Infrastructure, Resilience and Sustainability

Strategic Approaches

Professor Peter Guthrie

UNIVERSITY OF CAMBRIDGE

What is Resilience?

A definition of resilience

‘The ability of a **system**, **community** or **society** exposed to hazards to **resist**, **absorb, accommodate** to 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’

(UNISDR, 2009, p.24)

Resilience

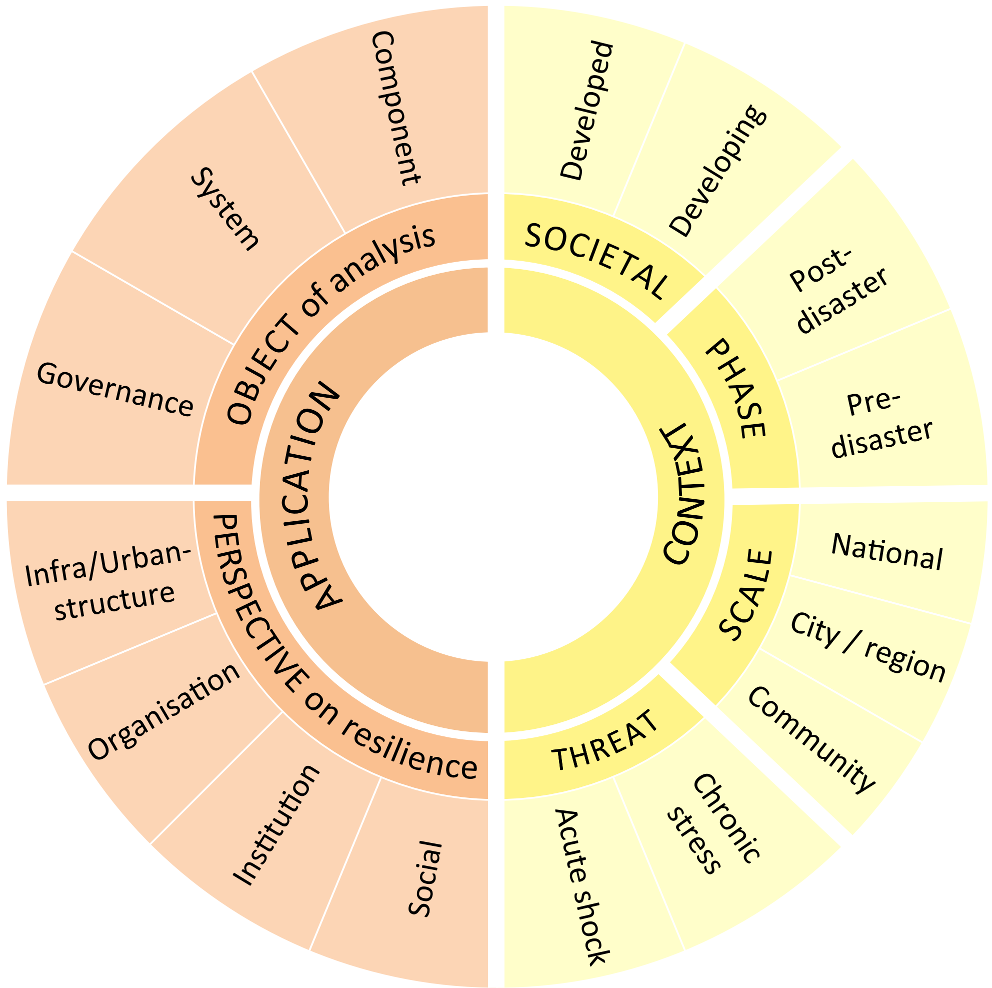
Precision: Resilience - an outcome, process or physical property. May relate to physical features, political strategies, organisations or community capacity.

Circularity: There can be an element of circular reasoning - is resilience a factor of, or the inverse of vulnerability?

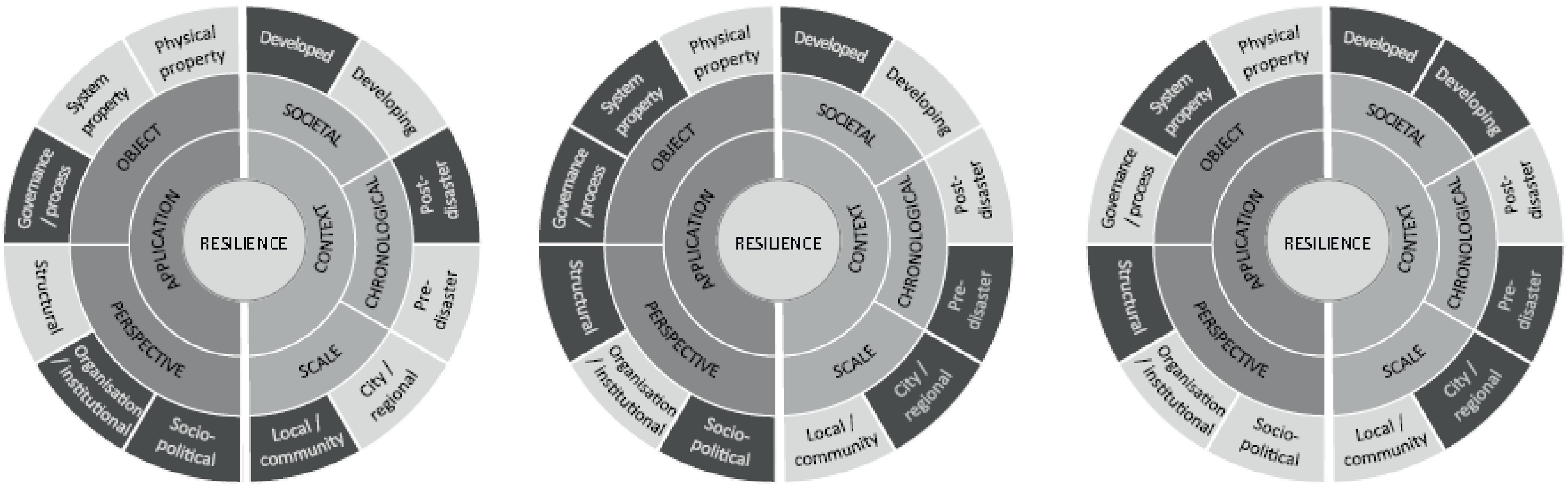
Context: Resilience is influenced by scale and location, cultural context and timing in relation to crises.

Completeness of knowledge: Interpretation of resilience has led to competing views and uncertainty around how 'resilience' should be described and measured.

Resilience for a More Secure Future



Resilience Interpretations



(a) Kuhlicke, 2010 (b) Chang *et al.*, 2014 (c) Milman and Short, 2008

MacAskill, K., Guthrie, P., 2014. *Multiple Interpretations of Resilience in Disaster Risk Management*. 4th International Conference on Building Resilience, 8-10 September, Salford Quays, United Kingdom. Elsevier BV

Retrofit City Futures: Visions for Urban Sustainability

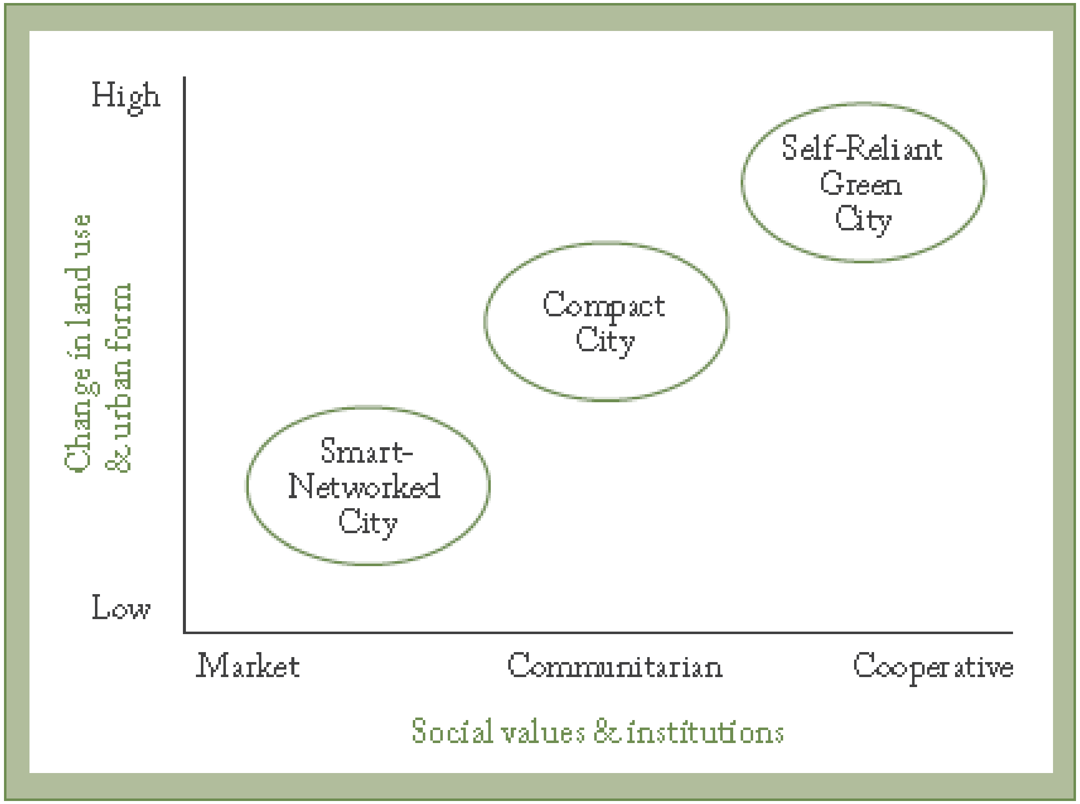
HONG KONG WORLD SBE 2017
WORLD Sustainable Built Environment Conference

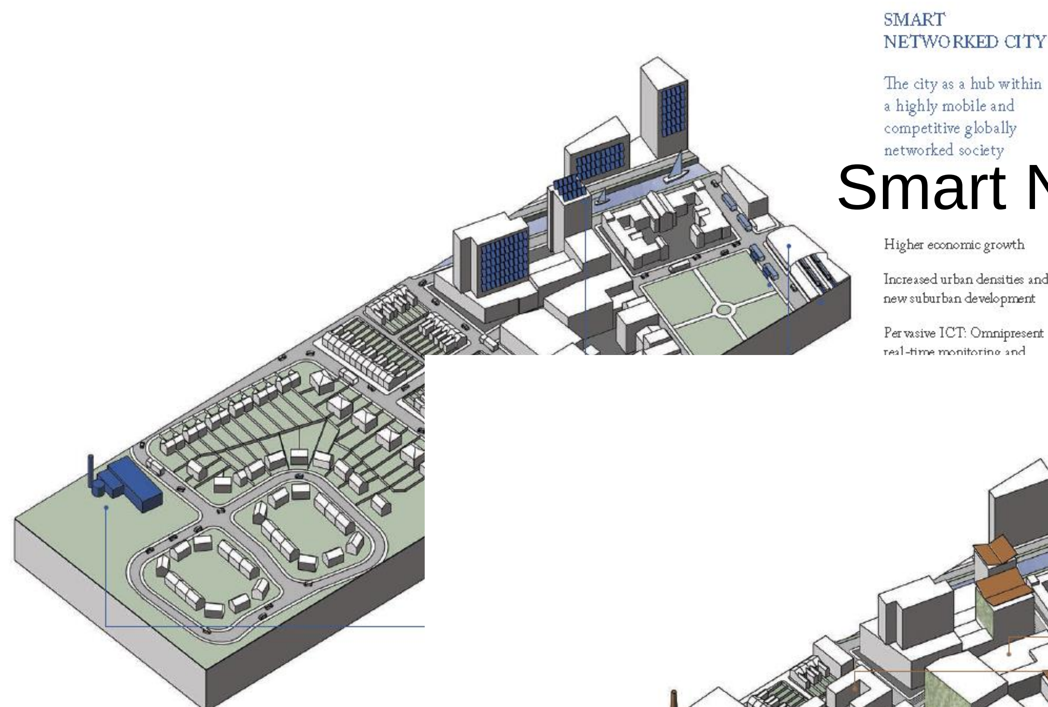
Organisers:
CONSTRUCTION INDUSTRY COUNCIL 建造業議會
HKGBC 香港綠色建築議會

SBE SERIES

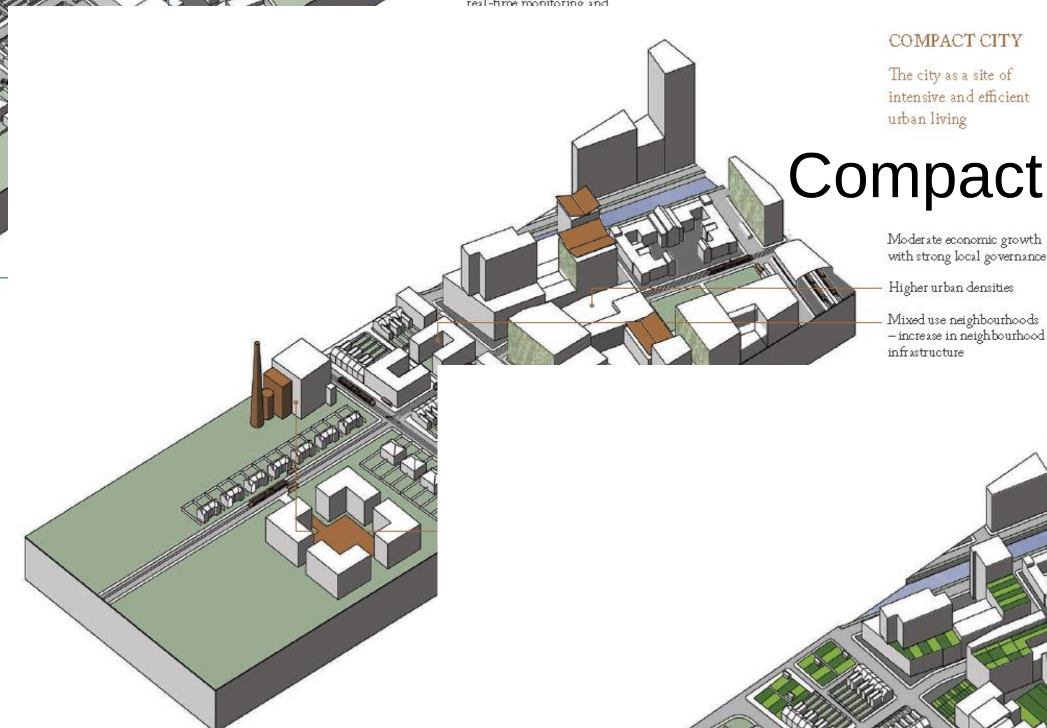
International Co-owners:
CIB
iiSBE
UNEP Sustainable Buildings and Climate Initiative
FIDIC
Global Alliance for Buildings and Construction

Three Scenarios Developed





Smart Networked City



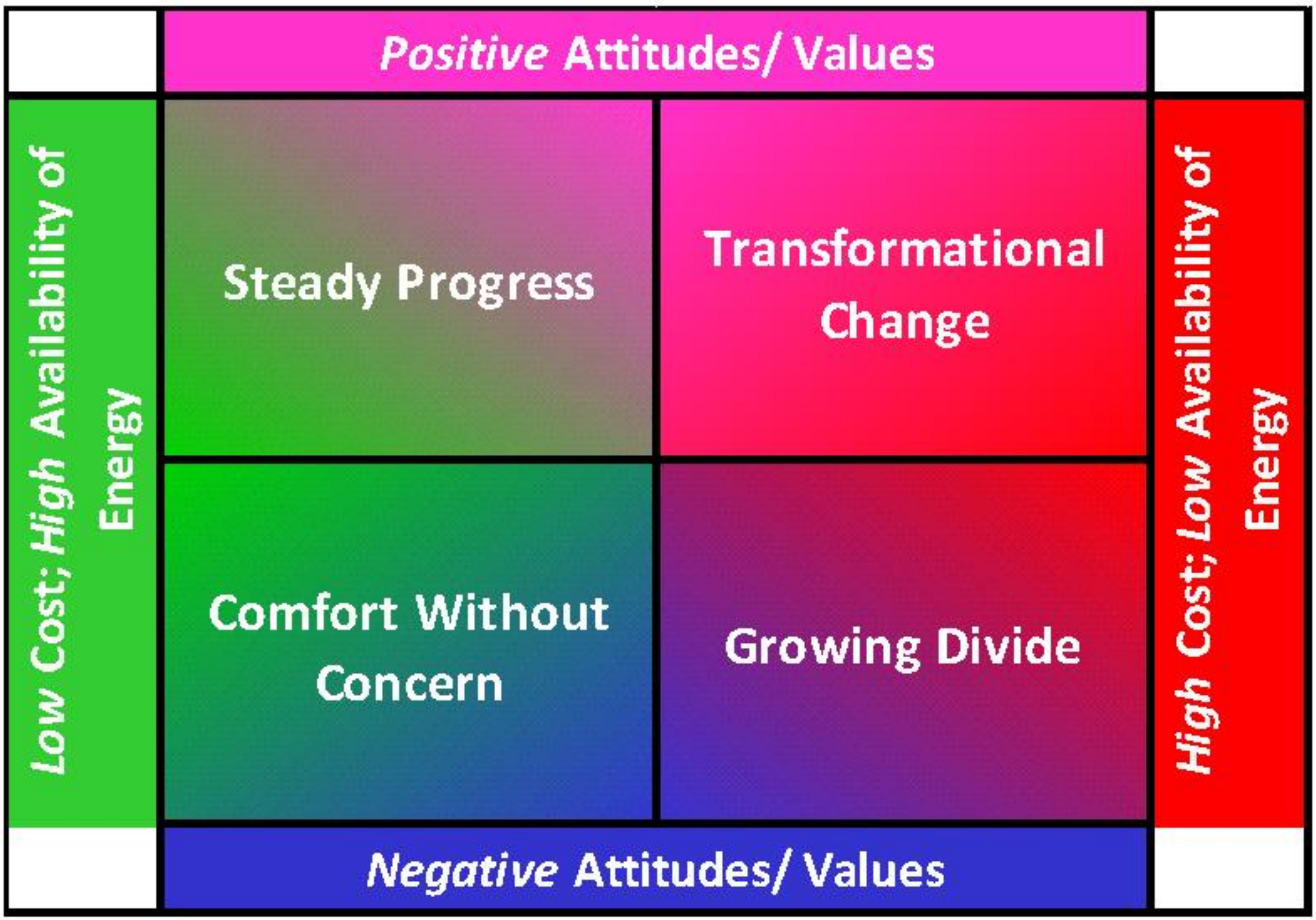
Compact City

Self-Reliant Green City

WORLD SBE HONG KONG 2017
WORLD Sustainable Built Environment Conference

Organisers:
CONSTRUCTION INDUSTRY COUNCIL 建造業議會
HKGBC 香港綠色建築議會

Energy Efficiency in the Built Environment (EEBE) Research Programme
Scenarios



Knowledge Mapping for Future Proofing

Uncertainty of High Impact Future Trends and Drivers

Availability of Product and Process Innovation

	Low	High
Available	**Straightforward** Available knowledge to accommodate predictable future trends	**Uncertainty-oriented** Need to prepare for a spectrum of plausible futures with the use of futures techniques
Unavailable	**Innovation-oriented** Need or new technologies, construction practices and an optimum combination of established sustainability assessment methods	**Comprehensive** Need for new technologies, construction practices and new generation future-oriented decision-support techniques

Types of future-proofed design

Georgiadou M C, Hacking T, Guthrie P., 2012. *"A conceptual framework for future-proofing the energy performance of buildings". Energy Policy; 47: 145-155*

Categorisation of Future-Proofed Design Approaches

X-axis: Coverage of SD Issues

X_1: Financial considerations

- X_{1a}: Capital cost assessment
- X_{1b}: Cost-Effectiveness Analysis
- X_{1c}: Financial incentives

X_2: Environmental considerations

Hierarchical approach to low-energy design

X_3: Socio-economic considerations

- X_{3a}: Sustainability information and education
- X_{3b}: Demand-side management strategies
- X_{3c}: Assessment of energy-related social impacts

Y-axis: Adopting Lifecycle Thinking

Y_1: Operational energy performance

- Y_{1a}: Predictive studies
- Y_{1b}: Post-Construction Audit/ Post-Occupancy Evaluation

Y_2: Embodied energy and carbon

- Y_{2a}: Design for 'cradle-to-gate'
- Y_{2b}: Design for 'cradle-to-grave'
- Y_{2c}: Design for 'cradle-to-cradle'

Y_3: Lifecycle Assessment

- Y_{3a}: Building material and/or construction component scale
- Y_{3b}: Building scale
- Y_{3c}: District scale

Y_4: Lifecycle Costing

Z-axis: Accommodating Risks and Uncertainties

Z_1: Steady-state modelling

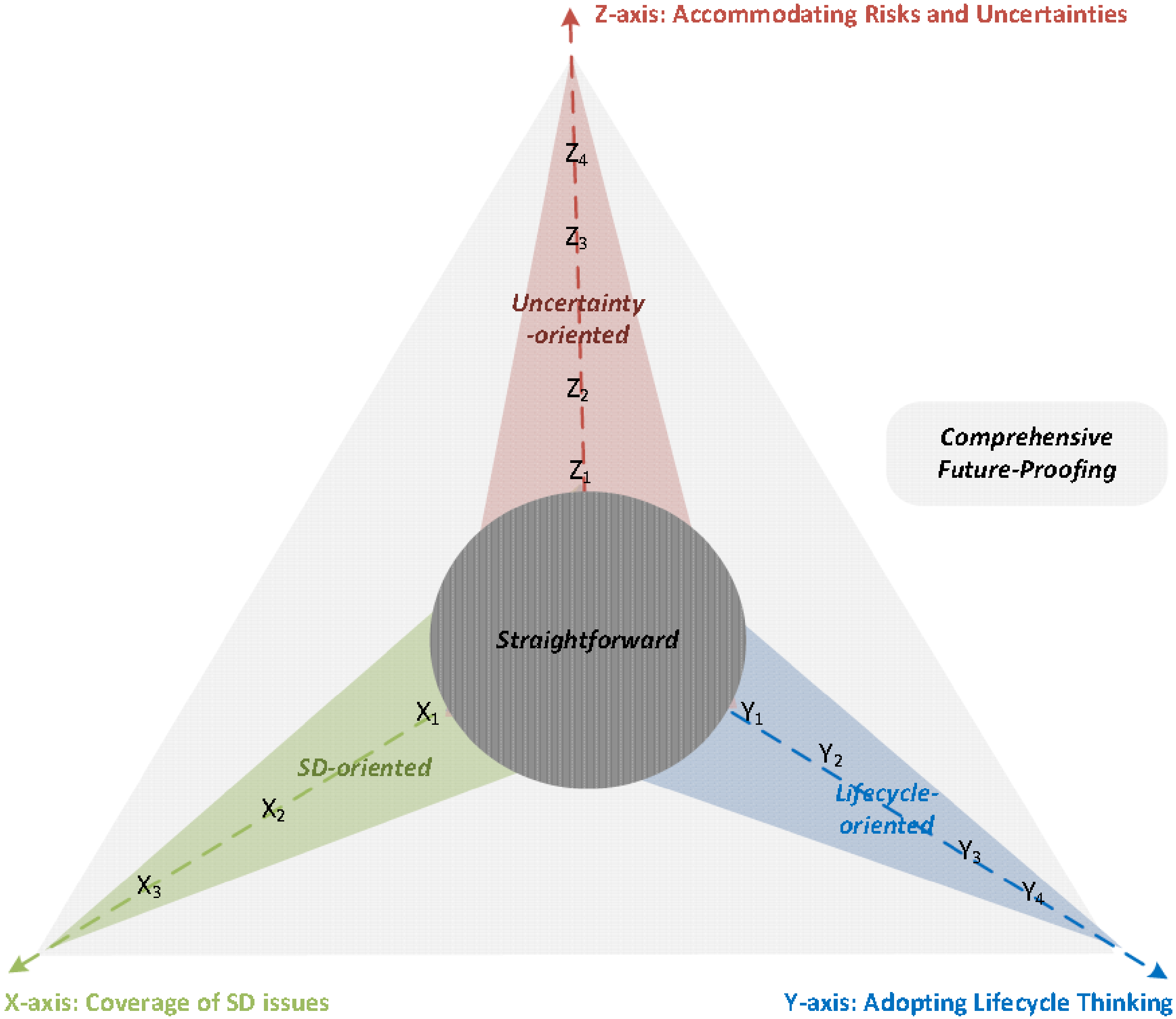
Z_2: Adoption of standards beyond statutory minima

Z_3: Design for adaptive capacity

- Z_{3a}: Design for resilience to overheating
- Z_{3b}: Design for flexibility

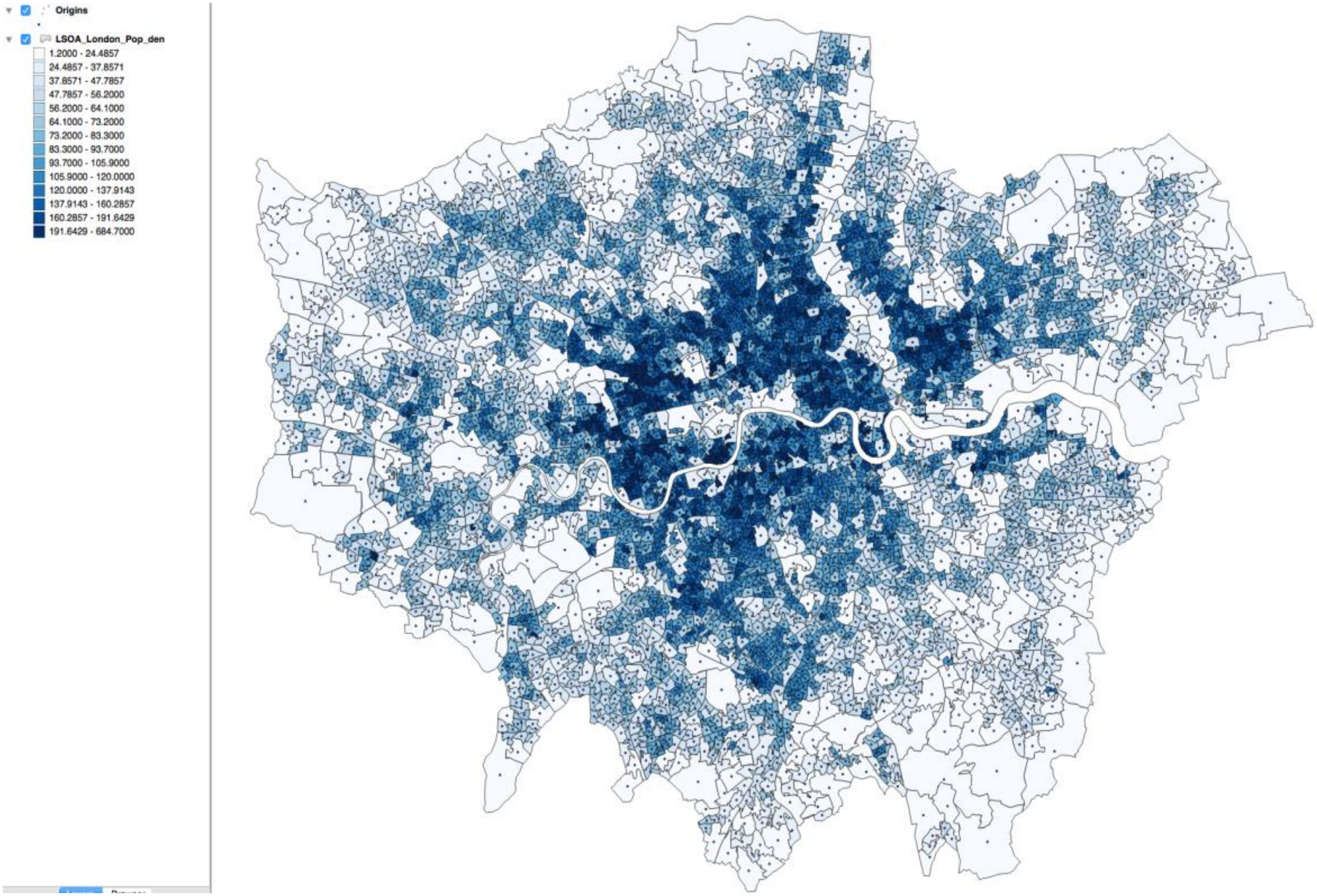
Z_4: Advanced future-oriented analysis

- Z_{4a}: Dynamic building performance evaluation
- Z_{4b}: Stochastic modelling of future overheating risk
- Z_{4c}: Use of futures techniques

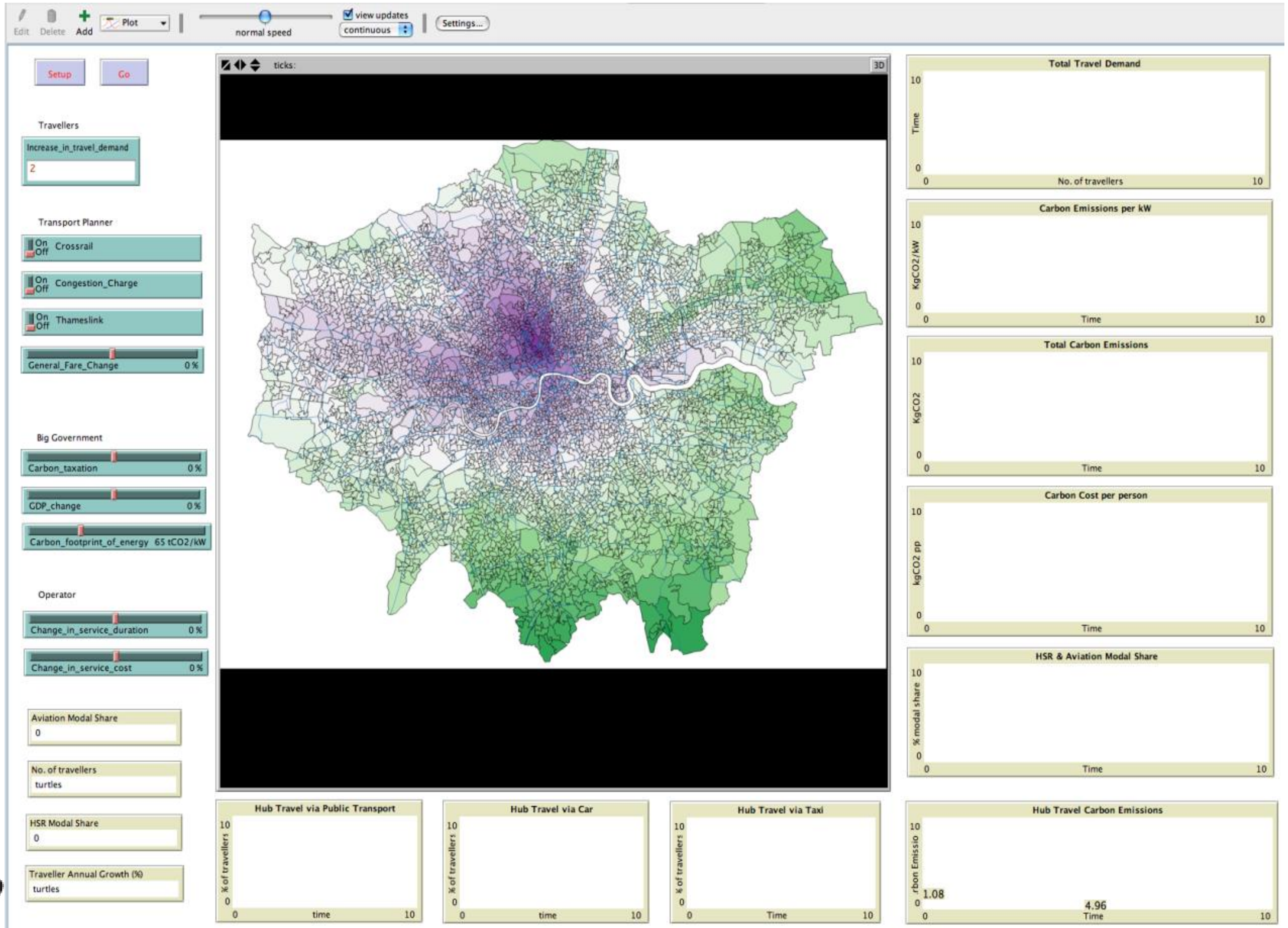


Future-Proofed Design of Low-Energy Housing Developments
Conceptual Framework and Case Studies from the UK and Sweden
Maria Christina Georgiadou
PhD Thesis October 2013

Agent Based Modelling (ABM)



Scenarios can be tested



Civil Infrastructure

- The framework upon which society can function
- Providing connectivity
- The building blocks of an integrated society
- Operationally interdependent but functionally separated

Civil Infrastructure Characteristics

- Long life
- High initial investment
- Geographically widespread
- Compatibility with existing systems

Civil Infrastructure

- Building on historic decisions and embedding them (railways)
- Reinforcing existing systems (roads and railways)
- Enshrining distinctiveness
- Resulting obsolescence (canals)

WEF Global Risks 2017

- Decision makers may see the provision of infrastructure as unlikely and of limited impact
- Risks of extreme event may cause infrastructure failure
- Infrastructure failure through system collapse would lead to societal breakdown

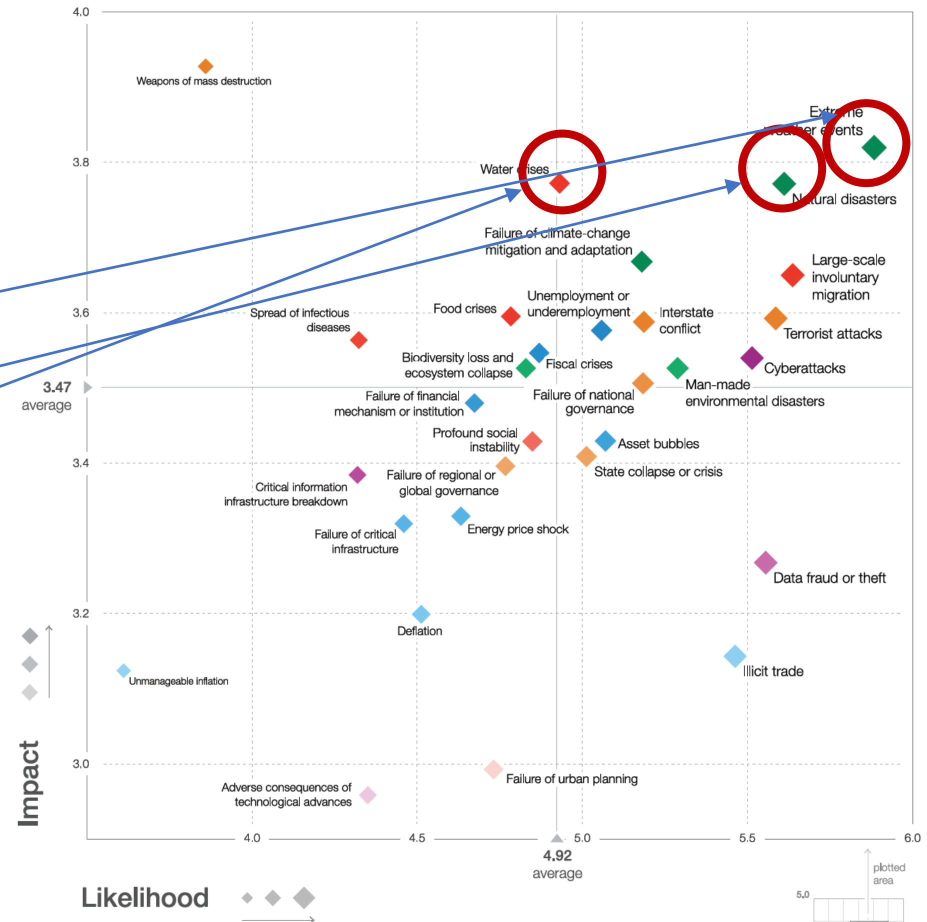
World Economic Forum Global Risks 2017

Catastrophic Risks GAC at WEF:

3 of top 4 for Impact:

- Extreme Weather
- Natural Disasters
- Water Crises

Figure 3: The Global Risks Landscape 2017



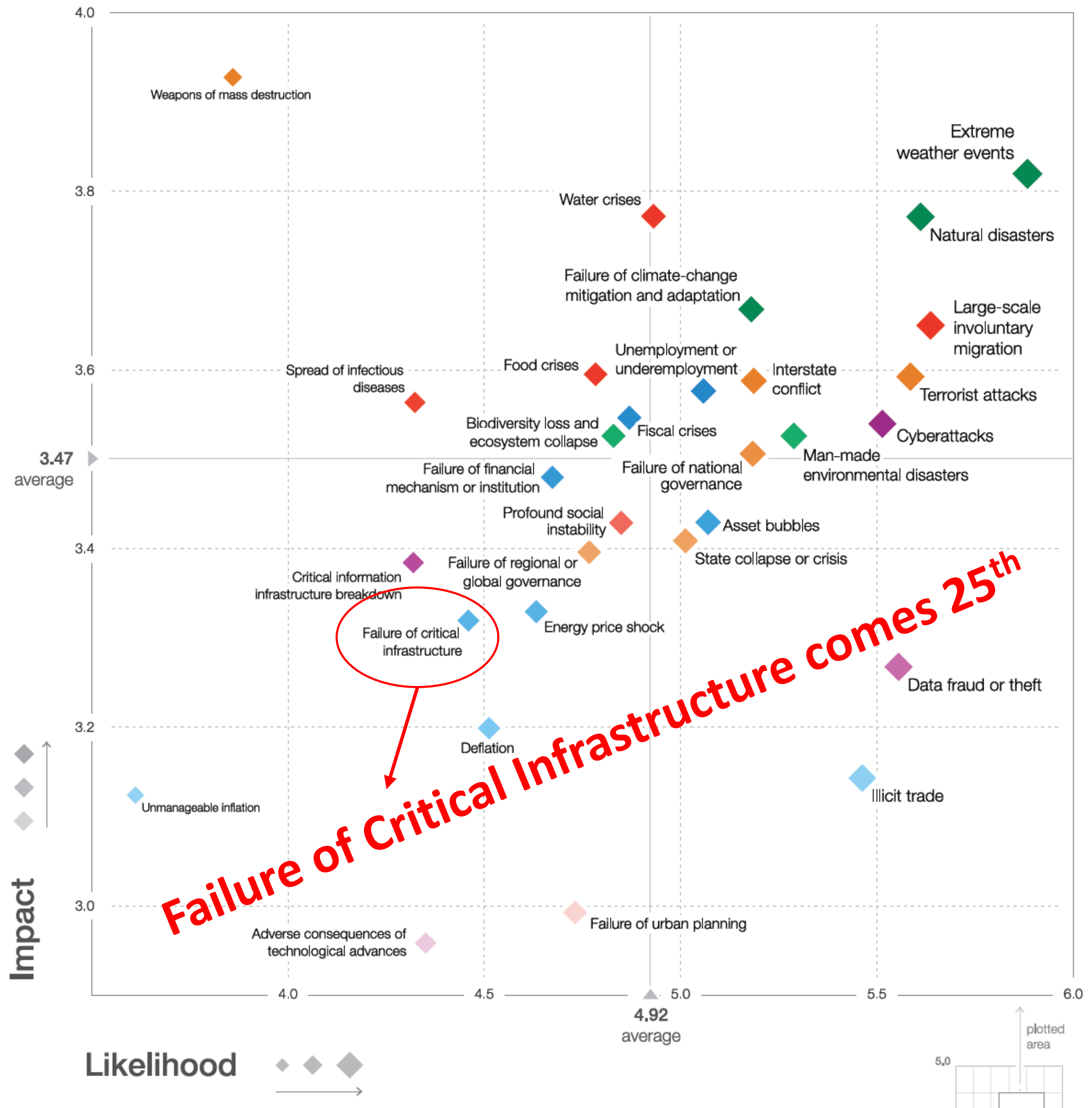
Organisers:

CONSTRUCTION INDUSTRY COUNCIL 建造業議會

HKGBC

WORLD Sustainable Built Environment Conference

Figure 3: The Global Risks Landscape 2017



Resilience

Inversely proportional to economic development

Developing economies are excellent at absorbing shocks - elastic

Sophisticated societies are strong and highly resistant - but brittle

Currently

- Total Assurance of Non Failure
- Assumption that Failure is Catastrophic
- Risk Allocation is Confined
- All Resource Use Now is Allowable

Potentially

- Design for Failure to Occur
- Design for Graceful Failure
- Risk is Shared More Widely
- Resource Use Now Balanced against Future Impacts

Sustainability in Infrastructure

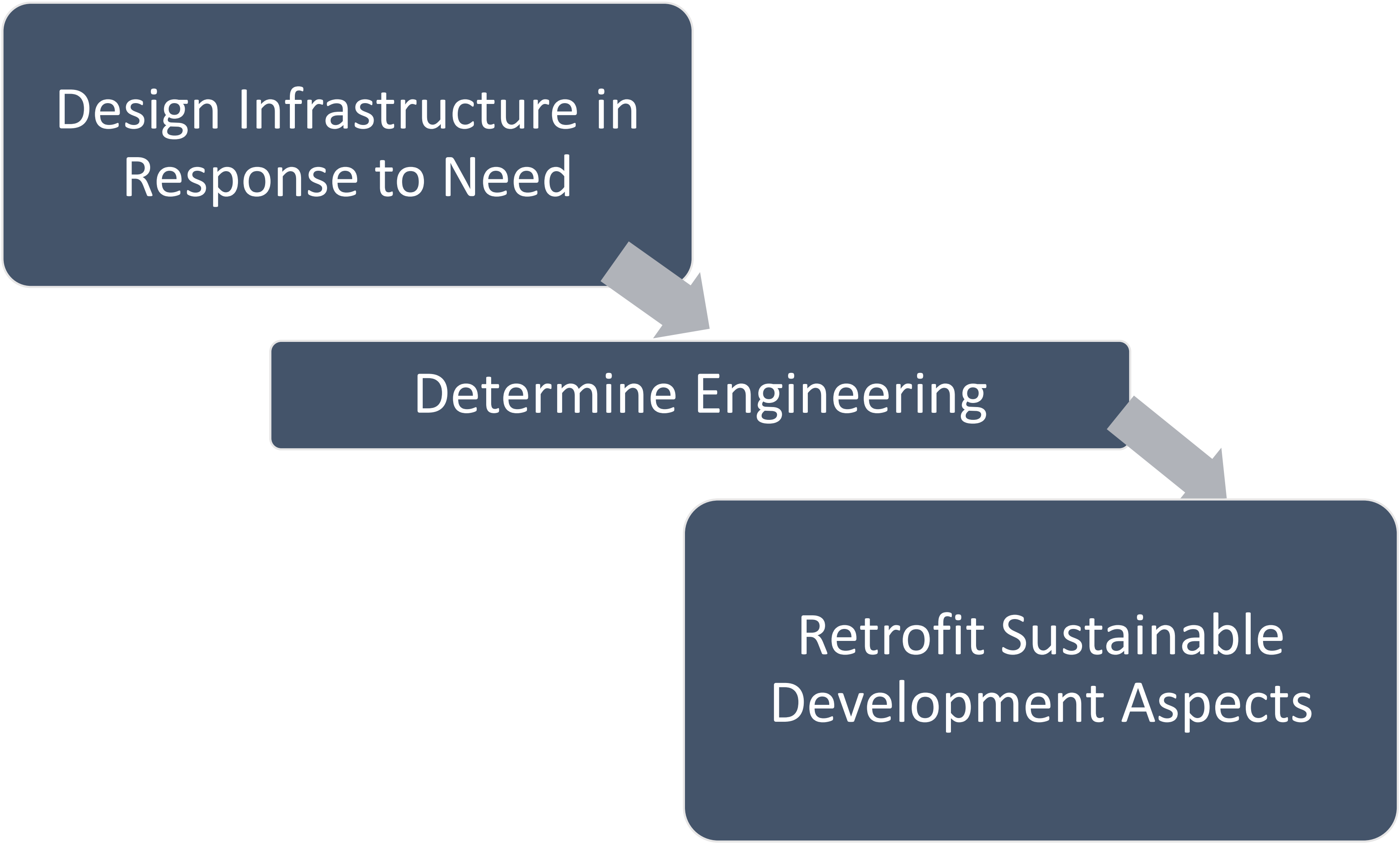
- Designed from response to need
- Sustainability is retrofitted to the design

But …

- Sustainability Goals should be the Starting Point
- Infrastructure designed to meet these aims

Sustainability in Infrastructure

Sustainable Infrastructure is Infrastructure that is Determined by Sustainable Development Goals


Design Infrastructure in Response to Need
Determine Engineering
Retrofit Sustainable Development Aspects

Design Infrastr re in
Response Ne

Determin gineering

Re fit stainable
Deve ment Aspects

Set Sustainable Development Vision

Introduce Societal Aspects

Design Sustainable Infrastructure

Figure 5: Map of shortlisted schemes

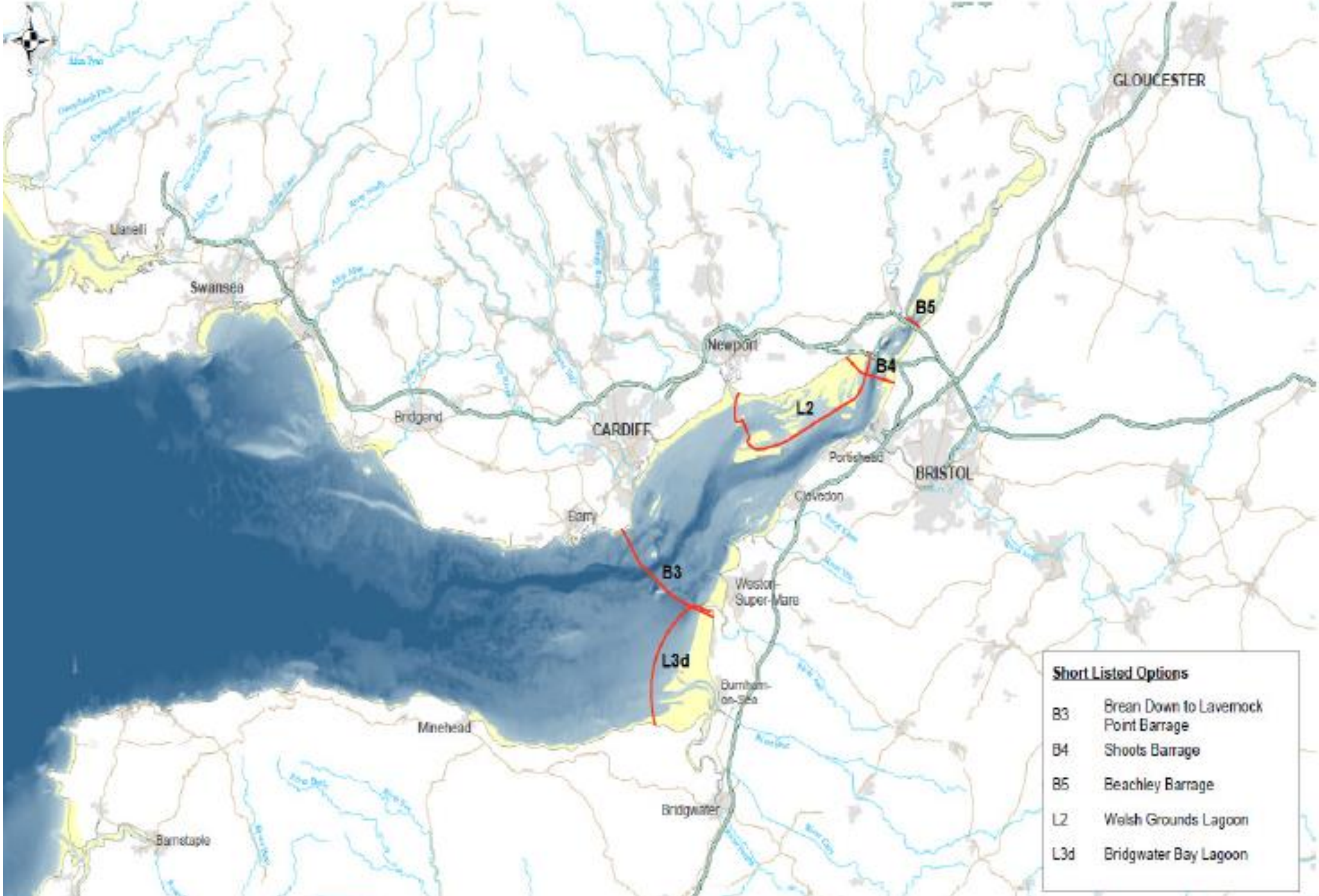


Figure 5: Map of shortlisted schemes

可持续发展目标

SUSTAINABLE DEVELOPMENT GOALS

HONG KONG WORLD SBE 2017
WORLD Sustainable Built Environment Conference

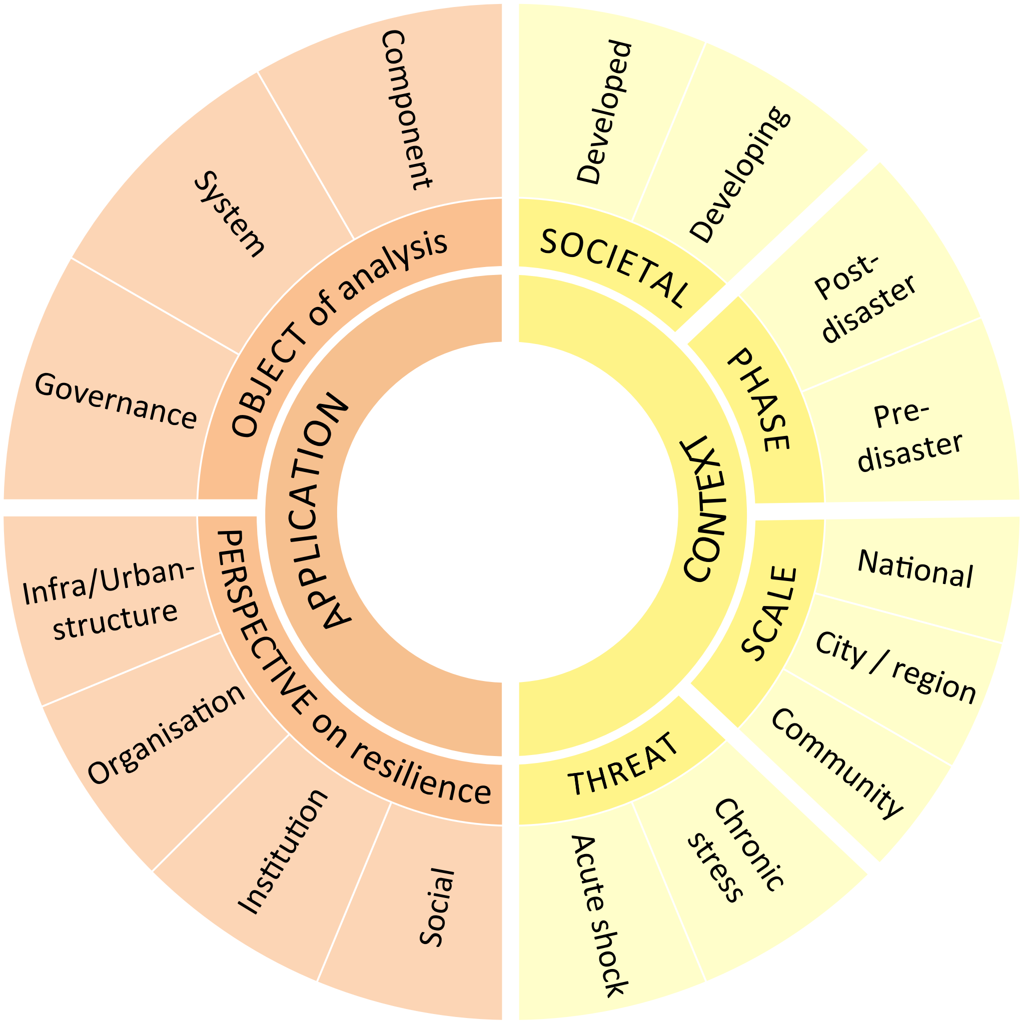
Organisers:
CONSTRUCTION INDUSTRY COUNCIL 建造業議會
HKGBC 香港綠色建築議會

SBE SERIES

International Co-owners:
CIB
iiSBE
UNEP Sustainable Buildings and Climate Initiative
FIDIC
Global Alliance for Buildings and Construction


1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
PARTNERSHIPS FOR THE GOALS

Resilience for a More Secure Future



Thank you

Peter Guthrie pmg31@cam.ac.uk