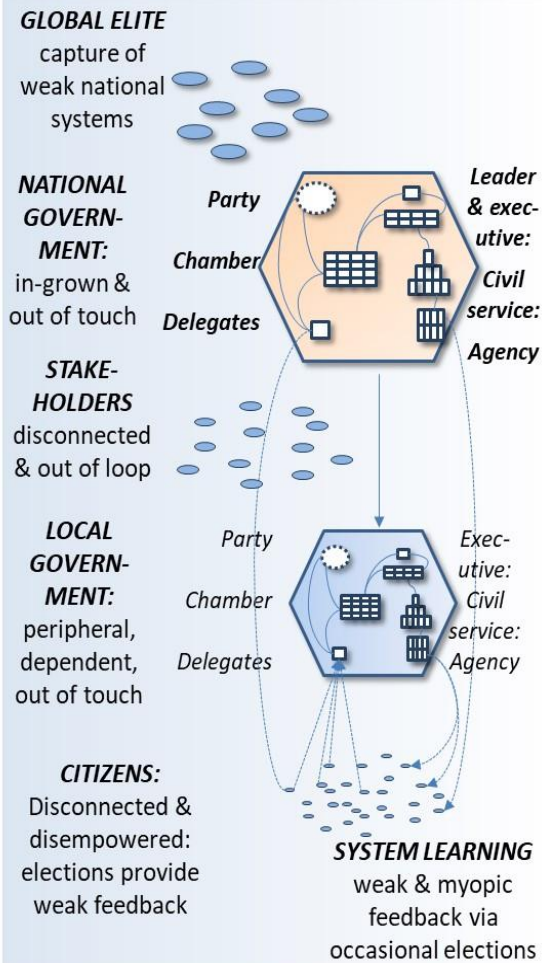
6.1.3 Multi-level governance: synergistic mapping

In terms of governance system structures, this can be visualized, as a shift from 'top-down government' to 'multi-level co-governance'. In this sense 'co-governance' (collaborative governance) could be taken as a shorthand for 'adaptive governance'. (Ravetz 2020)

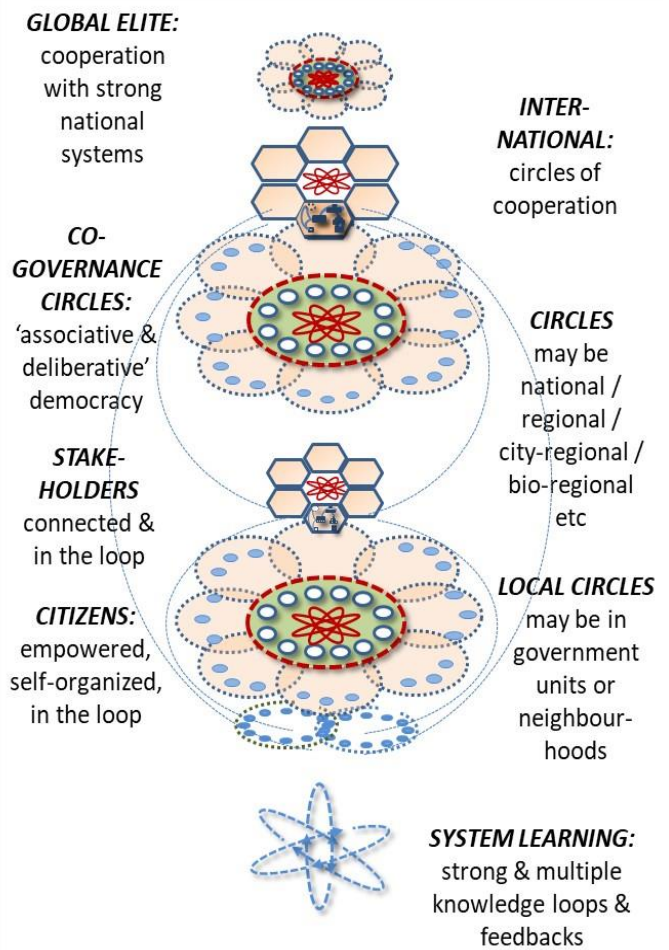
The **co-governance** concept then emerges as a systemic structure of network / circle / web of relations and interactions.

Figure xxx: from top-down government to multi-level co-governance.

(c) TOP-DOWN GOVERNMENT - I&II



(d) MULTI-LEVEL CO-GOVERNANCE - III



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	EXAMPLE: SOUTH PENNINES
PERI-URBAN FRAMEWORK:		
("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>MAPS / INDICATORS</i>	<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>MAPS / INDICATORS</i>	<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>MAPS / INDICATORS</i>	<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>MAPS / INDICATORS</i>	<i>Tbc</i>	

THEMES	SCOPE & TOPICS	EXAMPLE: SOUTH PENNINES
CLIMATE FRAMEWORK		
("causes / hazards"):	General overview:	Fluvial flood, wildfire, heat & drought, soil erosion, landscape
Climate change direct effects:	<ul style="list-style-type: none"> temperature, precipitation, storm etc coastal effects 	Summer drought & storm: winter precipitation & storm.
<i>MAPS / INDICATORS</i>	<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>MAPS / INDICATORS</i>	<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>MAPS / INDICATORS</i>	<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>MAPS / INDICATORS</i>	<i>CO2 & GHG</i>	

THEMES	SCOPE & TOPICS	EXAMPLE: SOUTH PENNINES
VULNERABILITY FRAMEWORK		
'sensitivity / adaptive capacity'	General overview:	Landscape sensitivity & marginal livelihoods
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>MAPS / INDICATORS</i>		
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>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>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>THEMES</i>	<i>SCOPE & TOPICS</i>	<i>EXAMPLE: SOUTH PENNINES</i>
GOVERNANCE FRAMEWORK		
Adaptive action & governance	General overview:	Fragmentation of governance: self-help tradition & eco-social innovation
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>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>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>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>MAPS / INDICATORS</i>		

THEMES	SCOPE & TOPICS	EXAMPLE: SOUTH PENNINES
SYNERGISTIC MODEL		
<i>Based on synergistic process</i>	<i>General overview:</i>	<i>Growing pressure on fragile landscapes & settlements: potential for growing socio-eco-resilience</i>
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:
<i>MAPS / INDICATORS</i>		
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
<i>MAPS / INDICATORS</i>		
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
<i>MAPS / INDICATORS</i>		
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
<i>MAPS / INDICATORS</i>		

6.3 Interview template

Leading questions can be inserted for each of the 20 steps, but experience shows 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>

SYNERGISTIC THEMES:	
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>	GDP growth Demographic change (age, class etc)	
Global-local dynamics		
<i>MAPS / INDICATORS</i>	(Depends on the case)	

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>	CO2 & GHG emissions? Eco-footprint index?	

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??	

A further template is a summary of the synergistic process, i.e. the four stage cycle of co-learning & co-creation described above.

THEMES	LOCAL SPATIAL DATA	GLOBAL SPATIAL DATA
SYNERGISTIC FRAMEWORK		
Systems / syndromes (present baselines)	•	
<i>MAPS / INDICATORS</i>	<i>Select the most critical overlays of all the above maps</i>	<i>Select the most critical overlays of all the above maps</i>
Scenarios (future possibilities)	•	
<i>MAPS / INDICATORS</i>	Peri-urban maps: scenario modelling Climate maps: scenario modelling	Peri-urban maps: scenario modelling Climate maps: scenario modelling
Synergies (future ideas, opportunities)		
<i>MAPS / INDICATORS</i>	<i>(depends on the case)</i>	
Strategies (present pathways, actions)		
<i>MAPS / INDICATORS</i>	<i>(depends on the case)</i>	

6.5 Common types and typologies

There is a huge diversity of urban / peri-urban types, locations, conditions around the world. This 'peri-urban global typology' identifies the range of possible conditions. Likewise there is a huge diversity of climate impacts, hazards, vulnerabilities, and adaptive actions. The tables here do not aim to cover every possible combination, more to illustrate the range, with examples of different types, for each of the peri-urban-climate model themes.

6.5.1 Urban types

The 'global urban typology' takes an overview of cities /city-regions around the world, with an overlay of wealth (high / low): urban change (rapid / slow): and governance type (mainly formal / mainly informal):

- Peri-urban development: rapid – slow (depending on spatial patterns: decentralization, de-concentration, nucleation etc).
- Economic development: lower – higher income (industrial structures & social inequality are the other key measures).

Political development: informal – formal (such definitions are complex but there are national level indicators). For the peri-urban there are further issues with the mismatch of admin boundaries to urban agglomerations.

Table xxx: global urban typology:

	RAPID EXPANSION & CHANGE:		SLOWER EXPANSION & SHRINKAGE	
	INFORMAL	FORMAL	INFORMAL	FORMAL
Lower income: spatial effects	Unplanned rapid peri-slums: (many cities)	Formal low-income mass housing, e.g. Chinese model	Unplanned gradual peri-slums, e.g. Colombia	planned low-income settlement, e.g. post-Soviet NIS
Higher income: Spatial effects	Unplanned middle class enclaves, e.g. India,	Planned rapid low density ex-urbanization e.g. USA, AU	Unplanned incremental middle class enclaves, e.g. Mexico	Planned affluence, cannot manage socio-economic effects: e.g. UK

The peri-urban spatial typology looks at the overlay of population density (high/low) with regional proximity to urban gravity fields (near / far):

Table xxx: peri-urban spatial typology

	NEAR – URBAN FRINGE	FAR – RURAL HINTERLAND
Structured & centralized	Urban extensions, commuter villages, urbanized rural towns	Urbanizing village & settlement structure
Scattered & decentralized	Urbanized sprawl	Rural scattered farms & settlements

6.5.2 Climate & risk types

Table xxx: climate location typology

	Coastal	Inland
Dry climatic types	e.g. Doha	Mexico City
Wet climatic types	Chennai	Manchester

Table xxx: climate change risk typology

	Direct impacts	Indirect / secondary impacts
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<i>Extreme events (storm, flood, sea-level etc)</i>	<i>e.g.drought</i>	<i>e.g. soil loss & desertification</i>
<i>Systems change: (ecosystems, food-energy-water systems etc)</i>	<i>e.g. crop failure</i>	<i>e.g. food system disruption</i>

6.5.3 Adaptive capacity types

Table xxx: socio-cultural communities

	<i>Low diversity</i>	<i>High diversity</i>
<i>High social cohesion & mutual aid</i>	<i>Traditional rural communities</i>	<i>Vibrant metropolitan communities</i>
<i>Low social cohesion & mutual aid</i>	<i>Peri-urban enclaves of competition & distrust</i>	<i>Transient & fragmented metropolitan communities</i>

Table xxx: adaptive infrastructure systems

	<i>Human centred</i>	<i>Technology centred</i>
<i>Centralized</i>	<i>e.g. public management of building stock & grid</i>	<i>e.g. AI-controlled centralized smart energy grid</i>
<i>Decentralized</i>	<i>e.g. user-controlled building level micro-climatic systems</i>	<i>e.g. AI-controlled building level micro-climatic systems</i>

6.5.4 Adaptive governance & action types

Table xxx: socio-political-economic context (scenarios types)

	<i>Public & ecological values</i>	<i>Private & economic values</i>
<i>Globalized dynamics</i>	<i>‘big government’ scenario</i>	<i>‘big business’ scenario</i>
<i>Local & regional dynamics</i>	<i>‘local community’ scenario</i>	<i>‘local enterprise’ scenario</i>

6.6 Spatial definitions of the peri-urban

This section is a more detailed review of the spatial parameters of population density. In particular it compares the PLUREL scheme to the GHSL databases (see Pesaresi et al 2016 & 2018).

6.6.1 Previous peri-urban research - 'PLUREL'

The forerunner to the Peri-cene and its spatial analysis program, was the PLUREL project (www.plurel.org) This used a range of spatial analytics including the RUG and MOLAND models (Ravetz et al 2013). The overall urban typology (for the EU case) was defined:

Table 5: Rural-urban-region area types

U_1: urban high density:	urban fabric class inside U_2
U_2: urban low density:	urban fabric (without urban green, industry) and population > 20.000
P_1: peri-urban high density:	population density > 75 inhabitants/km ² or population > 10.000 and inside P_2
P_2: peri-urban low density:	population density > 40 inhabitants/km ² and adjacency to the U_2 sub-region
R_1: rural high density:	population density > 10 inhabitants/km ²
R_2: rural low density:	population density > 0 inhabitants/km ²

- On this typology, large parts of the EU central areas are in peri-urban land-use types.
- The benefit of this approach is a clear definition of a new category, between urban & rural
- The disbenefit of this approach: data is purely based on residential address: the results are very dependent on the unit / grid resolution: the thresholds of 40 and 75pph can be argued: relevance of an EU scheme to the developing world is an open question.

6.6.2 GHSL categories:

The PERI-CENE concept & proposal included for a state of the art global level data layer, i.e. the GHSL. With multiple data sources at different scales, this represents a significant advance on anything previous.

The PERI-CENE research will include for a careful analysis of the GHSL categories and thresholds, in relation to the various concepts of the peri-urban and its wider significance.

Table 6: GHSL typology

(from the Atlas of Human Settlements, Pesaresi et al 2016)

	<i>Grid cell population</i>	<i>Grid cell built up</i>	<i>Total population</i>
Urban centres	<i>1km cell > 1500 (15pph average)</i>	<i>Or - 1km cell >50% built</i>	<i>And: >50,000 pop. (contiguous 4-connectivity+ gap filling)</i>
Urban clusters	<i>1km cell > 300 (3pph average)</i>	-	<i>And: >5,000 (contiguous 8-connectivity)</i>
Rural	<i>1km cell >0</i>		<i>And: <5000 (Single or contiguous)</i>

6.6.3 Peri-urban spatial patterns

Other possible measures of significance to wider peri-urban systems thinking: (Bruegman et al 2006)

- Proximity & distance from urban centre / gravity field: + edge conditions, i.e. proximity to urban or rural
- Urbanization level from GHSL (Urban cluster / intermediate / rural).
- spatial patterns: various forms of decentralization, de-concentration, nucleation etc).
- industrial areas: most approaches are based on residential population but ignore large infrastructures or industrial sites with few or zero population:
- poly-centricity: most definitions assume a 'central place' with gravity field: polycentric agglomerations may have a different kind of logic, i.e. a continuum of low density sprawl with occasional concentrations.
- Desakota & similar patterns of inter-penetration / inter-connections of urban & rural:

Table 7: PERI-URBAN spatial typology

	<i>Urban Proximity</i>	<i>Urbanization level (GHSL)</i>	<i>Spatial pattern</i>
NEAR URBAN	<i><1 hour journey / 25km radius</i>	<i>Urban cluster / intermediate / rural</i>	<i>Centralized / decentralized: Larger towns / larger villages / dispersed population</i>
MEDIUM			
NEAR RURAL	<i>< 100km radius??</i>	<i>Urban cluster / intermediate / rural</i>	<i>Centralized / decentralized: Larger towns / larger villages / dispersed population</i>

6.7 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