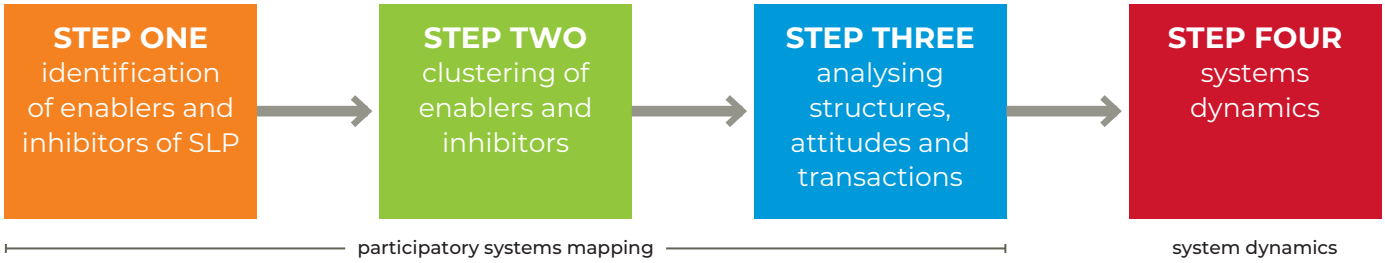
NATIONAL ENGINEERING POLICY CENTRE

Royal Academy of Engineering

Sustainable living places: System dynamics 'how to guide'

The Sustainable living places (SLP) project applied a systems approach to generate a map of the current planning, housing and infrastructure system in the UK. This 'how to guide' summarises the main steps taken to produce this map, using the content generated from a series of stakeholder workshops. See full report here.

The project includes a participatory system mapping stage and a system dynamics analysis. The steps listed below took place after a series of scoping interviews across a wide range of stakeholders. Steps 1–3 are included in the participatory system mapping stage of the project. Step 4 includes the system dynamics analysis.



In the SLP report, you can find a high-level overview of the system dynamics phase (step 4). We have attempted to provide further detail and a step by step guide to enable policymakers and interested stakeholders to replicate, or trial and test the approach; applying it to their specific policy challenge.

Participatory system mapping stage

Figure 1 | Participatory mapping stage

This diagram shows the steps involved in the participatory mapping process. The steps are: Identifying enablers and inhibitors (dark blue), clustering enablers and inhibitors (orange to green) in preparation for an analysis of structures, attitudes and transactions (blue). The emerging themes (red) fed into the system dynamics analysis.

STEP ONE

Identification of enablers and inhibitors of SLP

The purpose of this stage is to share a diversity of perspectives and identify a range of factors that enable SLP. Participants reflect on enablers and inhibitors individually and then share them in group discussion.

An enabler is a significant force in the environment that supports, encourages or increases the health and effectiveness of the system as by the overall purpose. An enabler might be an accessible digital platform that enables a range of stakeholders to share data.

An inhibitor is a significant force in the environment that undermines or prevents the health and effectiveness of the system as defined by the overall purpose. An inhibitor might be, for example, 'siloes between organisations in the housing sector', which prevents meaningful collaboration.

Table 1 | Example of enablers and inhibitors for 'High-level national governance strategy'

Enablers	Inhibitors
Mechanisms to improve transparency	Lack of joined-up thinking
Political and public will to change	Dysfunctional governance at various levels
Appropriate communication and consensus at all levels	Small number of actors and different objectives at a general level
Clarity of governance structures	Poor political intervention
Mechanisms to promote transparency	Lack of focus on infrastructure beyond transport
Willingness of stakeholders to support a spatial strategy that clearly defines the roles and responsibilities at national, regional and local levels	Lack of political will sustained over political cycles as a systemic problem
Focused effort at all levels of government to define what a spatial strategy would mean for households and neighbourhoods if implemented with a green mandate in mind	Fragmentation and lack of alignment
Opportunity to use data to connect silos and increase visibility	Lack of collaboration between the stakeholders that deliver policy on the ground and society
Better awareness of the urgency of issues	Lack of future visioning in planning
Widespread enthusiasm for better development	Lack of long-term, sustained political will
Mission oriented approaches	Lack of connection between government budgets regarding housing and health policies
Alignment of values and stewardship of landowners and developers	Uncertainty about how to rank/prioritise decisions
	Political inertia/short-term electoral cycles

STEP TWO

Clustering and prioritising enablers and inhibitors

The purpose of clustering enablers and inhibitors is to dive deeper into each thematic area that reflects the dominant priorities of stakeholders. Participants cluster related enablers and inhibitors into **themes** and select two to three (See Figure 2). For example, enablers related to planning and finance at a national level might be clustered as 'coordination and governance'.

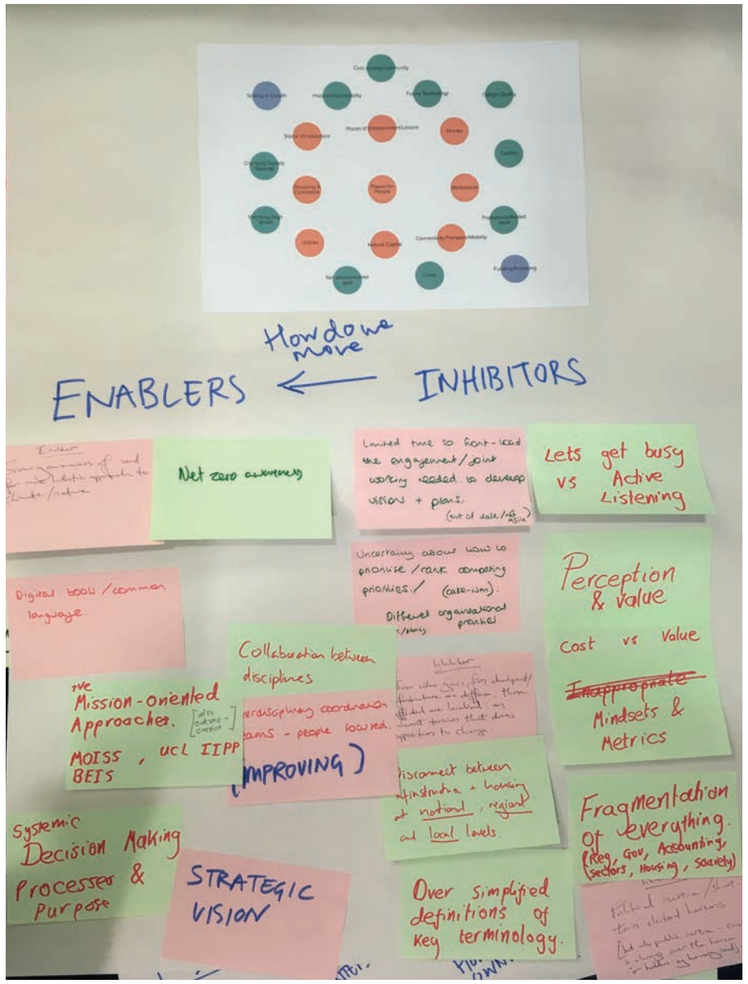
A full description of these prioritised themes is included in the main report. Link to full report here.

The stakeholders across iterations of the workshop, converged on the following six themes:

1. Coordination and governance for housing delivery
2. Role of education in creating holistic places
3. Different motivations between new and existing residents
4. Mindsets to change include attitudes that enable or inhibit systems thinking
5. Zero-carbon home in the wider spatial strategy for the UK
6. Setting a green vision.

These six themes form the basis for the SAT analysis, whose process is described in the next section.

Figure 2 | Clustering and prioritising enablers and inhibitors



STEP THREE

Analysing structures, attitudes and transactions – 'SAT analysis'

SAT analysis

Participants analysed the **structural**, **attitudinal** and **transactional** (**SAT**) aspects of the themes identified to understand their composite parts and how they operate in the system.

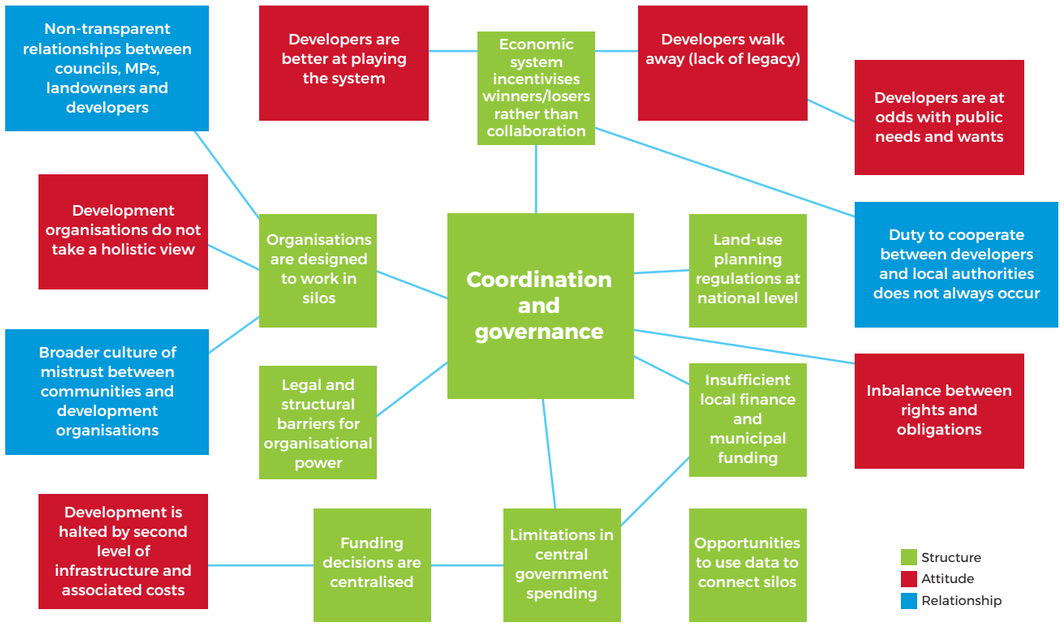
- **Structural** aspects of the system refer to the institutions, processes and stakeholders that are involved.
- **Attitudinal** aspects refer to widely held perceptions, values, norms and intergroup relations that affect how large groups of people think and behave.
- **Transactional** aspects refer to the relationships and interactions among individuals and organisations as they deal with important social, political and economic issues.

The SAT analyses for each of the six themes is captured in a diagram, like the one shown in Figure 3.

- The green elements describe the current situation (Structure).
- The red elements illustrate attitudes and perceptions of the system by different stakeholders (Attitude).
- The blue elements illustrate relationships between stakeholders, which together influence the current situation (Relationship).

These images represent a snapshot, or particular point in time, shared during the workshop and are by no means exhaustive.

Figure 3 | SAT analysis for 'Coordination and governance' theme



System dynamics analysis

STEP FOUR

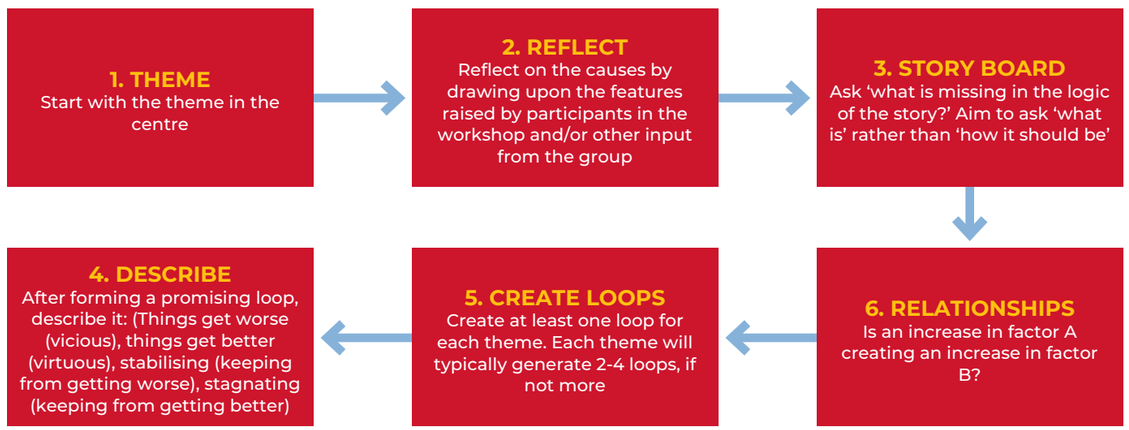
System dynamics

Part one: Creating clusters of loops from the SAT Analysis

The purpose of this exercise is to identify patterns within the SAT Analysis that may be interrelated. **analysis are included below**. Figure 4 (below) works through an example to show how these loops are generated. **The system map which emerged from this analysis is shown on page 10**.

The steps taken in carrying out systems dynamics

Figure 4 | Generating feedback loops from SAT analysis



Part two: Validation of loops

a. Ask stakeholders first to reflect on the extent to which the data represented was accurate and to provide input on **gaps or assumptions** that need to be researched further.
b. A question that may arise during the process is: **How do we know when we are done creating the loops?** To answer this question, explore/ask:
c. No full description of the system is complete without a story of ____? We cannot understand the system for coordination and governance, if we do not understand how the planning system is organised.
d. Did new and important stories emerge? Are these captured?
e. The feedback loops should be validated by testing them with stakeholders.
f. Figure 6 (page 8) works through an example. It reflects just one of several iterations of the loops that emerged during a workshop. The team captured connections between elements shared by stakeholders. The three colours represent the themes identified in the SAT analysis (**step three**): blue = structural, orange = attitudes, and green = transactional elements.

Part three: Building a map using the deep structure

This section's purpose is to consider the different loops created, making a note of the most **important, repeating elements and relationships** (for example, new factors, causal relationships, loops). The team applied the following approach to deriving a deep structure. Figure 5 summarises the steps taken.

A compelling deep structure should be:
a. **Real** (evidence based from the feedback loops built)
b. **Powerful** (capture the essence of the system and how it behaves)
c. **Functional** (anchor point for the other loops in the map).

Figure 6 also illustrates the different regions of the map. This represents one of several iterations with stakeholders and iterations within the team to group common elements where there may be duplication throughout the map.

Building upon the SAT analysis (illustrated by colours), Figure 7 (page 9) takes the map one step further; it **illustrates loops that share a common theme** with pastel colours. These thematic regions are amended and updated based on stakeholder feedback. This is an important stage in the overall process; it informs the initial layout of the loops in the map.

Figure 5 | Discovering the deep structure

Figure 6 | Generating loops for SLP

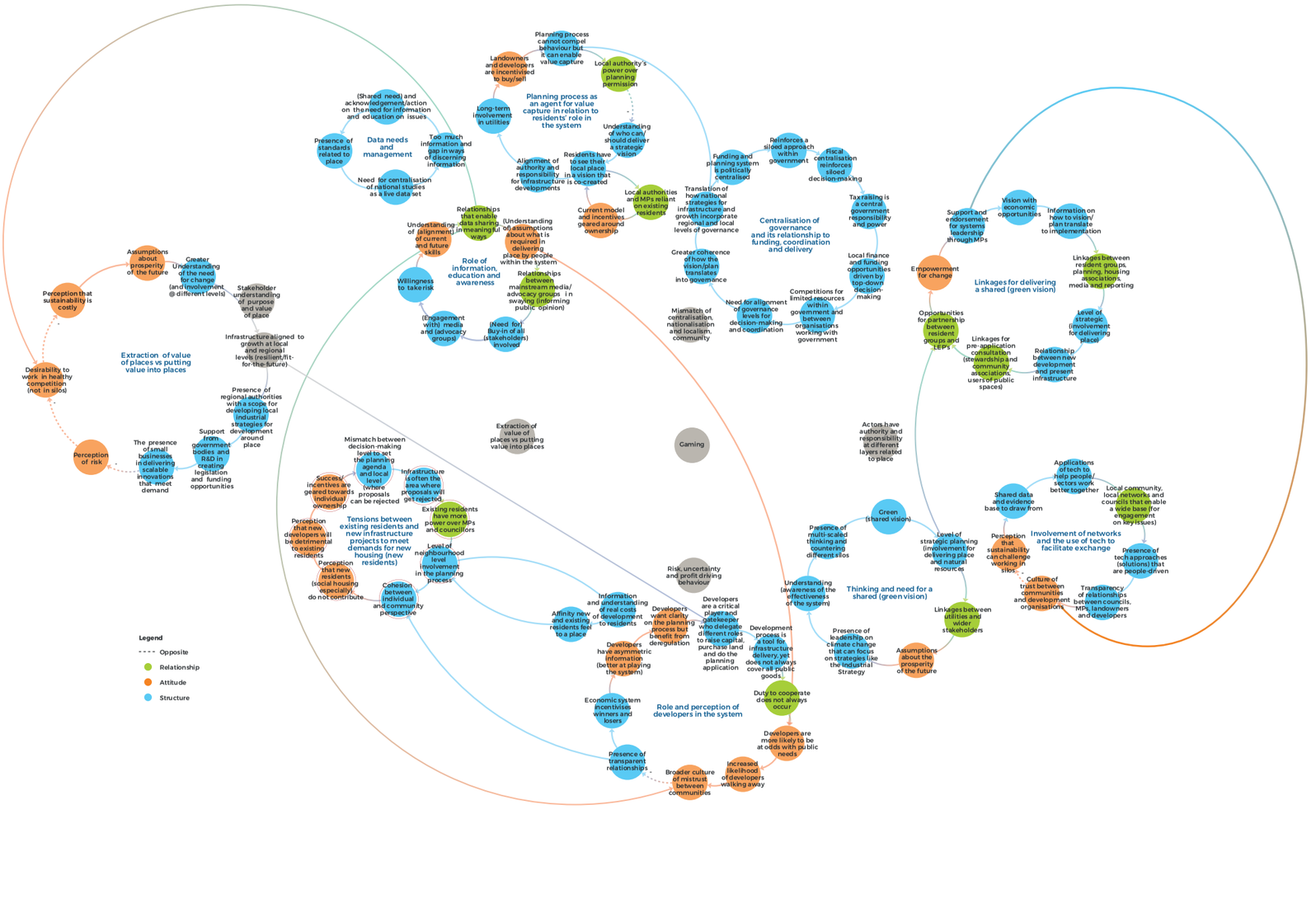
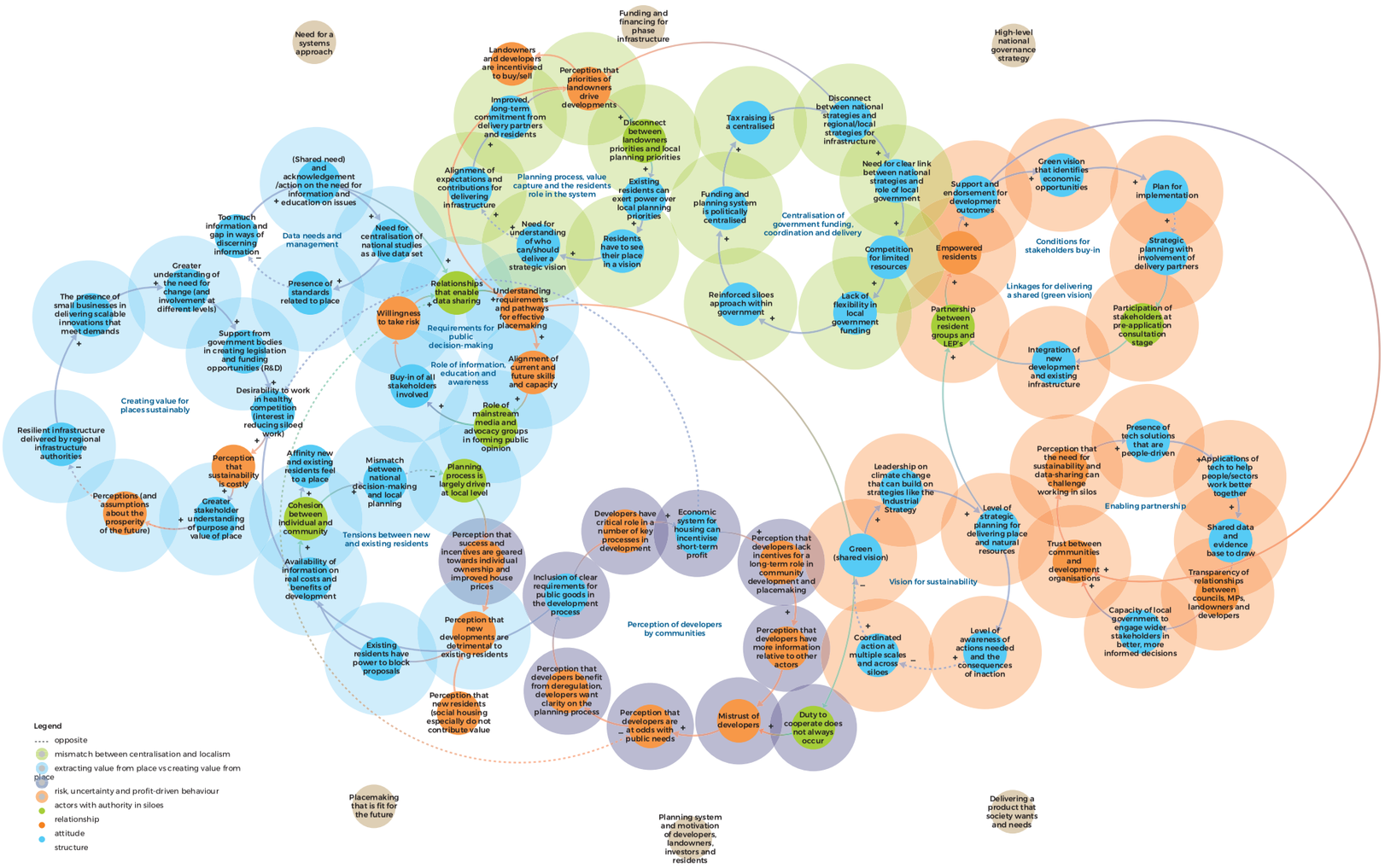


Figure 7 | Discovering the deep structure for SLP



Part four: Mapping interdependencies

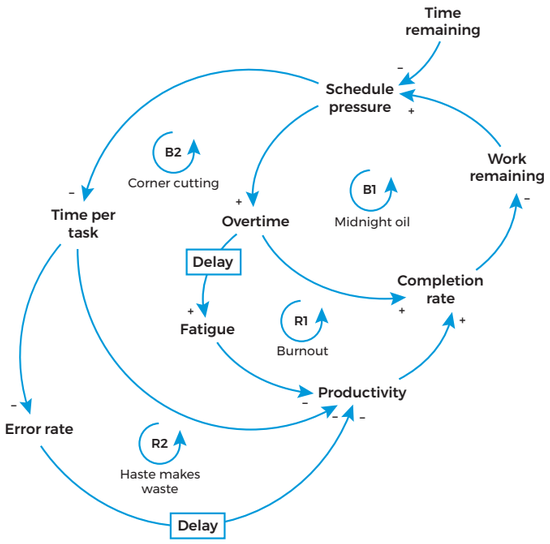
a. The approach to system dynamics draws from the Acumen+ approach and Sterman's approach to generating individual feedback loops.[1]
b. The purpose of this interdependencies exercise is to **identify areas within the system that may be interrelated, for example causal linkages**. The assumption is that forces that drive the system are tied together in feedback loops.[2] The following example emerges from Sterman's work on causal loop diagrams (Figure 8).
c. Each of the feedback loops has a series of links that have a positive or negative polarity, which indicate **how the elements relate to one another**. This translates into a direct correlation (+), inverse (-) correlation. For example in the cluster related to 'leadership on climate change', 'recognition of the need for a shared agenda to address net zero from across government and local authorities' has led to 'leadership on climate change, through mechanisms such as the Committee on Climate Change (CCC) and cross-departmental policy commitments from government'. These are linked to one another by a positive relationship – where the former is increasing/influencing the latter.
d. The mapping exercise resulted in several iterations of the map being generated to develop a shared narrative that captures the depth and breadth of the stakeholder perspectives.

Part five: Journey through the map

Through a process of validation, the map (Figure 9) was shared with a series of stakeholders to amend and adapt. Stakeholders were asked to describe the map in a way that builds a narrative about the different parts of the map. This 'Journey through the map' is fully described in the main report.

Figure 10 (page 12) shows the final map after this validation process.

Figure 8 | Causal loop diagram example of the causes of late delivery for design work adapted from Business Dynamics (Sterman 2000)



The how to guide draws extensively from the final report *Sustainable Living Places – a systems perspective on planning, housing and infrastructure* that was released July 2020.

The full report is available here.

If you have questions, comments and/or want to get involved, please direct enquiries to nepc@raeng.org.uk

1 Sterman, John (2000) 'Causal Loop Diagrams' In *Business Dynamics: Systems Thinking and Modelling For the Complex World*, 137–90. TBS
2 The researchers are aware that there may be other arrangements (not solely loops), yet used this approach to provide a starting point for identifying the types of relationships in the map. Relationships that are not causal or loop based are identified and described as such

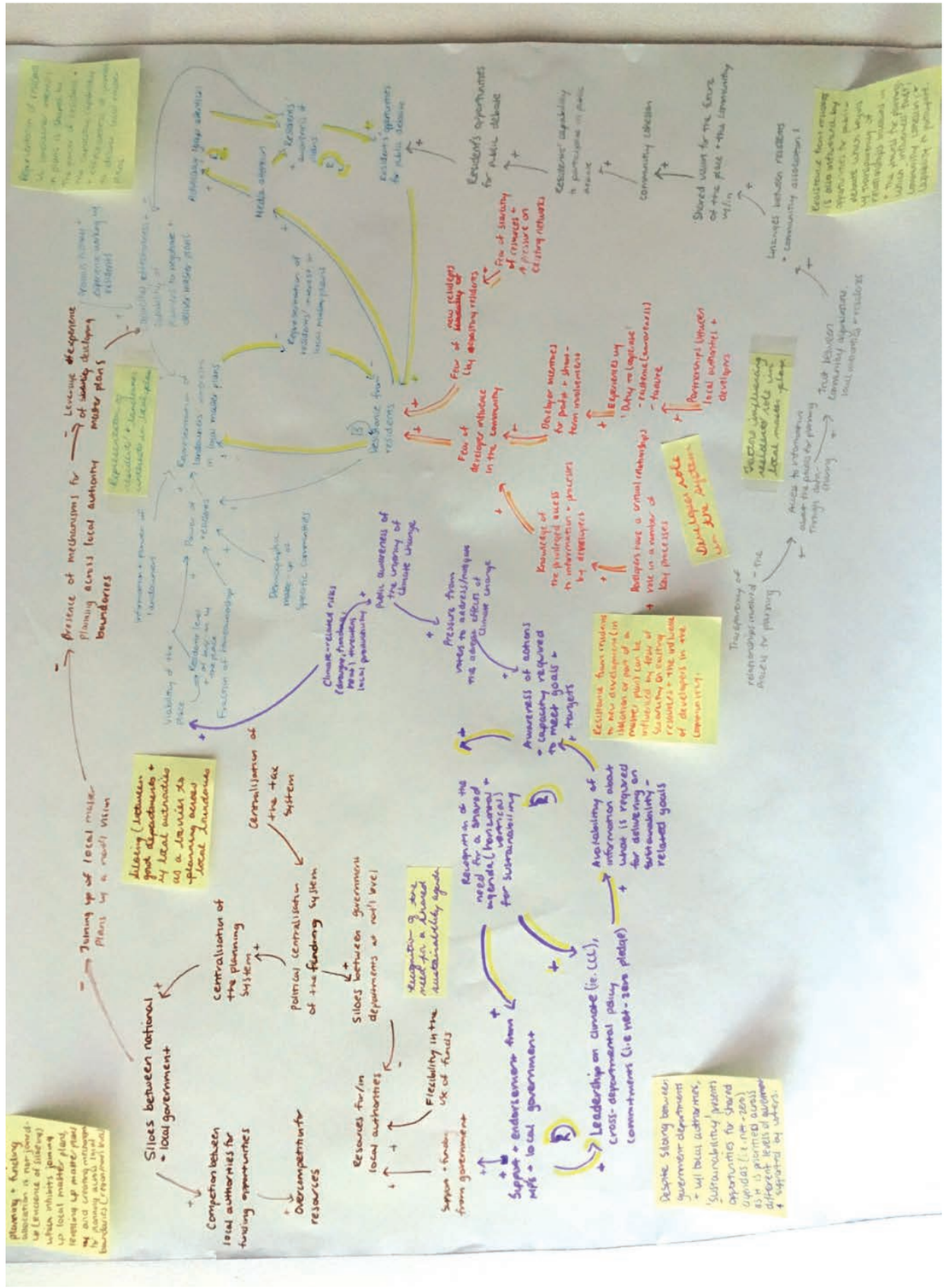
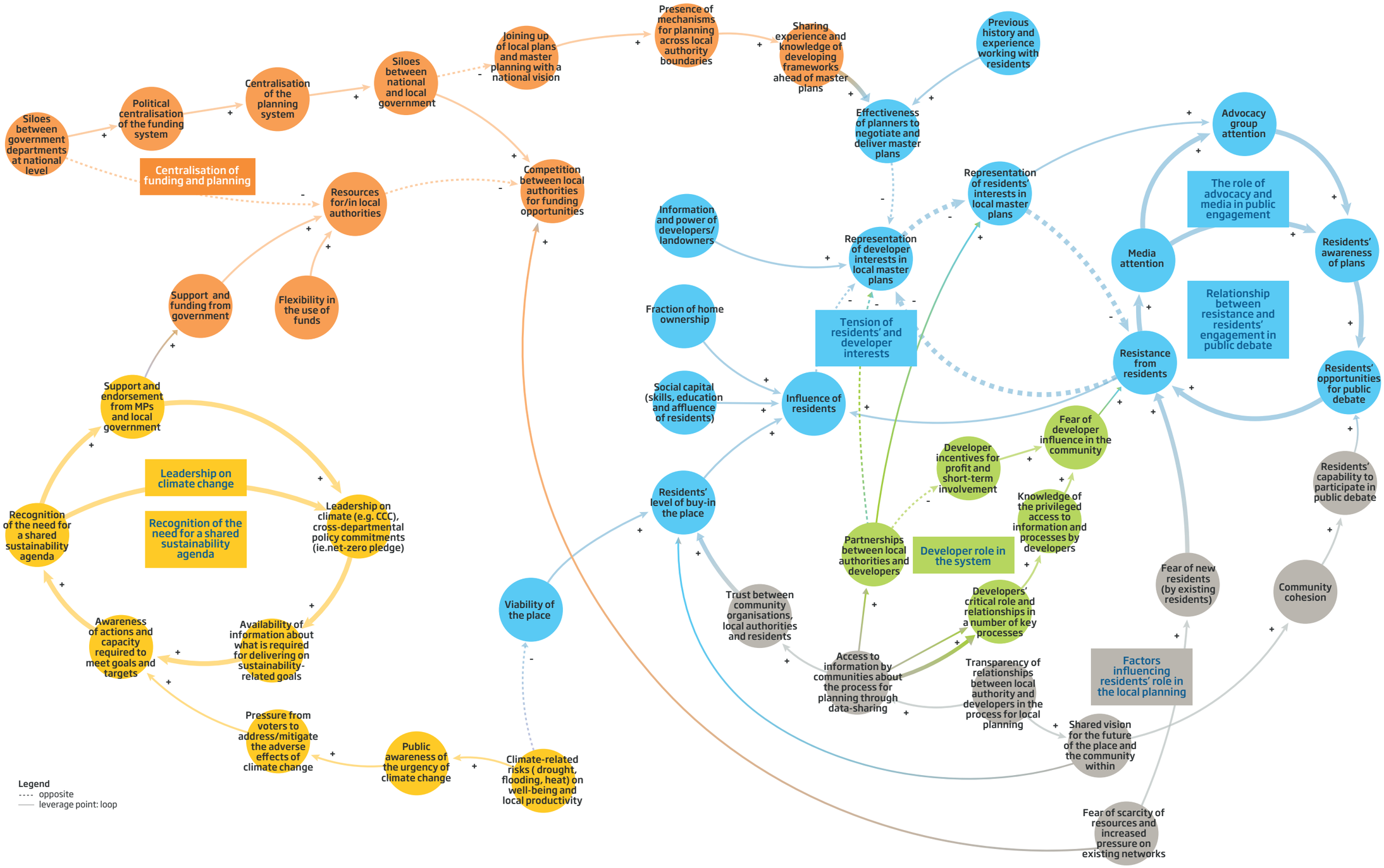


Figure 9 | System dynamics map of SLP (pre-validation)

Figure 10 | System dynamics map of SLP (post validation)



DELIVERING SUSTAINABLE LIVING PLACES THAT ARE Happy, HEALTHY, LOW-CARBON & FIT FOR THE FUTURE
CENTRALISATION OF PLANNING & FUNDING
GOVERNANCE
RESOURCES FOR LOCAL AUTHORITIES
SUPPORT & FUNDING FROM GOVERNMENT
COMPETITION BETWEEN LOCAL AUTHORITIES FOR FUNDING OPPORTUNITIES
SILOES BETWEEN NATIONAL & LOCAL GOVERNMENT
SILOES BETWEEN GOVERNMENT DEPARTMENTS AT NATIONAL LEVEL
CENTRALISATION OF THE FUNDING SYSTEM
CENTRALISATION OF THE PLANNING SYSTEM
FLEXIBILITY IN THE USE OF FUNDS
SHARING EXPERIENCE & KNOWLEDGE OF DEVELOPMENT FRAMEWORKS
JOINING UP OF LOCAL PLAN & MASTER PLANNING
WITH A NATIONAL VISION
PRESENCE OF MECHANISMS FOR PLANNING ACROSS LOCAL AUTHORITY BOUNDARIES
VIABILITY OF THE PLACE
PLANNING
INFORMATION & POWER OF DEVELOPERS & LANDOWNERS
ISOLD
RESIDENTS LEVEL OF BUY
FRICTION OF HOME OWNERSHIP
INFLUENCE OF RESIDENTS
TENURE
SOCIAL CAPITAL OF RESIDENTS
RESISTANCE FROM RESIDENTS
RESIDENTS AWARENESS OF PLANS
MEDIA ATTENTION
RESIDENTS & DEVELOPERS' INTEREST IN LOCAL PLANNING
ADVOCACY GROUP ATTENTION
PREVIOUS HISTORY WORKING WITH RESIDENTS
EFFECTIVENESS OF PLANNERS TO NEGOTIATE & DELIVER MASTER PLANS
RESIDENTS OPPORTUNITIES FOR PUBLIC DEBATE
FACTORS INFLUENCING RESISTANCE FROM RESIDENTS
STAY AWAY!
FEAR OF NEW RESIDENTS
RESIDENTS CAPACITY TO PARTICIPATE IN PUBLIC DEBATE
SHARED VISION FOR THE FUTURE OF THE PLACE & THE COMMUNITY WIN
TRANSPARENCY OF RELATIONSHIPS BETWEEN LOCAL AUTHORITY & DEVELOPERS
ENGAGEMENT
FEAR OF SCARCITY OF RESOURCES & INCREASED PRESSURE ON EXSISTING NETWORKS
ACCESS TO INFORMATION BY COMMUNITIES ABOUT THE PROCESS FOR PLAN-MAKING THROUGH...
DATA SHARING
TRUST BETWEEN COMMUNITY ORGANISATIONS
LOCAL AUTHORITIES & RESIDENTS
PARTNERSHIPS BETWEEN LOCAL AUTHORITIES & DEVELOPERS
DEVELOPERS CRITICAL ROLE & RELATIONSHIPS IN KEY PROCESSES
DEVELOPMENT
KNOWLEDGE OF THE PRIVILEGED ACCESS TO INFORMATION
& PROCESSES BY DEVELOPERS
FEAR OF DEVELOPER INFLUENCE
INVESTOR INCENTIVES FOR GROWTH & SHARED TEAM INVOLVEMENT
FACTORS INFLUENCING TRUST & PUBLIC PARTICIPATION IN LOCAL PLANNING
CLIMATE RELATED RISKS - DROUGHT, FLOODING, HEAT - ON WELL BEING & LOCAL PRODUCTIVITY
SUSTAINABILITY
PRESSURE FROM VOTERS TO ADDRESS THE ADVERSE EFFECTS OF CLIMATE CHANGE
PUBLIC AWARENESS OF THE URGENCY OF CLIMATE CHANGE
NET ZERO PLEDGE
THE NEED FOR A SHARED SUSTAINABILITY AGENDA
FOR DELIVERING ON SUSTAINABILITY RELATED GOALS
AVAILABILITY OF INFORMATION
LEADERSHIP ON CLIMATE
CROSS-DEPARTMENTAL POLICY COMMITMENTS
AWARENESS OF ACTIONS NEEDED TO MEET GOALS & TARGETS
NICE ONE!
SUPPORT & ENDORSEMENT FROM MPs & LOCAL GOVERNMENT
THE NEED FOR A SHARED SUSTAINABILITY AGENDA
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