PLANNING FOR CLIMATE CHANGE AND RAPID URBANISATION

CONTINUING PROFESSIONAL DEVELOPMENT, LECTURE SERIES FOR PROFESSIONALS

Thank you for joining!

This lecture will begin shortly, at 11:00am UTC, 12:00noon BST

Image credit:
Morley von Sternberg for Allies and Morrison

Lecture Series

Overview of the seven lectures forming part of this series:

1. **Introduction to the UN 2030 Sustainable Development Goals**, Mina Hasman, SOM
   Provides an overview of the UN 2030 SDGs together with other related international agreements, and describes the importance of the Goals for Built Environment Professionals.

2. **Planning for Rapid Urbanisation,** Ben Bolgar, The Prince's Foundation
   Outlines a framework for use in secondary cities which are experiencing rapid growth but which may have little or no access to professional planning expertise.

3. **Planned City Extensions,** Alfredo Caraballo, Allies and Morrison
   Provides a reminder of key master-planning and urban design principles such as: site analysis, micro-climate design, density, mixed use, walkability etc.

4. **Resilient Infrastructure**, Ian Carradice, Arup
   Explains the context, relevance and drivers to develop resilient infrastructure by adopting an integrated design approach and considering planetary solutions to address climate related challenges.

5. **Climate Responsive Design,** Peter Clegg, Isabel Sandeman and Rachel Sayers from FCB Studios, and Rafiq Azzam, Shatotto
   Part one is focused on 'A Manifesto for delivering Climate Responsive Design', and Part Two, entitled 'Collaborating for Sustainable Development', provides a case study of how the principles of Climate responsive design have be used on a project in Bangladesh to create an inspiring and comfortable educational environment for the Aga Khan Academies Unit.

6. **Heritage-led Regeneration**, Geoff Rich, Feilden Clegg Bradley Studios
   Describes the value of heritage led regeneration in terms of the reuse of existing buildings, and the potential to generate social and economic development.

7. **Sustainable Outcomes Guide**, Gary Clark, HOK London Studio
   Provides a practical explanation of the outcomes that need to be delivered if we are to achieve development which is sustainable. Includes meaningful, measurable targets and associated metrics.

Resilient infrastructure:
from theory to practice

Ian Carradice
Director | Infrastructure London Group
Civil Engineering London

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Introduction and context

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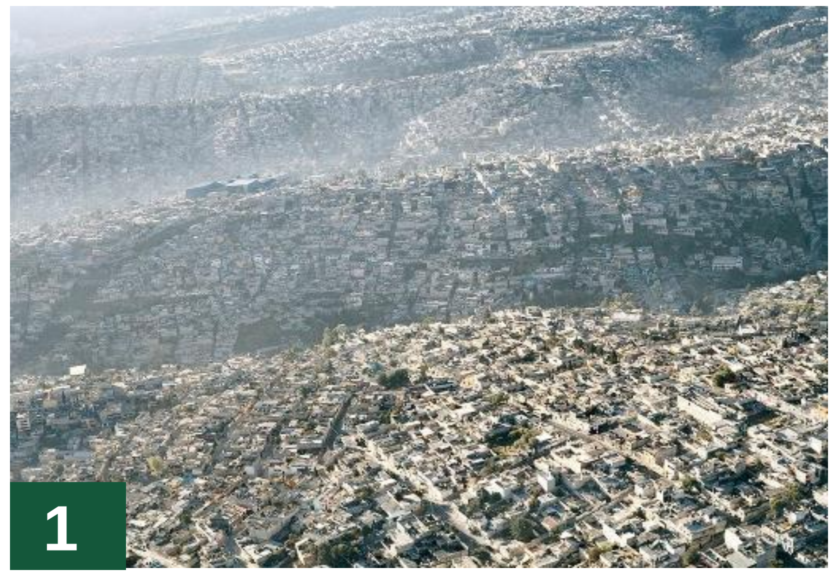
Challenges

Global exposure to disasters has risen over recent decades as a result of climate change, population growth, urbanisation, globalisation, poor land management and pollution.

Across the world, governments, businesses and scientists agree that the world is approaching a **developmental tipping point** and **radical change** is required over the next decade.

Most of our major infrastructure challenges relate to inadequate and/or unsustainable:

1. LAND USE
2. BEHAVIOURS
3. CONSUMPTION
4. CONSTRUCTION
5. DISTRIBUTION
6. HEATING
7. LOST NATURE
8. HARD SURFACING
9. SYSTEM CAPACITY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Introduction and context

Hazards

Natural and man-made hazards include:

- **Geo-hazards (terrestrial)**: Earthquakes, volcanic eruptions, landslides, flooding, erosion, subsidence and collapse, (e.g. mining, groundwater abstraction);
- **Geo-hazards (maritime/water):** Tsunamis, tidal surges, rising sea-levels, coastal erosion, groundwater rise
- **Man-made hazards:** Waste and ground contamination, groundwater pollution, pesticides, nitrates / phosphates from over-use of fertilisers, noise, air-quality;
- **Climatic hazards**: Drought, warming, increased intensity and variable rainfall, storms (hurricanes, typhoons, cyclones), dust-storms (e.g. harmattan), lightning (and bush-fires), land-degradation (e.g. deforestation), desertification
- **Bio-hazards**: Insects (e.g. locust swarm in East Africa), algal blooms, invasive species, disease (e.g. Covid-19)
- **Conflict**: war, terrorism, mass migration, and cyber threats

Introduction and context

Increasing urgency

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- Increasingly complex and interdependent infrastructure systems
- Growing demands of population growth and accelerating urbanisation
- Fragmented governance and a lack of investment
- Uncertain future
- An urgent shift is needed

Source: The Resilience Shift, 2019

4:1

FOR EVERY US$1 INVESTED IN INFRASTRUCTURE ADAPTATION, A FOUR-FOLD RETURN IS ESTIMATED

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International Guidance and Agreements

Planetary boundaries: A safe operating space for humanity

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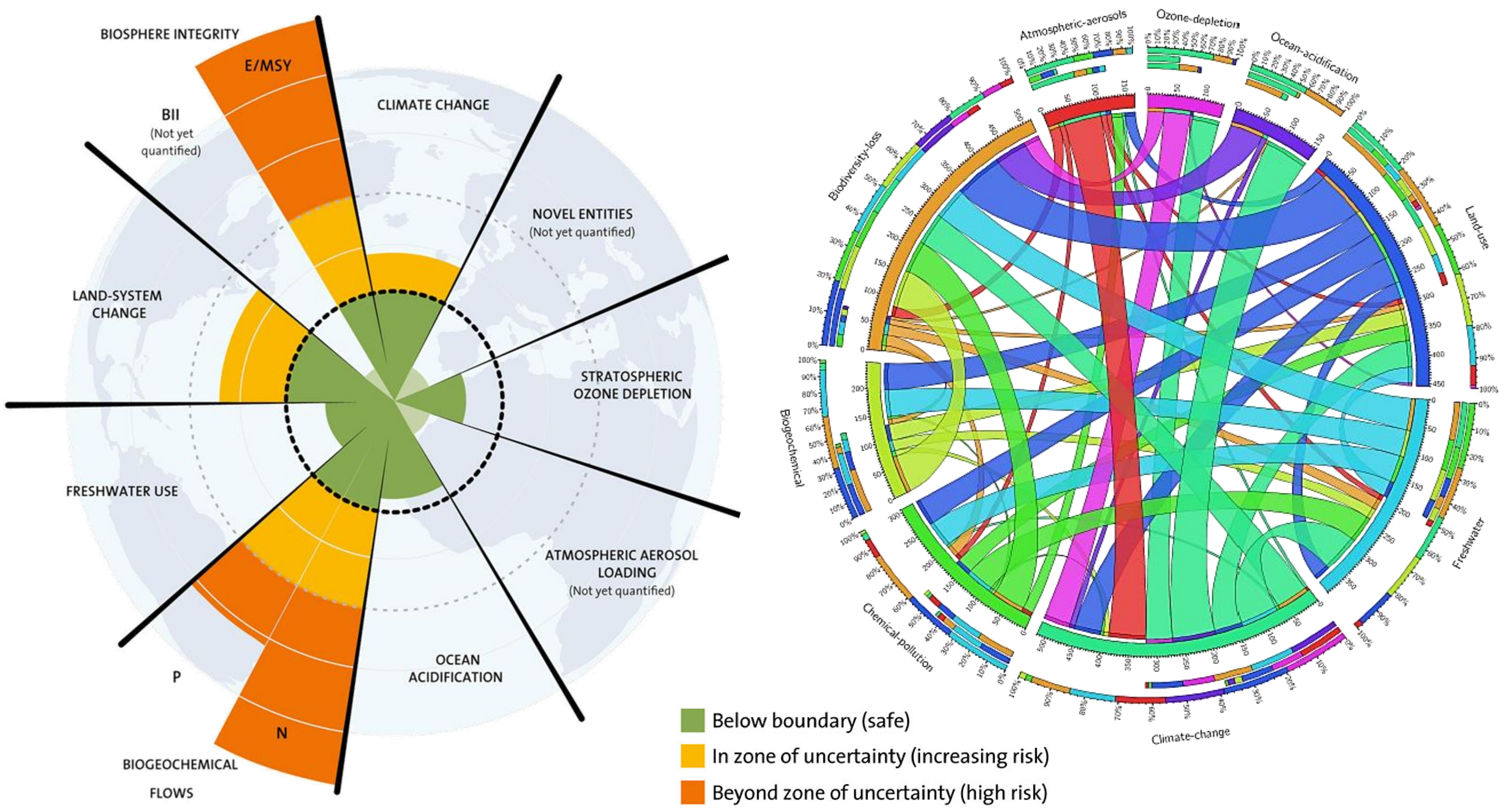
MORE INFO

The authors (Stockholm Resilience Centre) identified a set of nine planetary boundaries within which humanity can continue to develop and thrive for generations to come.

Four of them have already past the safe boundary to keep our planet hospitable to human life:

- Loss of biosphere integrity (biodiversity loss and extinctions);
- Biochemical flows to biosphere and oceans (nitrogen and phosphorus);
- Land use system change; and
- Climate change.



International Guidance and Agreements

UN Sustainable Development Goals (SDGs)

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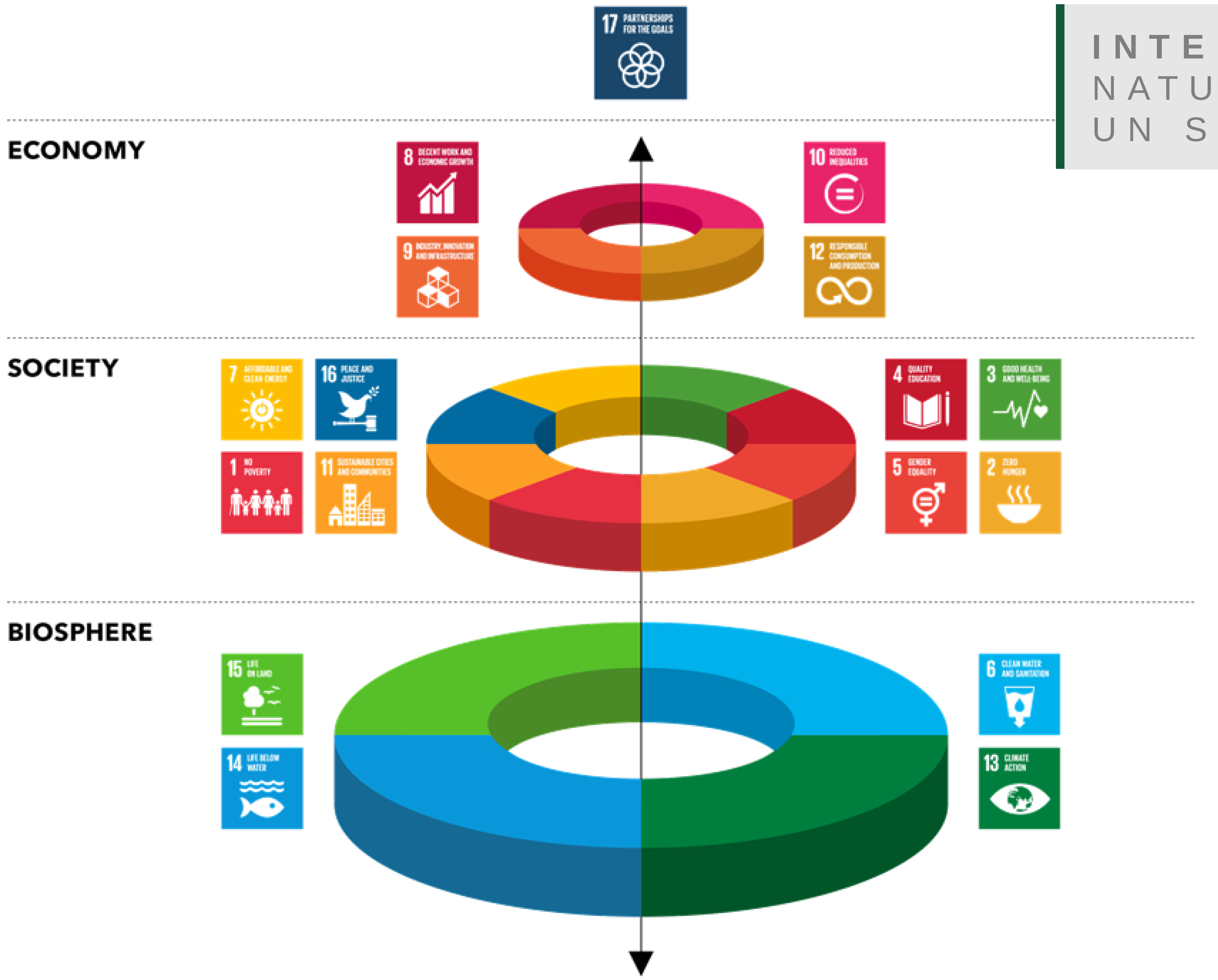
The UN SDGs are **a global response** to interconnected global challenges. The 17 goals and 169 targets provide a shared vision of what a better world looks like by 2030. Five million people from different countries, cultures and backgrounds contributed to their creation, and on 25 September 2015 they were adapted by the 193 countries of the UN General Assembly.

SDG 9 establishes specific targets related to resilient infrastructure



INTERCONNECTED NATURE OF THE UN SDGs

International Guidance and Agreements

COP 21 and the Paris Agreement

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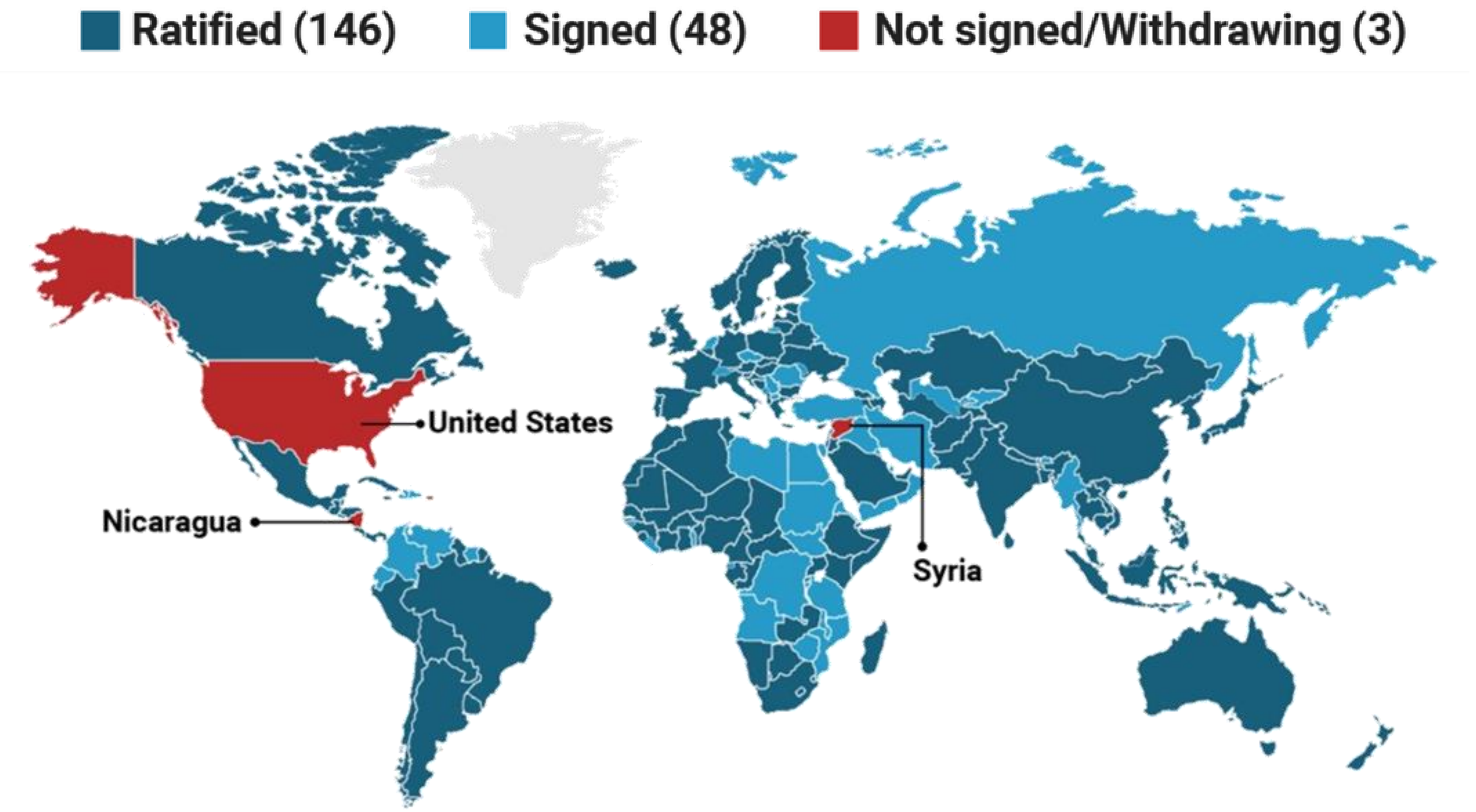
The agreement commits each nation to setting targets to reduce their carbon emissions in order to keep global average temperature increase **‘well below 2°C above per-industrial levels’**. All signatories have committed to ‘pursue efforts to limit temperature rise to **1.5°C**’ in the 21st century.

The agreement aims the increase each country’s ability to adapt to and foster resilience and encourage financial flows towards lowering greenhouse gas (GHG) emissions and climate resilient development.

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11



As part of the response to climate change agreements, 77 countries and 100 cities committed to **net zero carbon** emissions by **2050** at a one day summit in September 2019

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Definitions

Sustainable development (Brundtland Report)

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"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Source: United Nations Brundtland Commission, 1987

Needs: In particular the essential needs of the world's poor, to which overriding priority should be given.

Ability: Limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.

Definitions

The UN definition of Resilience

MORE INFO

> 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 based structures and functions.

Source: UNISDR, 2012

Definitions

Resilience for Infrastructure

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MORE INFO

“

Resilience covers both ‘physical and societal systems’ through four ‘R’ principles:

- **Robustness**: the inherent strength or resistance in a system to withstand external demands without degradation or loss of functionality;
- **Redundancy**: system properties that allow for alternate options, choices, and substitutions under stress;
- **Resourcefulness**: the capacity to mobilise needed resources and services in emergencies;
- **Rapidity**: the speed with which disruption can be overcome.”

Source: Bruneau et al, 2003

”

Source: Moor et al, 2015

Definitions

Net zero carbon

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CITY EMISSIONS < NATURAL SEQUESTRATION

The aggregated total of the emissions from construction, transport, energy use, food, clothing and other consumption equals the aggerated total of the emissions absorbed from land use change within the catchment.

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Risks and Existing Resilience Assessments

City Resilience Index

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The Index has been designed to enable cities to measure and monitor the multiple factors that contribute to their resilience. Its primary purpose is to diagnose strengths and weaknesses and measure relative performance over time.

This provides a holistic articulation of city resilience, structured around four dimensions, 12 goals and 52 indicators that are critical for the resilience of our cities.

In sum, the CRI aims to help cities understand and measure their capacity to:

- Endure;
- Adapt; and
- Transform.

Developed by Arup and Rockefeller Foundation

Risks and Existing Resilience Assessments

City Water Resilience Approach

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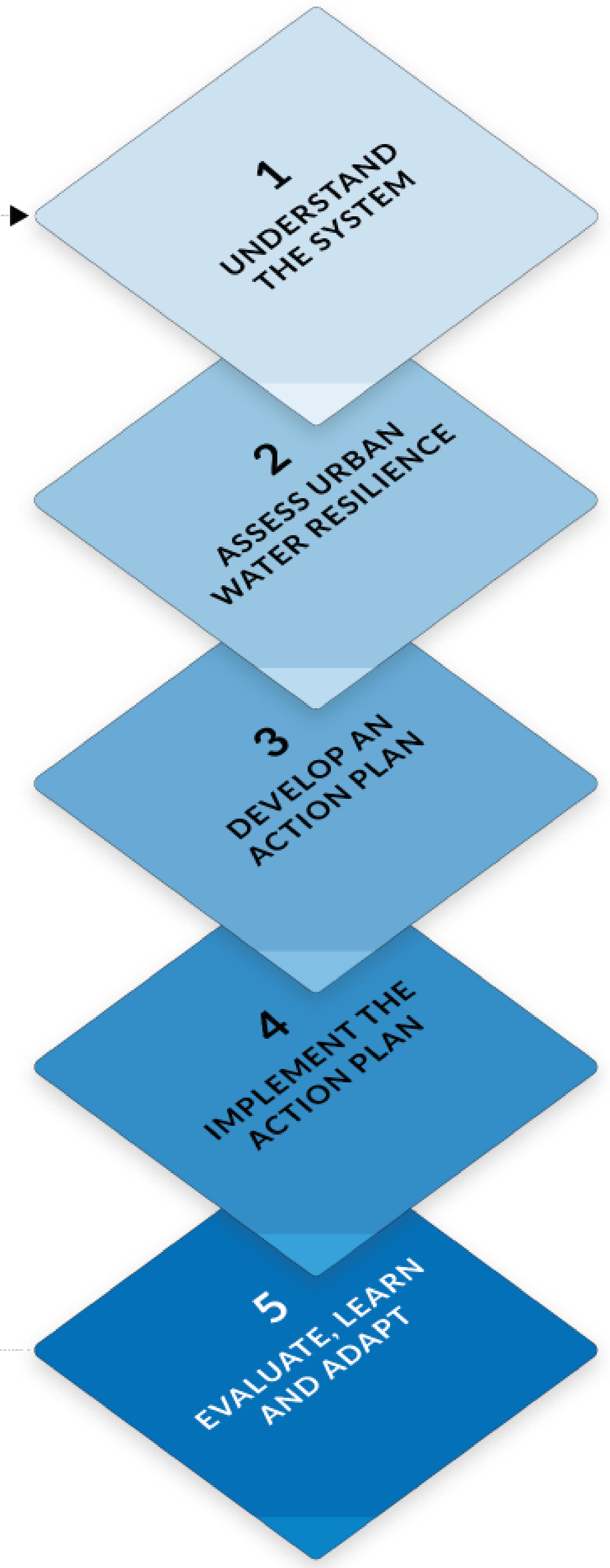


1. Establish a city champion
2. Collect background information
3. Multi-stakeholder inception workshop

Resources:
- OurWater

1. Research data collection
2. Assessment and diagnosis process
3. Findings report
4. Validation workshop

Resources:
- City Water Resilience Framework
- Stakeholder responsibility Matrix

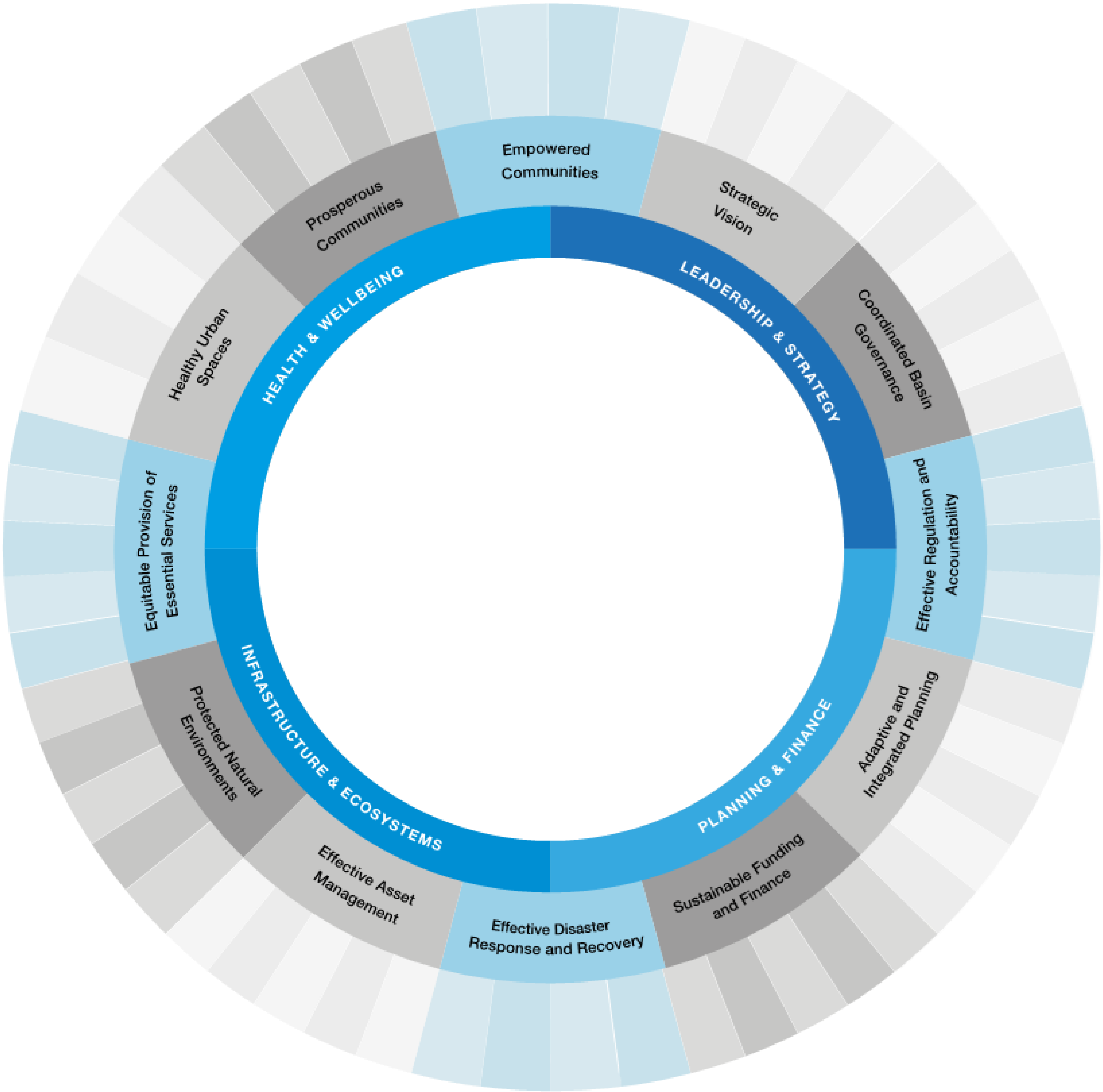
1. Interpretation of results
2. Prioritizing
3. Develop a Joint Action Plan

Resources:
- Governance analysis
- A CWR Action plan Toolbox

1. Develop a M&E mechanism
2. Engage Facilitators and coaches
3. Evaluation of the baseline assessment

Resources:
- A CWR Action plan Toolbox
- Workshop facilitator's guide book

1. Evaluate the implementation of resilience measures
2. Analyse changes in context and stakeholders involvement
3. Re-asses objectives for next period



Developed by Arup and SIWI

In collaboration with

WORLD BANK GROUP RESOLUTE development solutions THE RESILIENCE SHIFT The ROCKEFELLER FOUNDATION

Risks and Existing Resilience Assessments

Future Cities: Building Infrastructure Resilience

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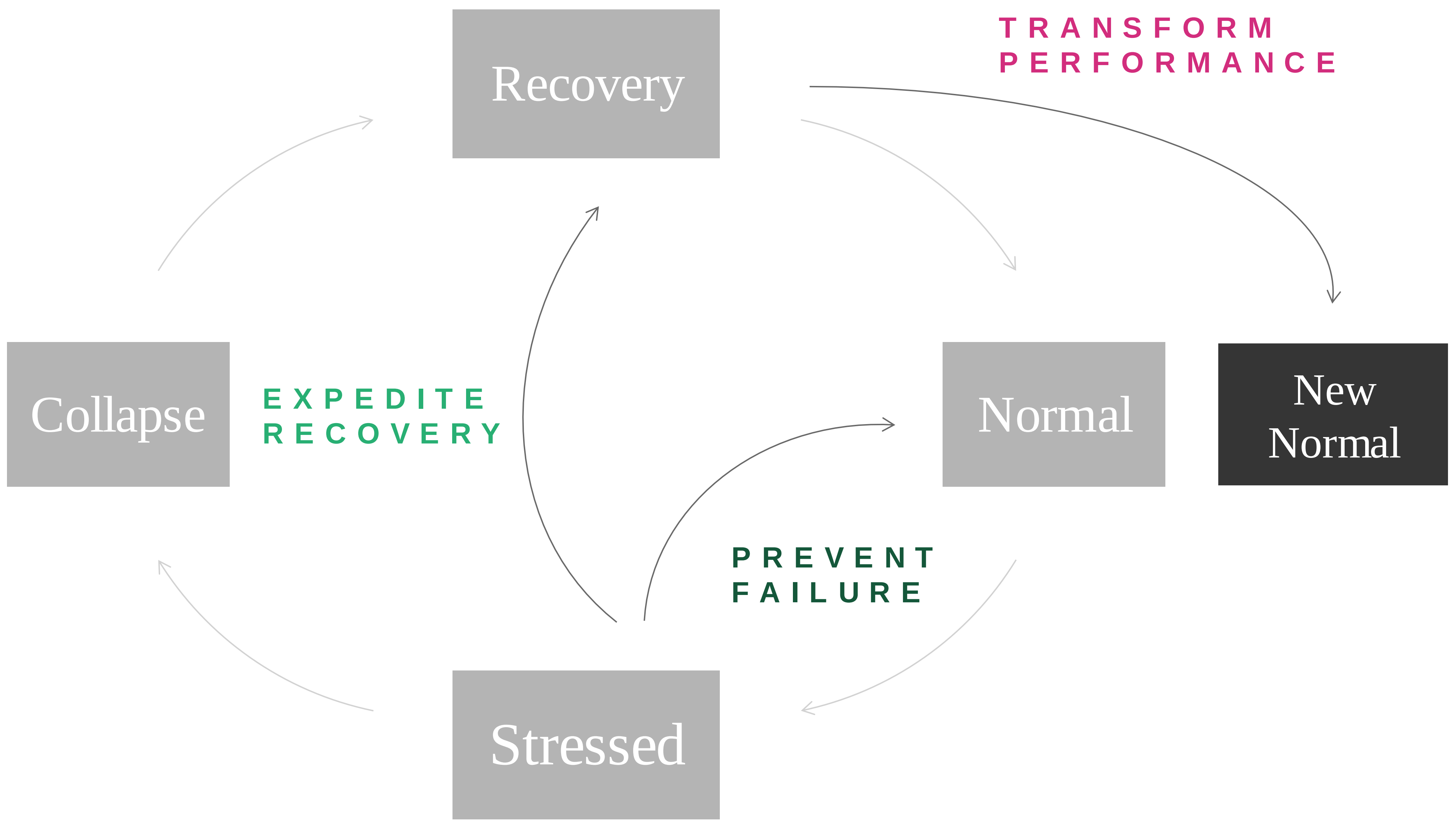
Three pathways to guide planning, design, construction and operation:

- **Prevent failure**: ensuring infrastructure systems can withstand the direct and indirect impact of hazards - the overall system continues to fulfil its normal functions, and also support any additional emergency demands that arise.
- **Expedite recovery**: supporting infrastructure systems to become functional as soon as possible after stress or collapse. This can save lives, prevent 'cascading failure' of other urban systems, and minimise potentially devastating social and economic outcomes.
- **Transform performance**: working towards a new and improved state - requires reliction on successes and failures, learning and growing. Recovery after infrastructure failure or collapse provides a crucial opportunity – although not the only avenue for such change.



Adapted from Arup and Lloyds

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Designing for sustainability and resilience

Key approaches

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- Promote Integrated Planning
- Value Ecosystem Services
- Prioritise Emergency Preparedness
- Design for Robustness
- Incorporate Redundancy
- Increase Diversity
- Governance

Designing for sustainability and resilience

Planetary solutions

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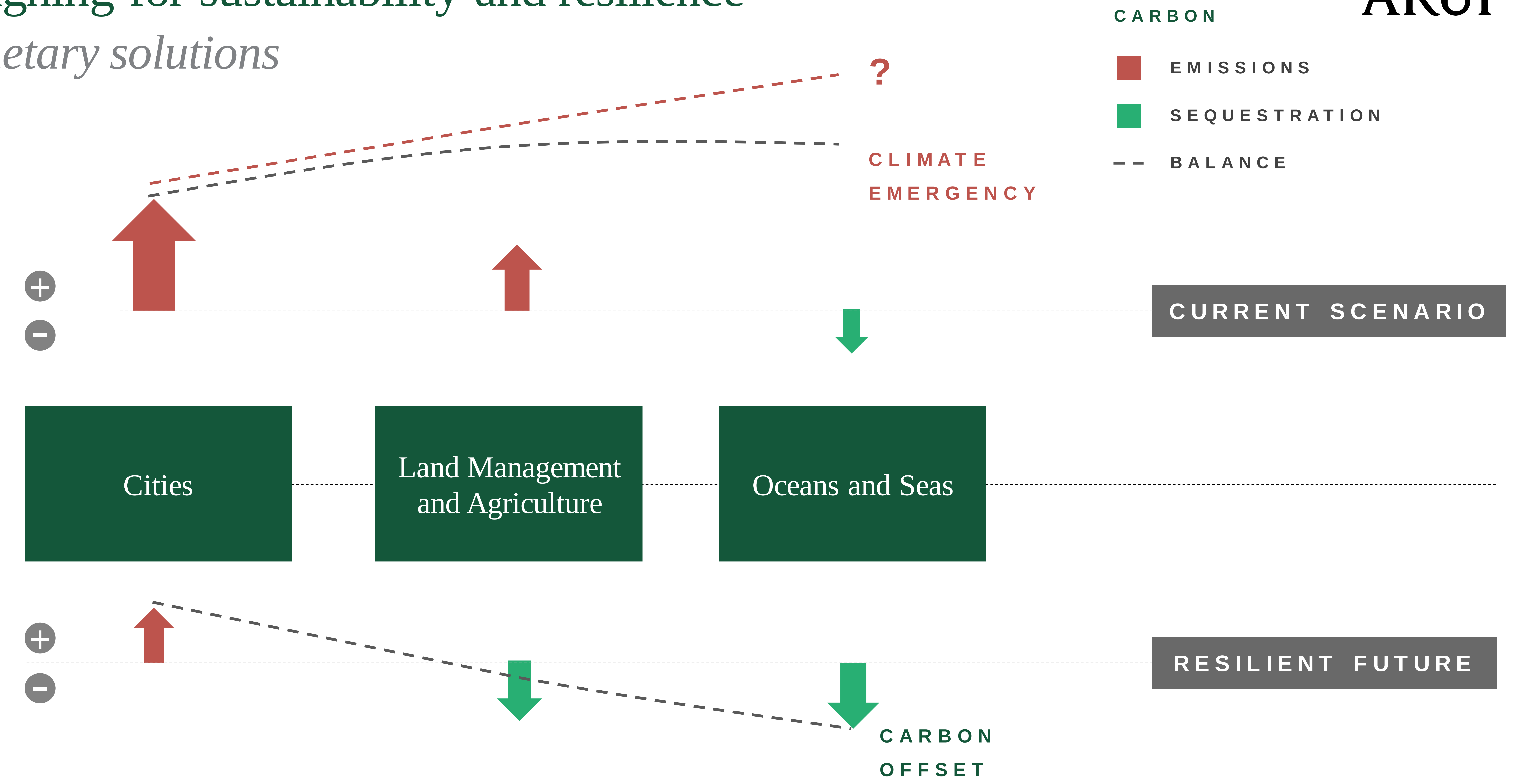

Designing for sustainability and resilience | Cities

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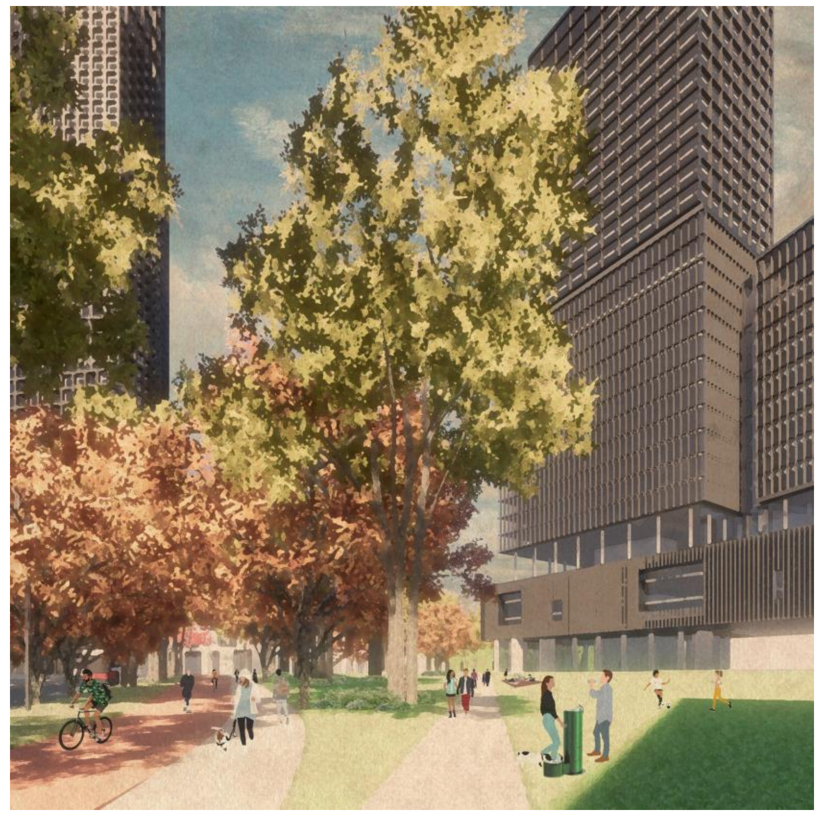
Systems with control during masterplanning

- Urban Design
- Existing Buildings
- New Buildings
- Landscape
- Earthworks and Levels
- Transport Systems
- Water Supply
- Foul Drainage
- Flood Risk Management and Surface Water Drainage
- Energy
- Solid Waste
- ICT and Smart Cities
- Lighting

Designing for sustainability and resilience | Cities

Urban design

Mixed-use development, relatively **high density**, orientated and located to suit climate, topography, geology and **site context**, designed to encourage walking and cycling and incorporation of public transport systems.



2150 Lake Shore – Toronto, Canada (Allies & Morrison)

Designing for sustainability and resilience | Cities

New buildings

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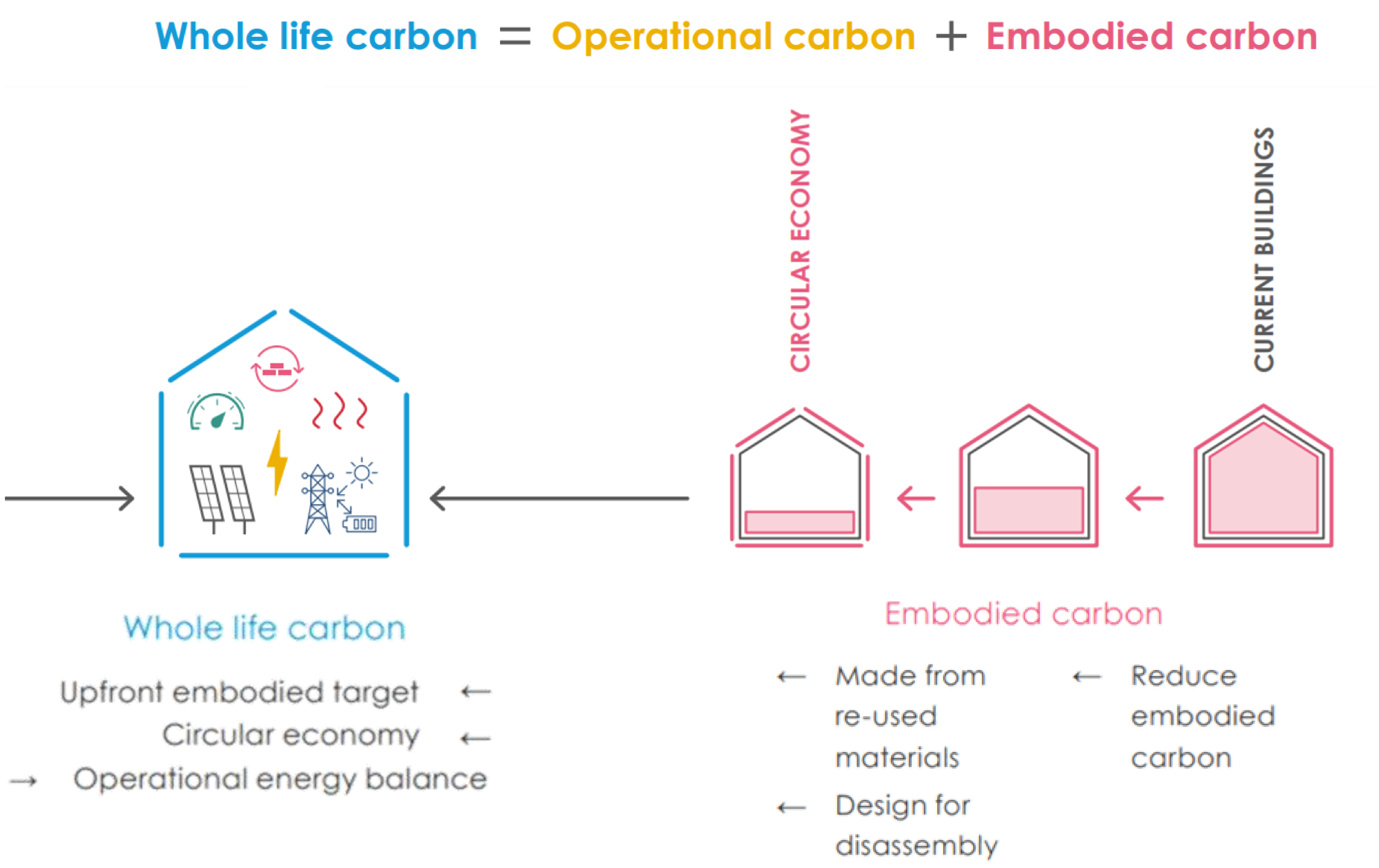
Typical solutions would include: appropriate density, orientation, glazing ratio, and façade performance to minimise heating and cooling; and use of **circular economy** principles for all construction and replacement materials and use of **low carbon** materials.



Operational and embodied carbon of a building
Source: LETI Climate Emergency Design Guide

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Existing buildings

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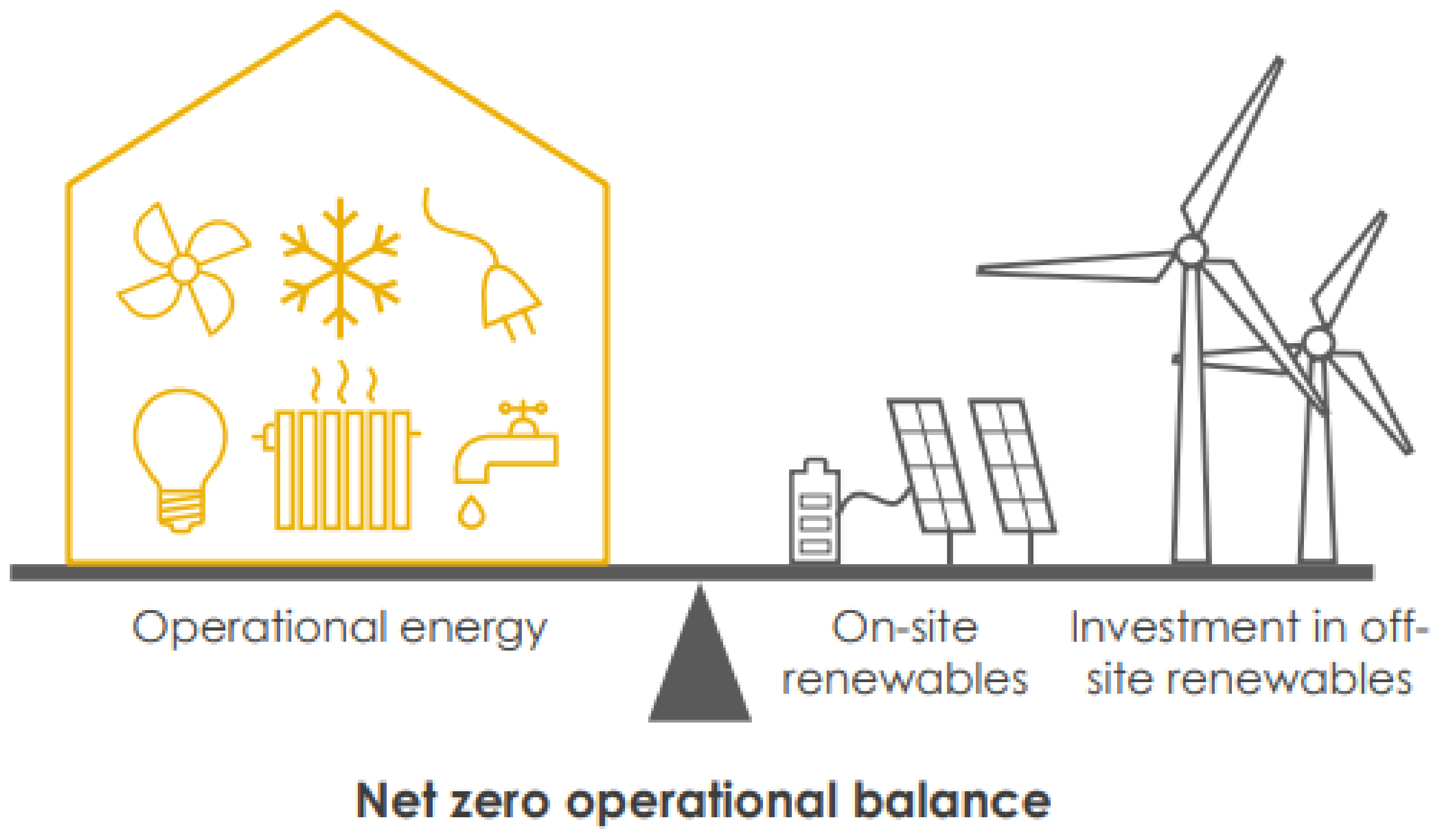
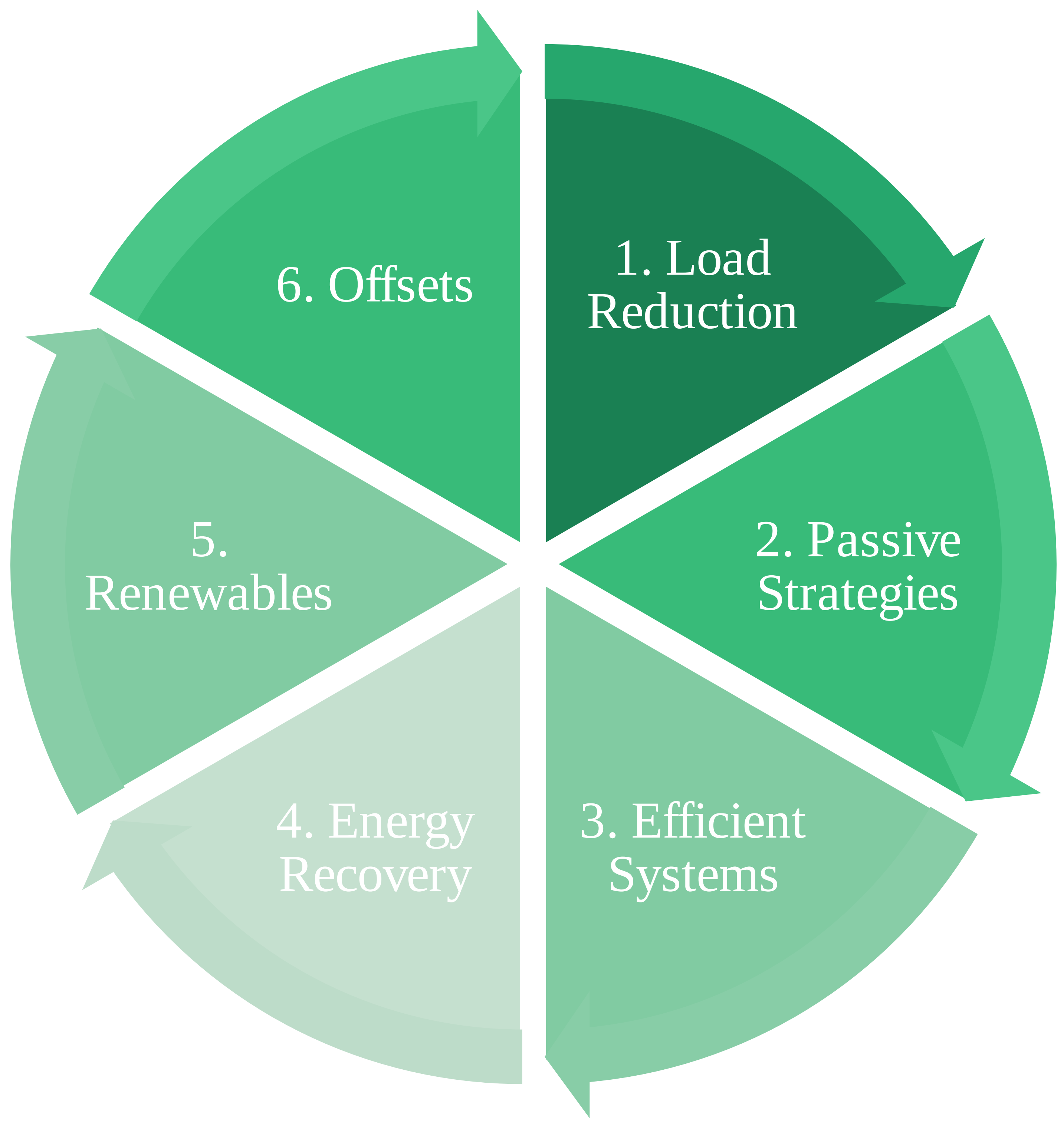
Typical solutions would include: demand reduction, insulation, triple glazing, electrification, space heating using air or ground source heat pumps, incorporation of batteries and or possible transition to hydrogen, and continued use of the gas network and use of circular economy principles for all new and replacement systems.



Source: LETI Climate Emergency Design Guide

HIERARCHY OF MEASURES



Designing for sustainability and resilience | Cities

Landscape

Oman Botanic Gardens (top) and Shigu River eco-landscape, China (bottom)

Work with existing natural landform where appropriate, aim to link into existing natural systems, use indigenous plant species appropriate for enhancing local ecology, develop the soil ecology, use natural growing techniques and avoid use of chemicals, integrate with the surface water and flood risk management strategy, aim to be **restorative** and **regenerative**.

Key **outcomes**:

- Biodiversity net gain;
- Catchment-wide land management;
- Climate appropriate species;
- Increased area of habitats & improved connectivity of habitats;
- Regenerate natural ecosystems and soil restoration;
- Multi-functional landscapes (produce food, store stormwater, provide recreational facilities, health benefits);
- Sense of stewardship (connection between people and landscape).

Designing for sustainability and resilience | Cities

Earthworks and Levels

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Work with existing landforms where appropriate, create **cut/fill balance** and **minimise off-site disposal** of material, **integrate** with gravity drainage systems and flood risk management.

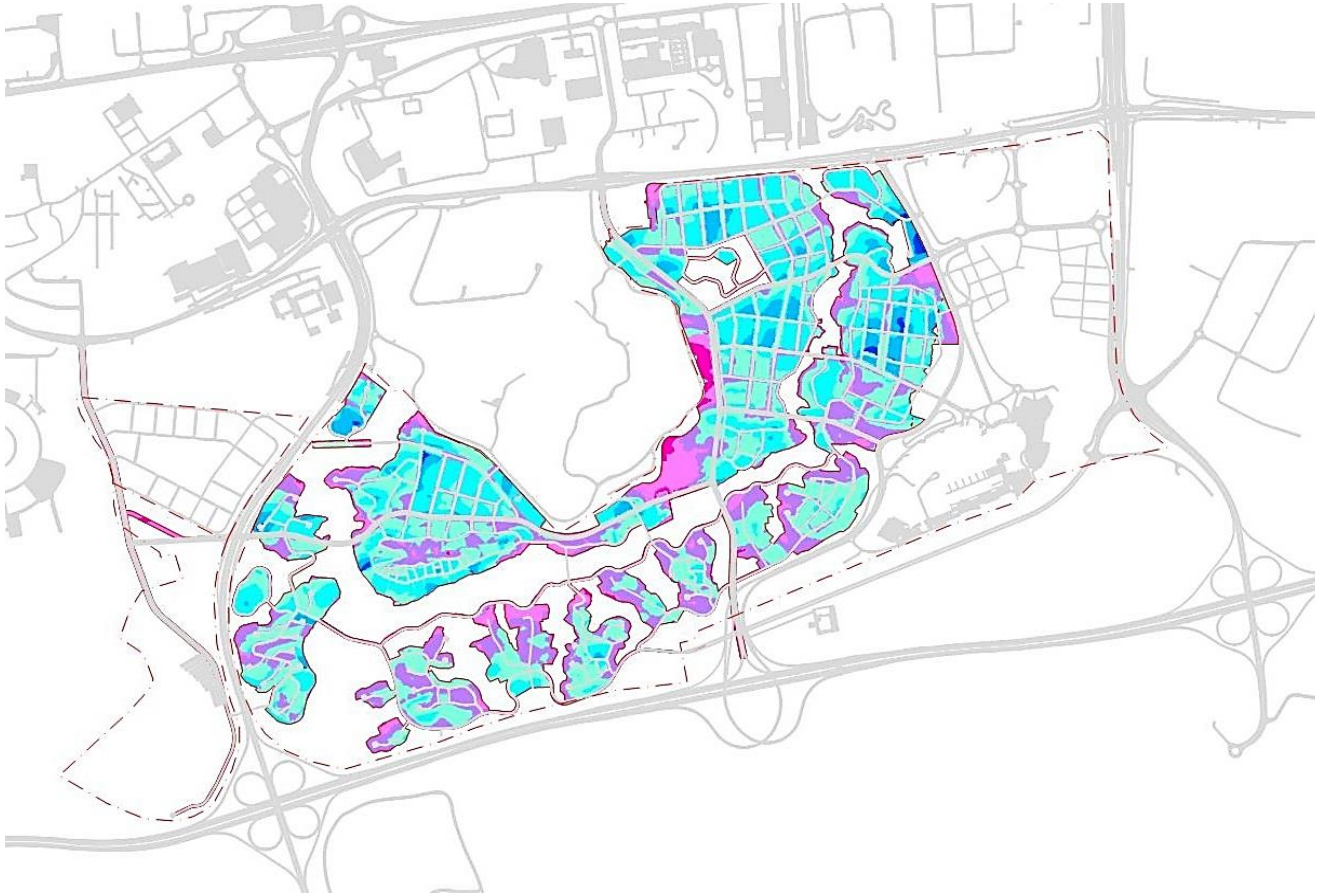
Minimum and balanced across the site

CUT

FILL

SURFACE LEVEL DATA			
NUMBER	MINIMUM LEVEL	MAXIMUM LEVEL	COLOUR
1	-15.00	-12.50	
2	-12.50	-10.00	
3	-10.00	-7.50	
4	-7.50	-5.00	
5	-5.00	-2.50	
6	-2.50	0.00	
7	0.00	2.50	
8	2.50	5.00	
9	5.00	7.50	
10	7.50	10.00	
11	10.00	12.50	
12	12.50	15.00	
13	15.00	17.50	
14	17.50	20.00	

Irfan ground levels strategy



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Transport Systems

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MORE INFO

Maximise walking, cycling and use of public transport, design in resilience for future transport systems and modal shift from the private car including electrification and charging systems, reduced need for car parking and flexibility of use within the design of parking structures and roads.

Key **outcomes**:

- Modal shift to walking and public transport;
- 100% of the city served by network for slow traffic (bikes, pedestrians, etc);
- Decarbonising (electrifying) the transport networks;
- Flexibility for emerging new modes of transport (EV & AV).

Future Transport (Arup, 2018)

Designing for sustainability and resilience | Cities

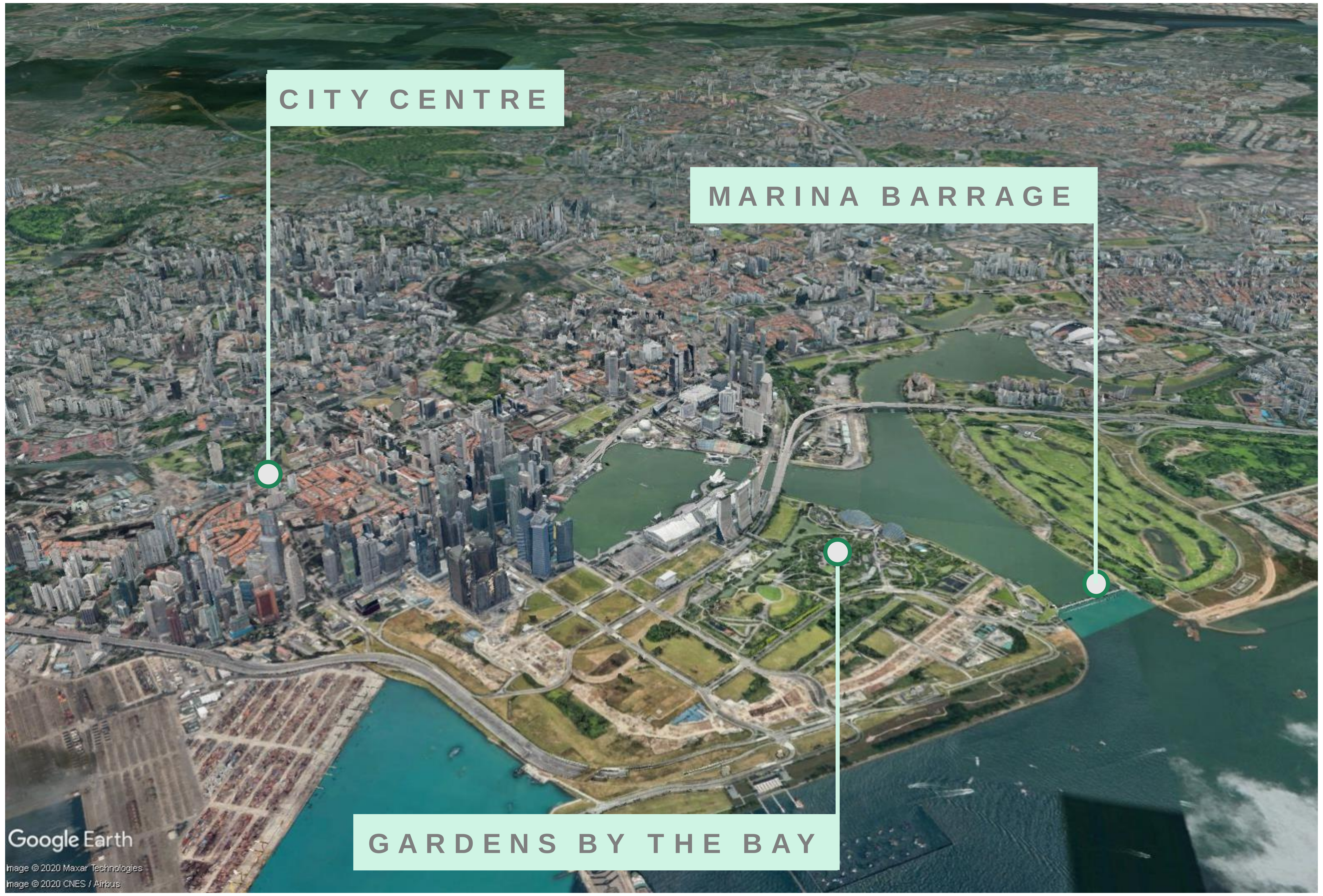
Water supply

Demand reduction strategies, recycling and reuse, non-potable supply systems for toilet flushing and irrigation and use of native species to minimise irrigation demand.

Key **outcomes**:

- Capture sediments and nutrients at intake and remove silt/sediment at source
- Catchment-wide planning, reconnect lake section and planned flooding;
- Demand Reduction;
- Ecological enhancement;
- Green and blue infrastructure;
- Continuous natural wetland treatment;
- Nitrogen and phosphorus recovery and recycling.

Gardens by the Bay, Singapore



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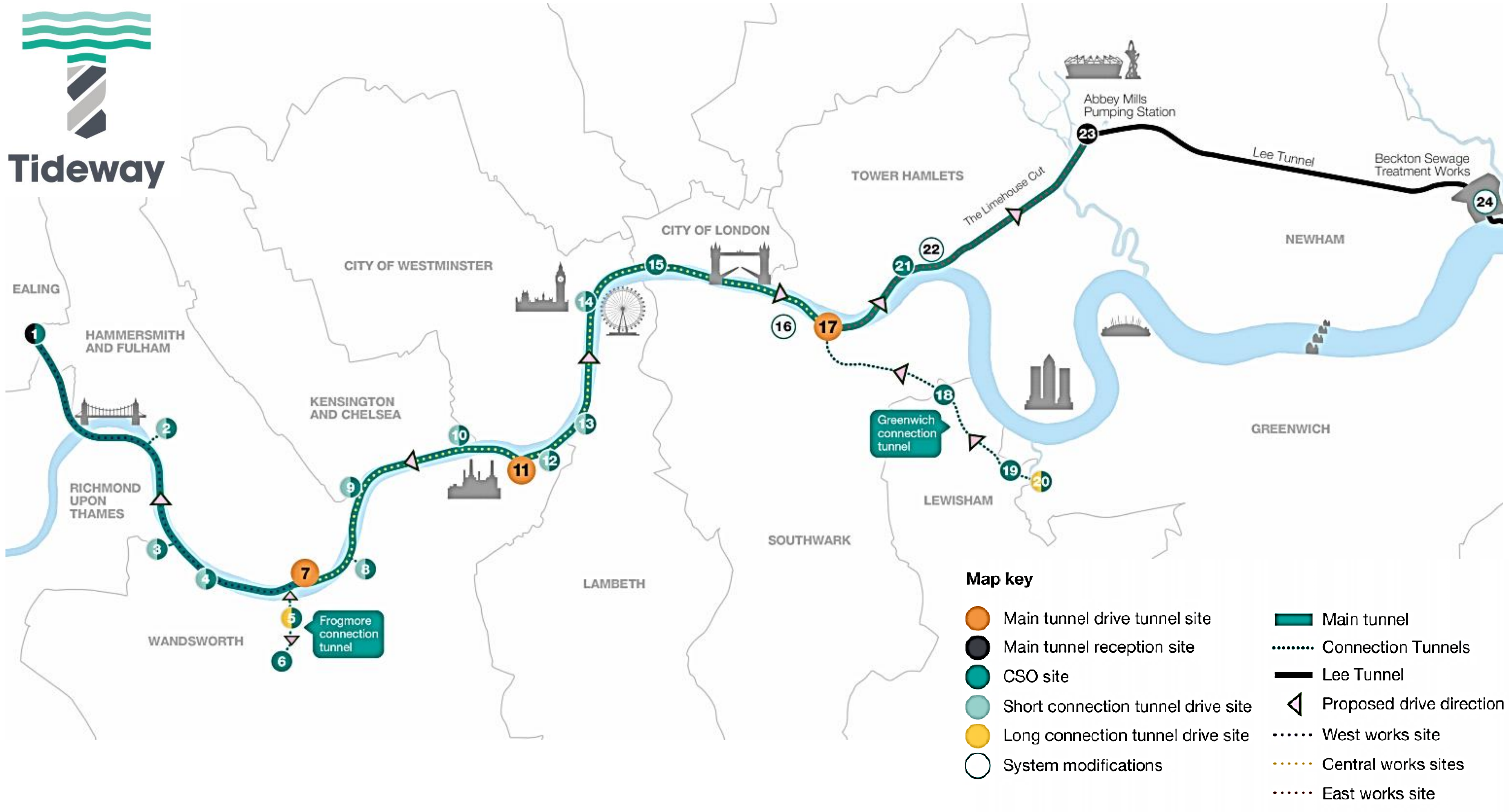
Foul Drainage

Maximise gravity systems and **minimise** need for pumping stations.



25km sewer under the River Thames to intercept a 150-year-old sewer system and clean up the river for the good of the city, its wildlife and London citizens

Designing for sustainability and resilience

Surface Water Drainage and Flood Risk Management

MORE INFO

Design to include **allowance** for climate change, use of **Sustainable Drainage Systems (SuDS)** integrated with the landscape design and aim to minimise **off-site discharges** and maximise **infiltration** and groundwater recharge.

Integrate with site levels strategy and create a hierarchy of levels to provide greatest flood resilience for buildings and critical infrastructure, allowing the landscape areas to flood in extreme events.

Shanghai drainage masterplan

1 UPPER CATCHMENT MANAGEMENT
2 SUSTAINABLE URBAN EXTENSION
3 AGRICULTURE AND FOOD
4 GREEN INFRASTRUCTURE
5 REVITALISED RIVER SPACE
6 WATER-RESILIENT INFRASTRUCTURE
7 RESTORED/REVISTALISED WATERWAYS
8 COASTAL DEFENCES
9 DYNAMIC NATURAL COAST

Designing for sustainability and resilience | Cities

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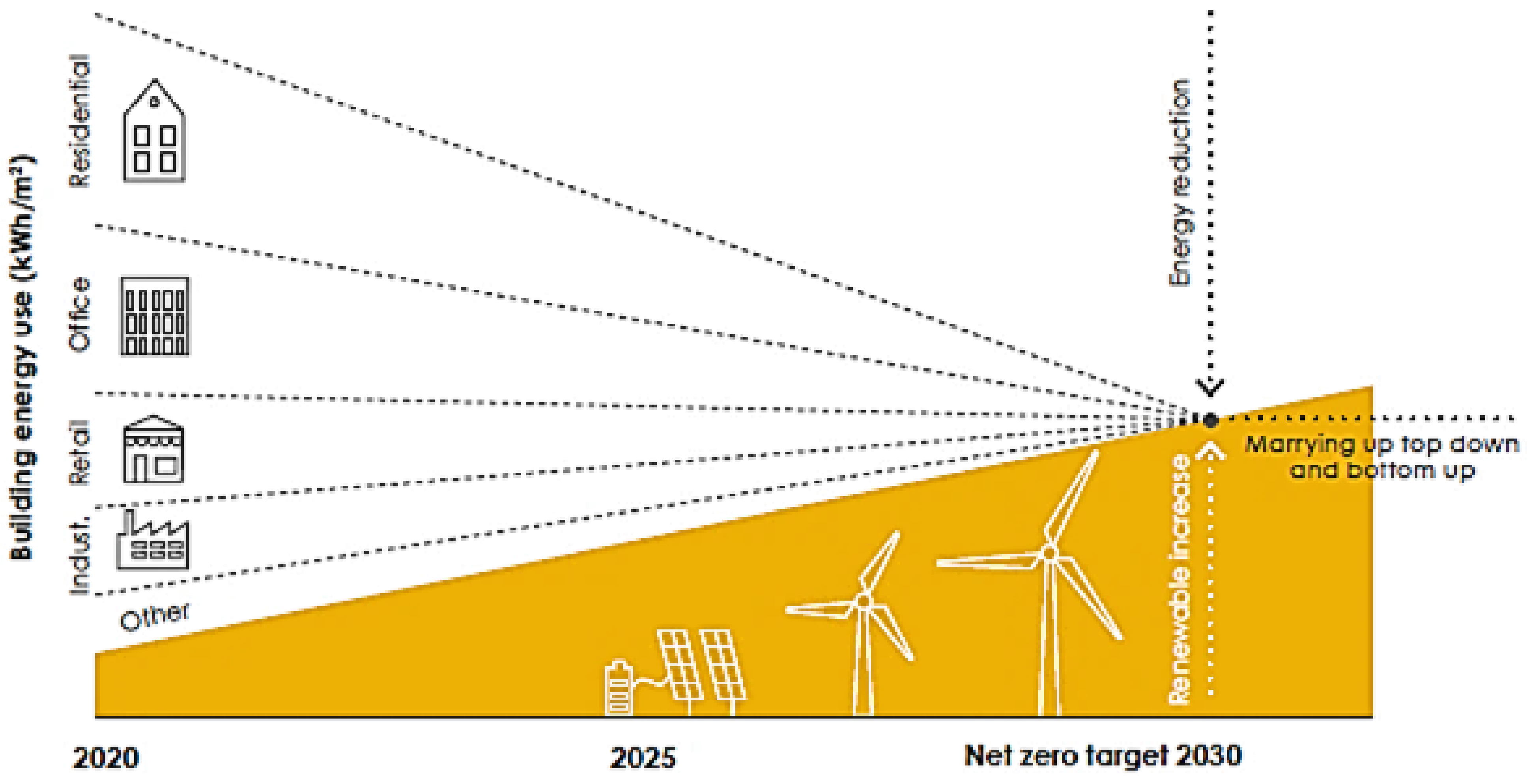
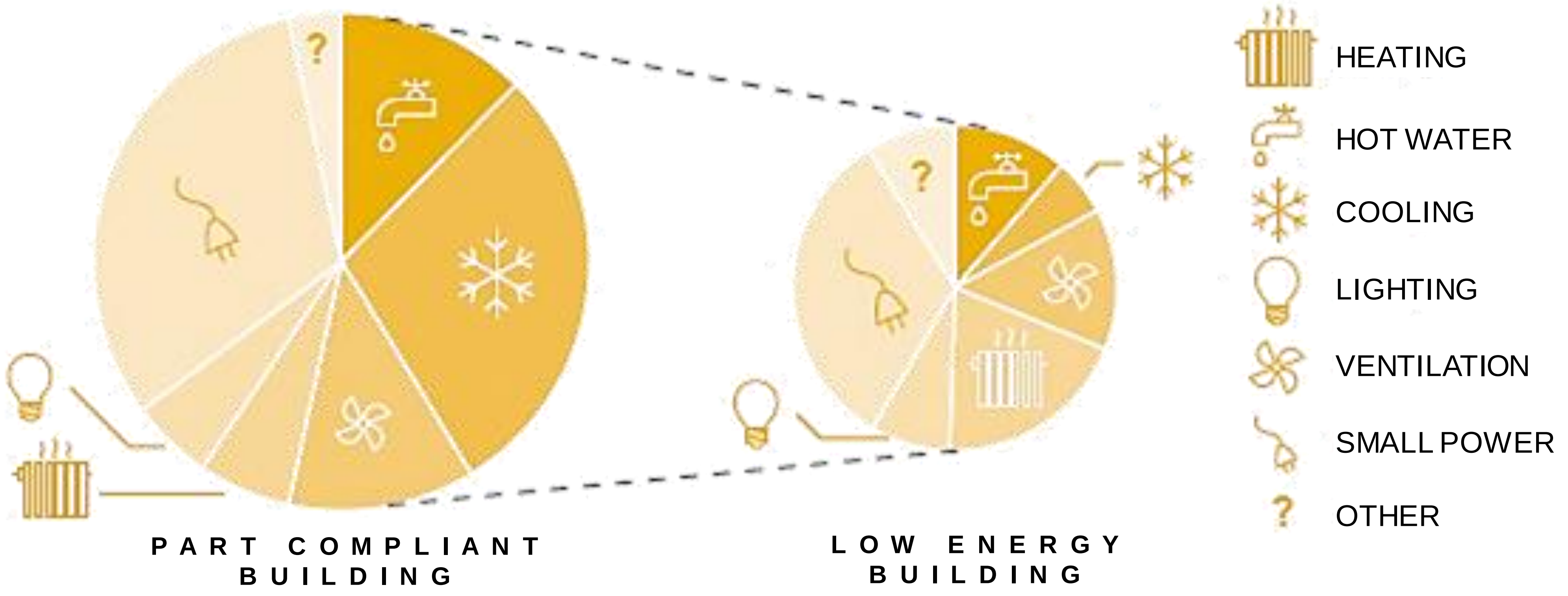
Energy | Design solutions

Minimise total and peak demand through good design and smart systems, allow for electrification of space heating systems, use of batteries, and potential transition of natural gas network to hydrogen.

Key **outcomes**:

- Demand Reduction but consider transition to EVs and electrical heating;
- Allow possible transition to hydrogen via gas networks;
- Decentralised infrastructure (microgrids, decentralised water treatment, etc);
- Low carbon, renewable energy generation;
- Locate appropriate energy sources: hydroelectric, solar, geothermal, wind, tidal, wave, biofuels, EFW, nuclear, hydrogen;
- Reduce/eliminate dependency on fossil fuels by considering all-electric options.





Ref.: LETI Climate Emergency Design Guide

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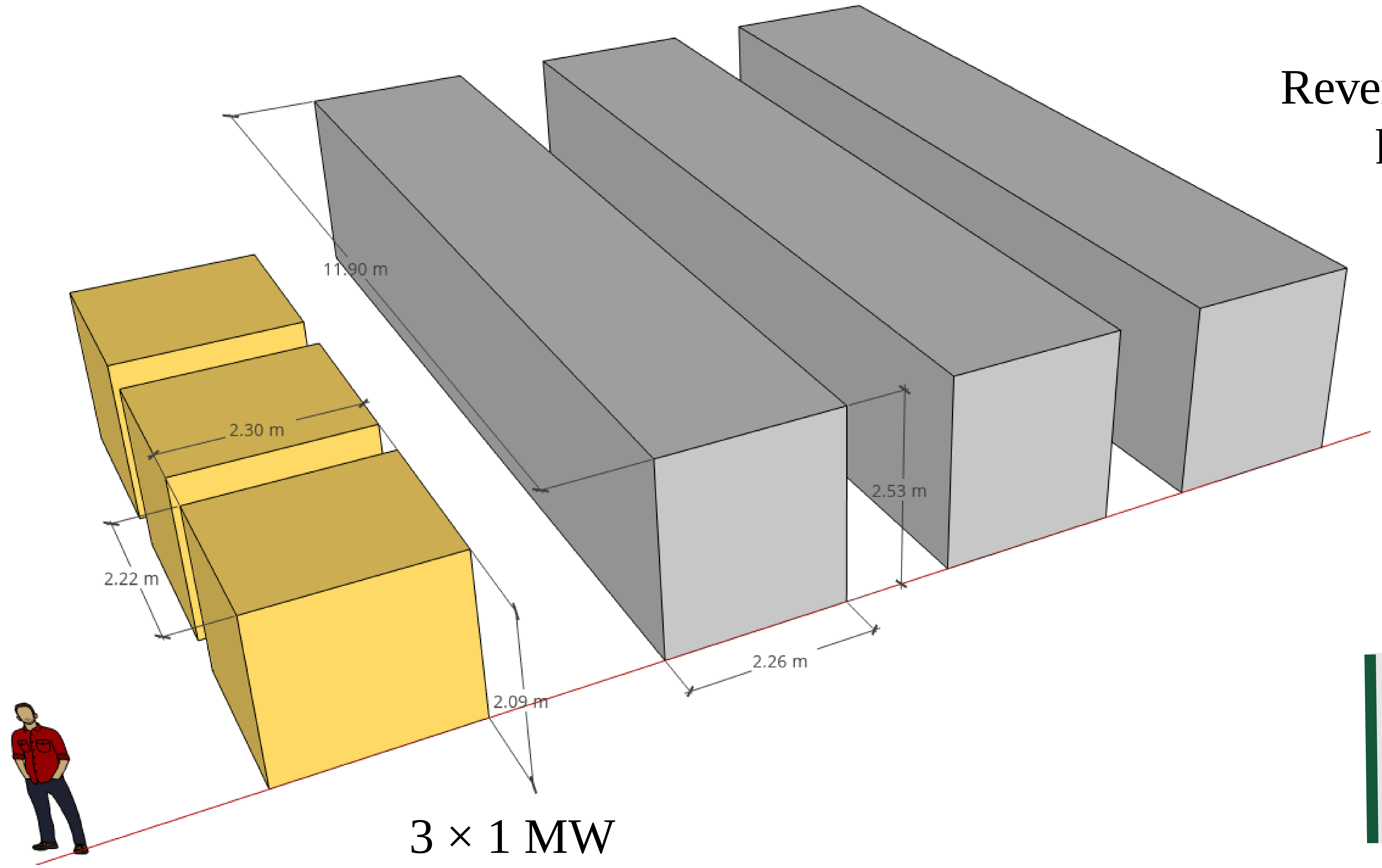
Energy | Spacing requirements



3 × 1 MW
Reversible air source
heat pumps

3 × 1 MW
Gas fired boilers

3MW heating capacity dimensions - **comparison** between gas boilers and heat pumps

Designing for sustainability and resilience | Cities

Solid waste

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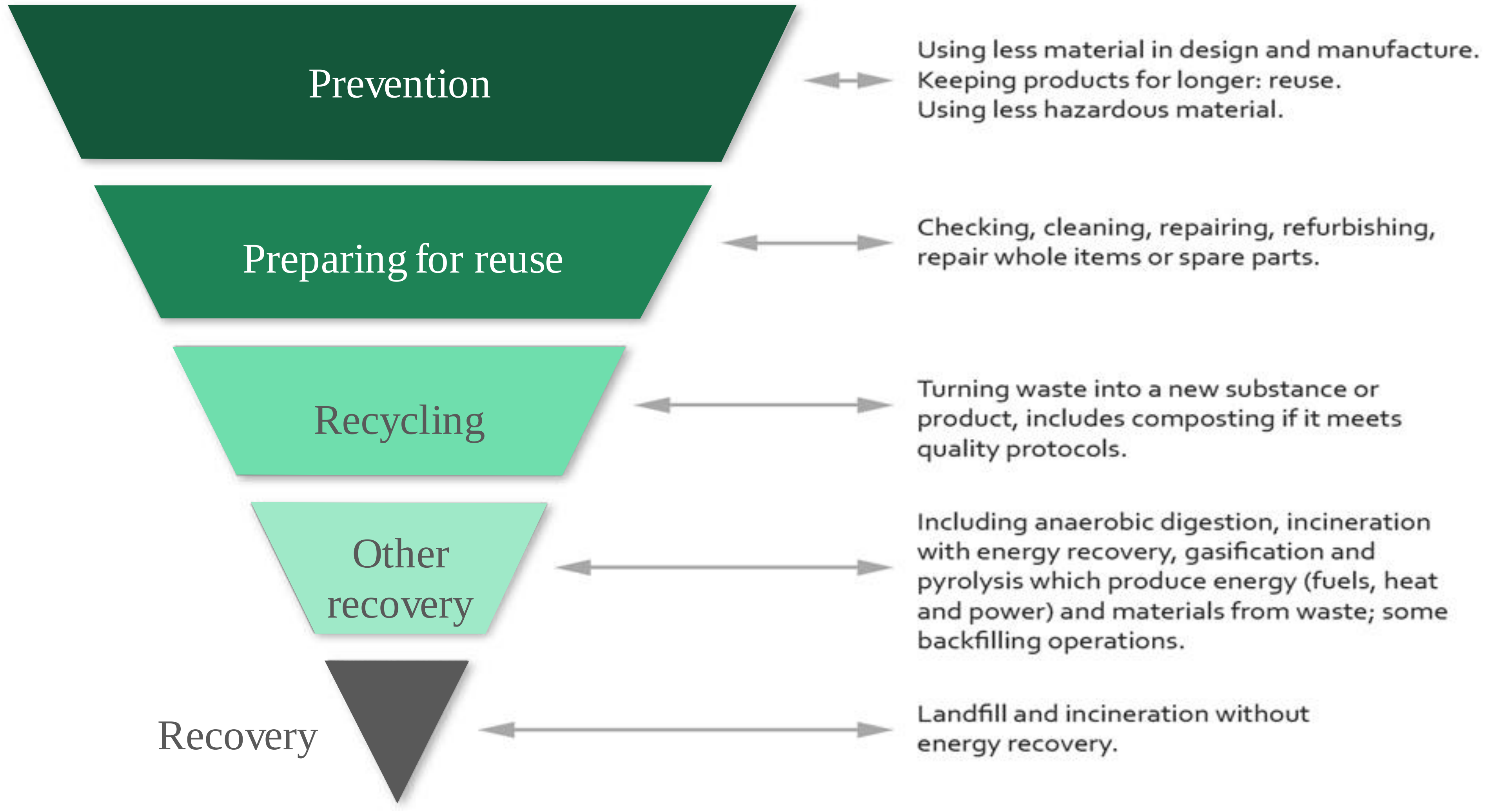
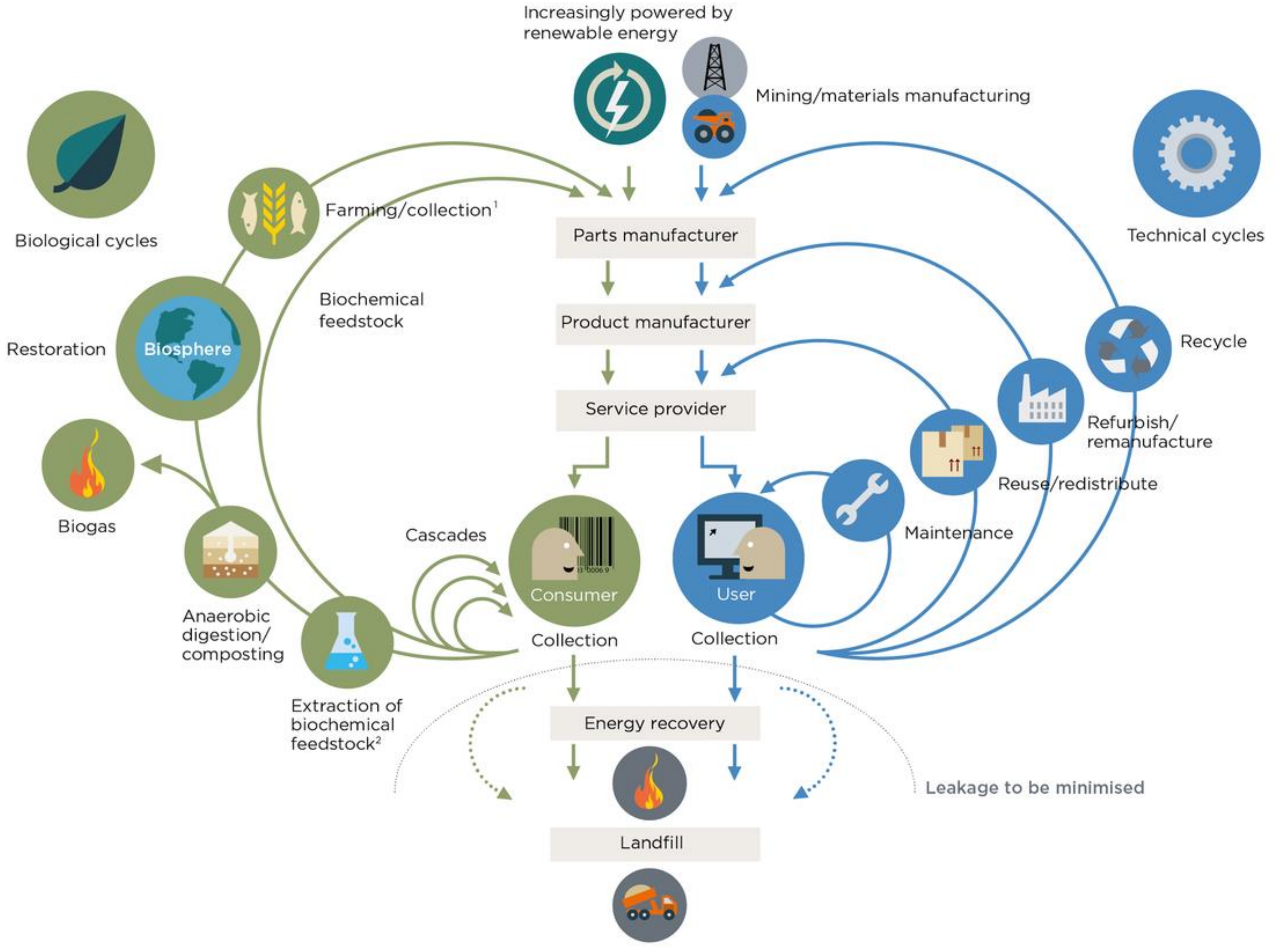
MORE INFO

Key principles:

- Circular economy principles
- Reduce consumption & Reduce waste production
- Increase resource efficiency and maximise the contribution to renewable energy generation (electricity, heat, cooling)
- Water-Energy-Waste Nexus



Stages **Includes**



Principles of circular economy – Ellen Macarthur Foundation

Designing for sustainability and resilience | Cities

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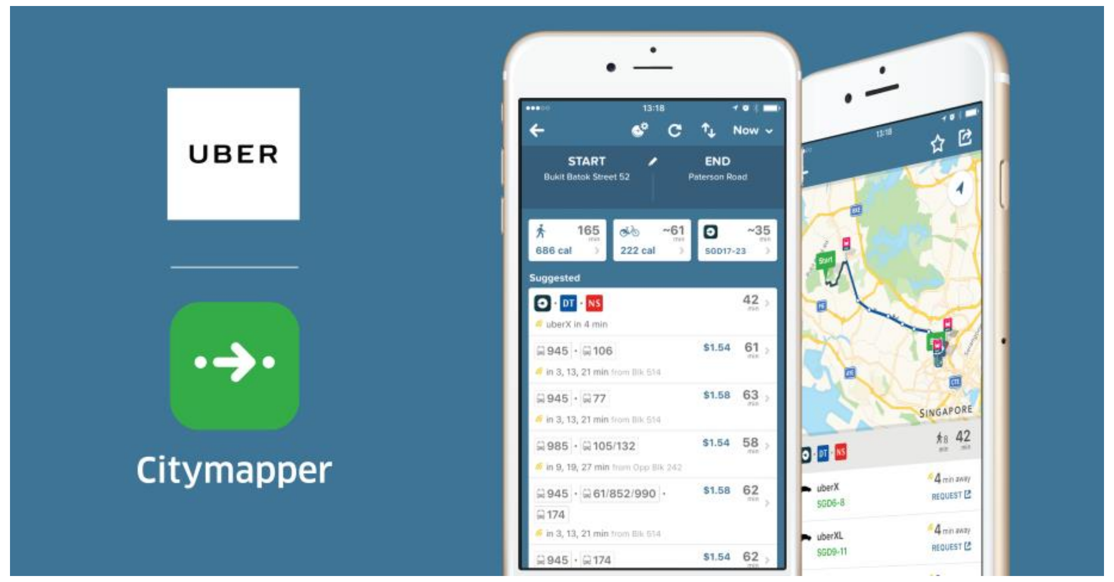
ICT and Smart Cities

Systems management and data collection to improve the efficiencies and **reduce demands and peaks** of the utility and city systems, including:

- Transport (Intelligent transport systems)
- Energy (data driven grid)
- Water systems (asset management)
- Waste (energy from waste - EfW, composting, online material banks)



Integrated Digital Portals to Create Positive Travel Experience and Enable Service Sharing
Making data available in public

Resource Sharing and Service Capacity Optimisation
Autonomous Vehicles Service, Personal Moving Device Sharing

Designing for sustainability and resilience | Cities

Lighting

Use of LED lighting to **reduce demand** and smart systems to light only when required; minimise **light pollution.**

Designing for sustainability and resilience | Land Management and Agriculture

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MORE INFO

Carbon sequestration on land

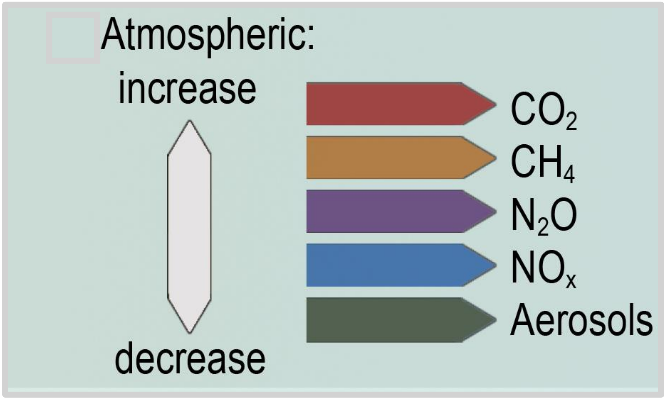
Carbon on land is found in:

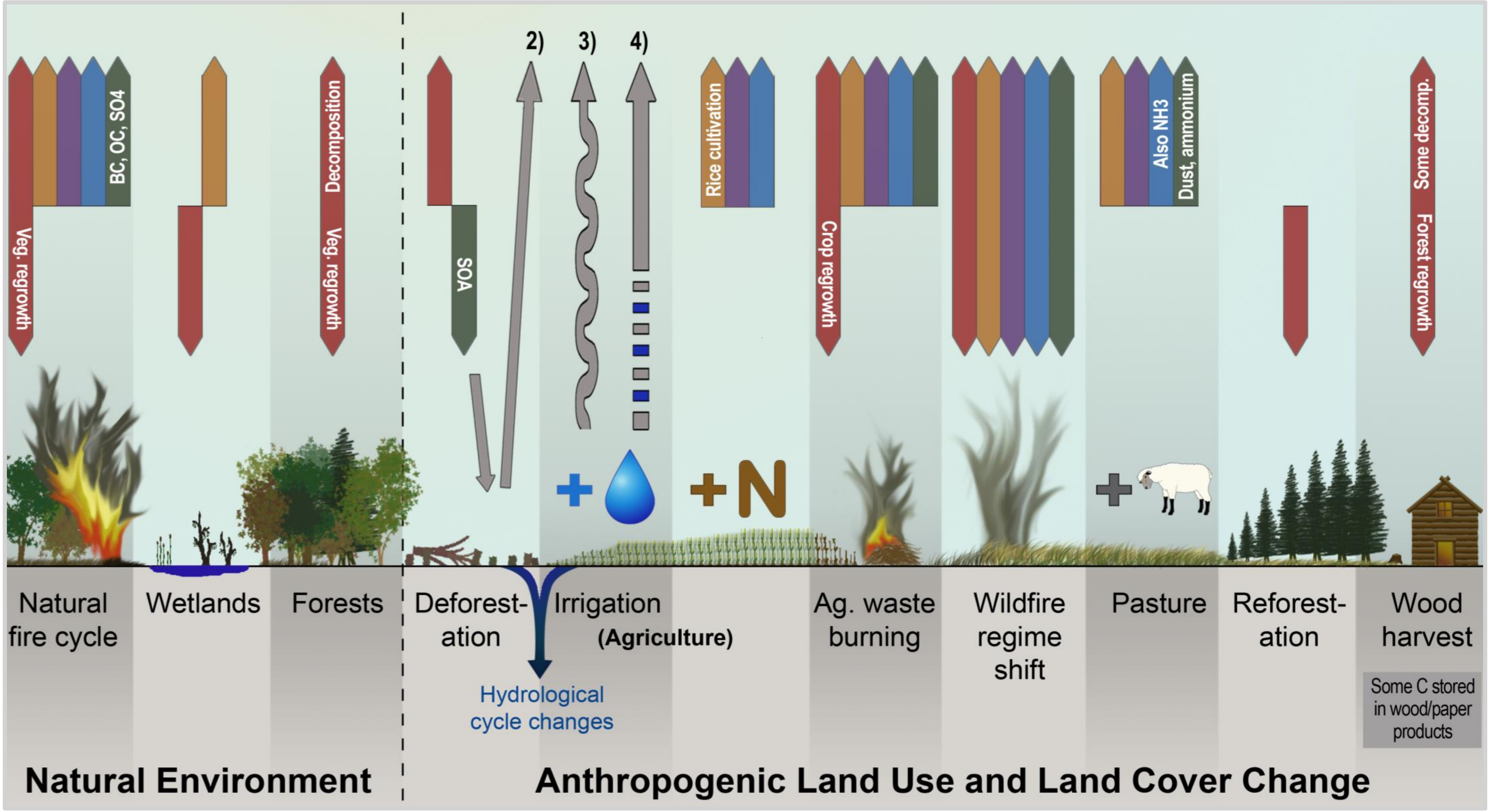
- Plants above ground – trees, grasslands, bushes, forests;
- Leaf and plant litter at the ground surface;
- The soil itself.

Even in well-managed forests, the carbon in soil is estimated to be almost **75%** of total forest carbon.

Carbon sequestration rates	
Trees (depending on type and stages of growth)	-14 tCO2e/ha
Intensive agriculture	+2 tCo2e/ha
Mob grazed grassland in temperate climates	-2 to -20 tCO2e/ha

Source: Climate Science Special Report (CSSR), 2017





Designing for sustainability and resilience | Land Management and Agriculture

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Carbon sequestration on land

A few key points are apparent:

- Land managed has a potential ability to sequestrate significantly more carbon than currently takes place;
- Research is required to properly assess the role of soil in land management and their ability to: sequestrate carbon; reduce flood, drought and fire risk; reduce needs for agrochemicals increase biodiversity; and produce healthier food.

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Food production

MORE INFO

CONTEXT

In most countries in the world, the solution to the challenges we face regarding climate change and environmental regeneration and restoration can only succeed if in addition to the interventions required for urban areas we also review and change the way we manage our land and produce our food. Currently the vast majority of our land is poorly managed and the way we farm, indeed what we produce has a massive negative impact on the environment and our health and well-being.

A strategy is required to allow the development of appropriate land use management plans which best suit the local context and best meet the wider sustainability and resilience objectives. This strategy should form a basis for deciding which land should be used for **rewilding, forestry, natural grasslands, wetlands,** and **agriculture**.

Source: Less is more – Greenpeace, 2018

Designing for sustainability and resilience | Land Management and Agriculture

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Food and land-use management

MORE INFO

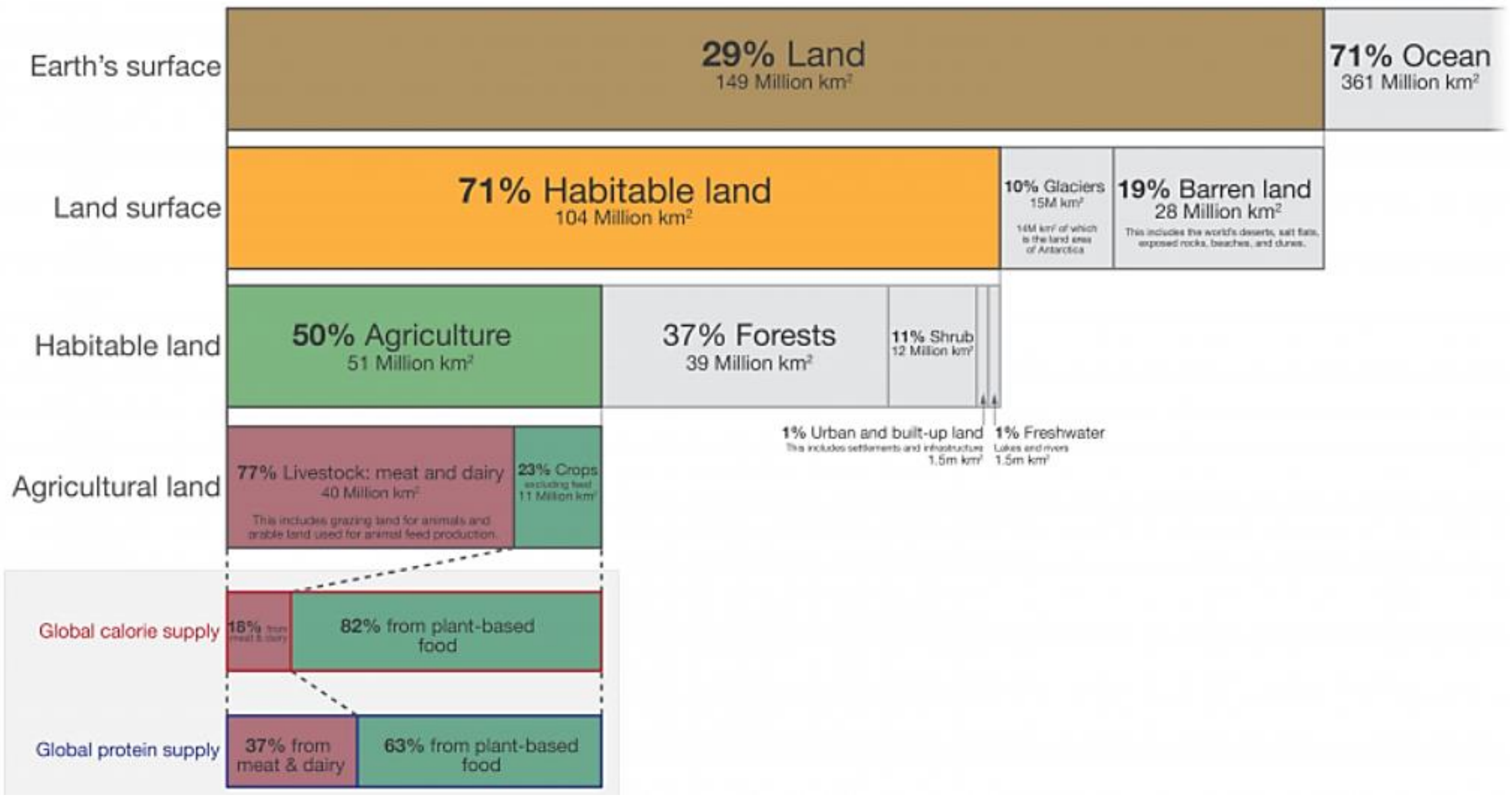
Agriculture is responsible for:

- **50%** of the world's habitable land take;
- **70%** of the world's freshwater consumption;
- **33%** of greenhouse gas emissions.

In addition to this, poor agricultural practices are believed to be:

- A major cause of soil erosion and loss;
- A major cause of biodiversity loss;
- Significantly responsible for the increased risks of flooding, droughts and fire.

GLOBAL LAND USE



Source: Our World in Data, 2019

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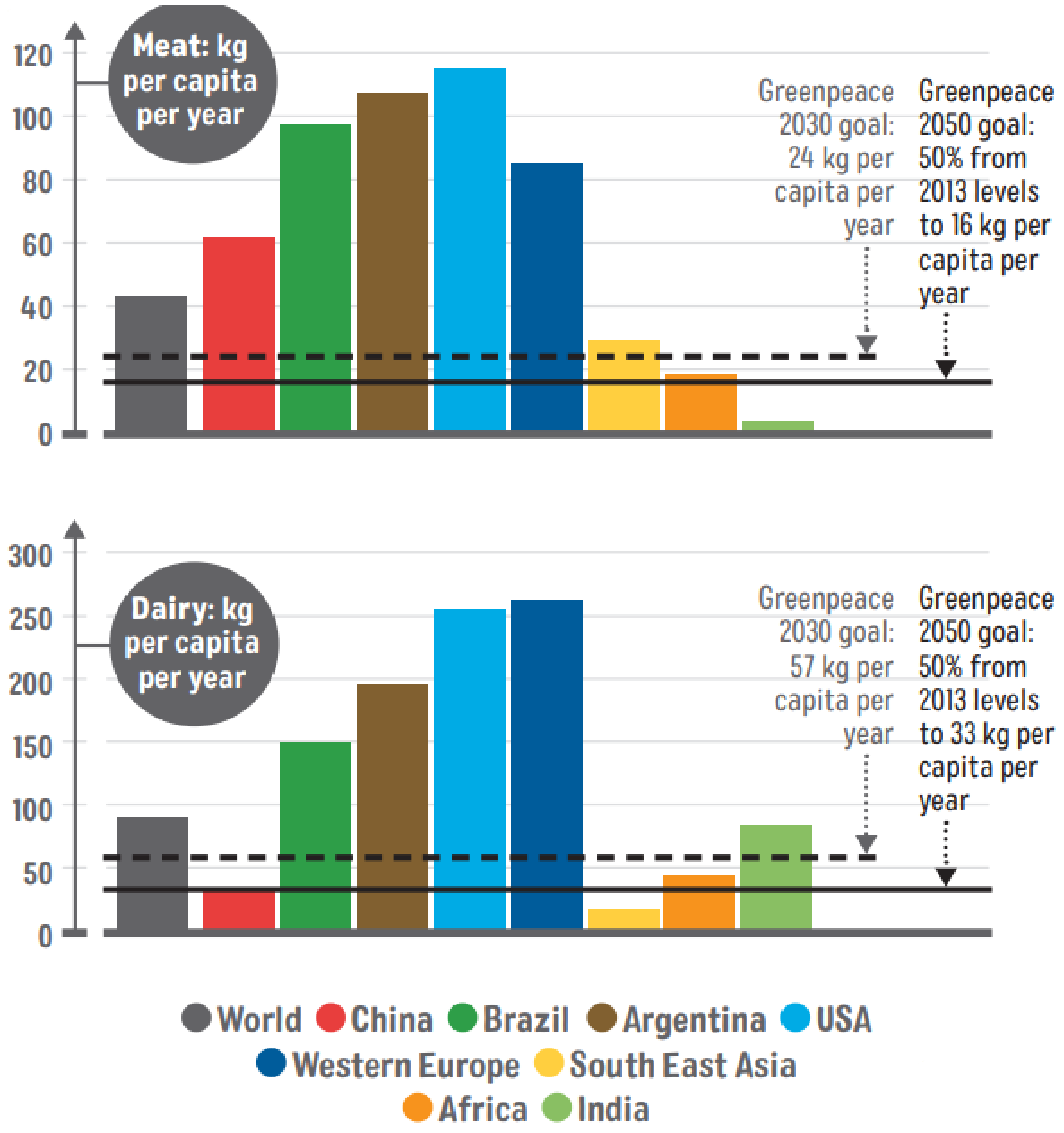
Transition in food production

Transitions are required in how food is produced and consumed, especially in relation to:

- Reducing meat consumption (unbalanced portions, not necessarily vegetarian/vegan diets);
- Increasing use of natural farming techniques and reducing monoculture practices;
- Using livestock to keep the land fertile for crop production, where appropriate;
- Using urban farming strategies as a solution to locally produce perishable food, such as fruits, vegetables and herbs – reduction of transport emissions, logistics costs and supply chain gains.

CURRENT ANNUAL AVERAGE MEAT AND DAIRY CONSUMPTION PER PERSON



Source: Less is more – Greenpeace, 2018

Designing for sustainability and resilience | Land Management and Agriculture

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Natural farming

The **transition** to natural farming – where and when appropriate – would include:

- Working with the existing land designated for agriculture and no further cutting down of existing forests woodlands and natural wetlands and grasslands;
- Reduced ploughing;
- Managed grazing – mimicking the way animals behave with predators;
- Combined growth of annual crops within perennial grasses;
- Seeding using direct drilling with minimum disturbance to existing perennial grasses;
- Soil testing, monitoring and restoration;
- Organic practices;
- Intercropping, Permaculture, and Silviculture;
- Reduced applications of biocides, herbicides or agrochemicals.

Rwanda Institute for Conservation and Agriculture

Designing for sustainability and resilience | Land Management and Agriculture

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Benefits of natural farming

The transition to natural farming – where and when appropriate – would include:

- Restoring and regenerating the lost and degraded top soils;
- Carbon sequestration rather than generation through Increasing the thickness and quality of top soils;
- Restoring Ecological biodiversity within and above the soils;
- Reducing and potential eliminating the need for agrichemical applications;
- Increasing flood, drought and fire resilience;
- Increase natural disease resilience;
- Improved quality of food containing micronutrients and trace minerals;
- Positive social impact, i.e. farmers are less reliant on costly inputs (e.g. herbicides, fertiliser) therefore are more resilient to price fluctuations;
- Improved air quality by growing certain plant species (e.g. lichens).

Designing for sustainability and resilience | Land Management and Agriculture

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Urban farming

Key aspects of urban farming:

- Increase urban food production with hydroponics and vertical farming;
- Rethink the supply chain system by increasing transparency and shift towards a circular economy;
- Move to sustainable consumption: changing diets and looking at food as a service;
- Managing and eliminating food waste by making the most from food systems;

Source: M&S indoor farms

Source: Smart farm on rooftop of Funan Mall in Singapore

Designing for sustainability and resilience | Oceans and Seas

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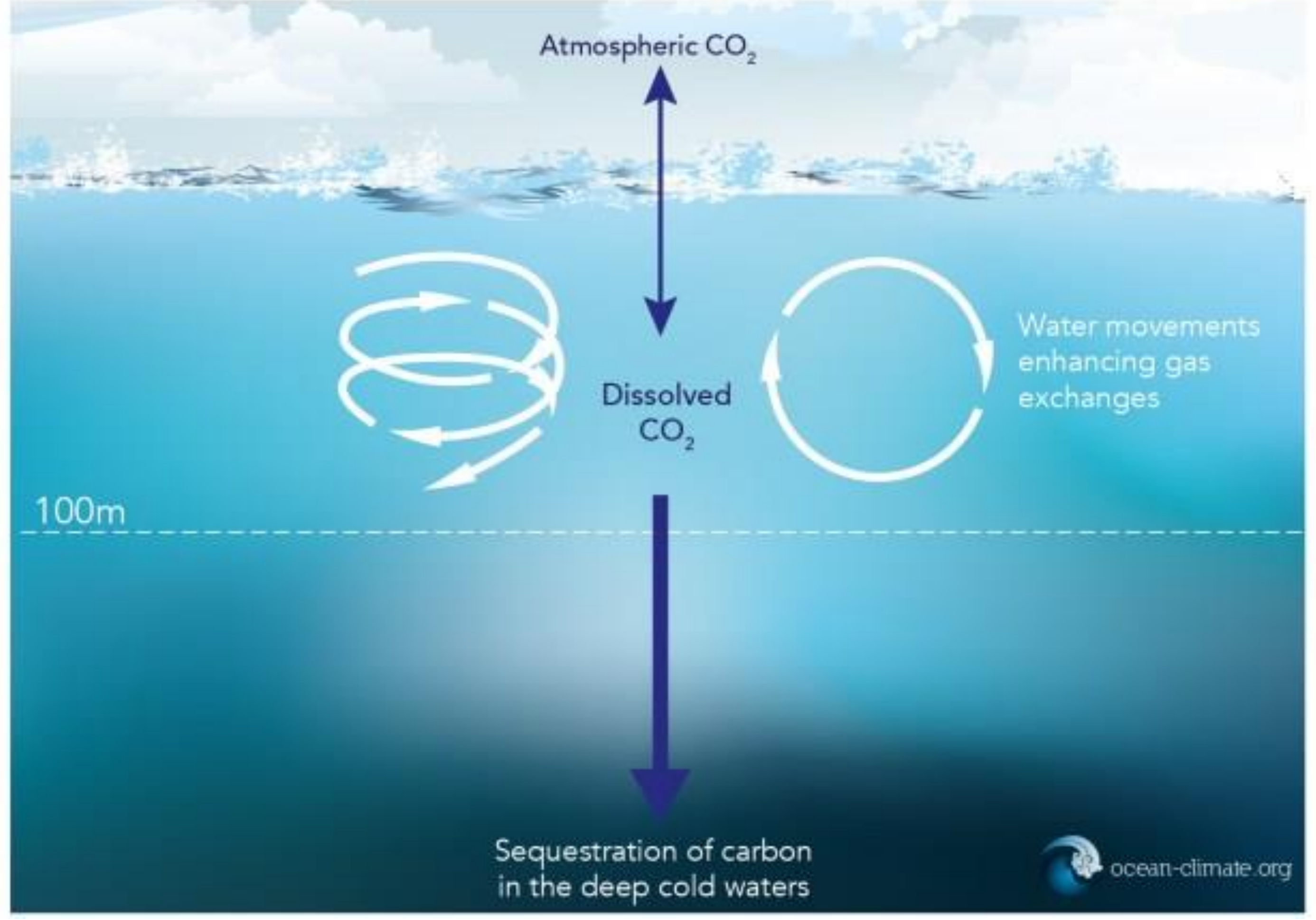
Ocean carbon pump

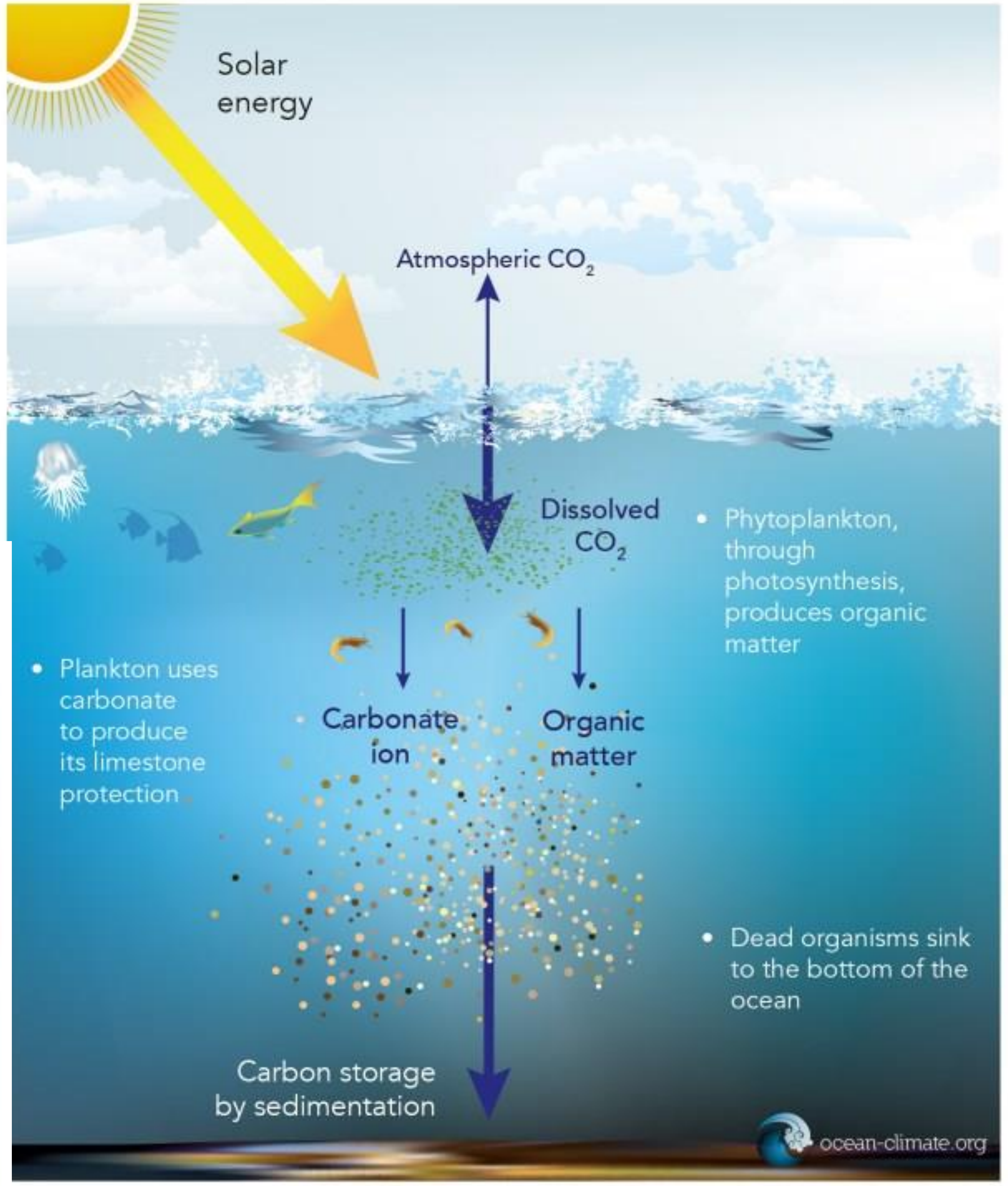
Source: The ocean, a carbon sink – Ocean & Climate Platform

Key principles:

- The ability of the oceans to **dissolve carbon dioxide** reduces as global temperature increases (low temperature usually facilitates atmospheric CO_2 dissolution);
- Carbon dioxide levels (**acidity**) in the oceans increase with growing carbon emissions; consequently, the biological carbon pump becomes less effective due to **lack of available carbonates**.
- Rising **acidity** and increased water **temperature** have a drastic impact on marine biodiversity.
- Together these factors can result in **eutrophication** (algal boom caused by excess nutrients), which can be particularly harmful to marine life.



PHYSICAL CARBON PUMP



BIOLOGICAL CARBON PUMP

Designing for sustainability and resilience | Oceans and Seas

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Marine ecosystem restoration

Restoration strategies should include:

- Cities and agriculture transitioning to net zero carbon practices;
- Pollution prevention and reduced nitrogen and phosphorus inputs;
- Strict and enforced bans on fishing in strategic areas;
- Controlled fishing in designated area with strict quotas;
- Establishment of Marine Protected Areas;
- Reduction and prevention of brine discharge from desalination plants into the ocean.

Contents

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Architect | Allies and Morrison
Infrastructure | Arup

I R F A N

STRATEGIC MOVES

Cost - Value - Carbon

The Scheme

- 7.9 million m² site
- 5.7 million m² built up area
- 58,000 residential population
- 152,000 working population
- 83,000 visiting population

The challenge

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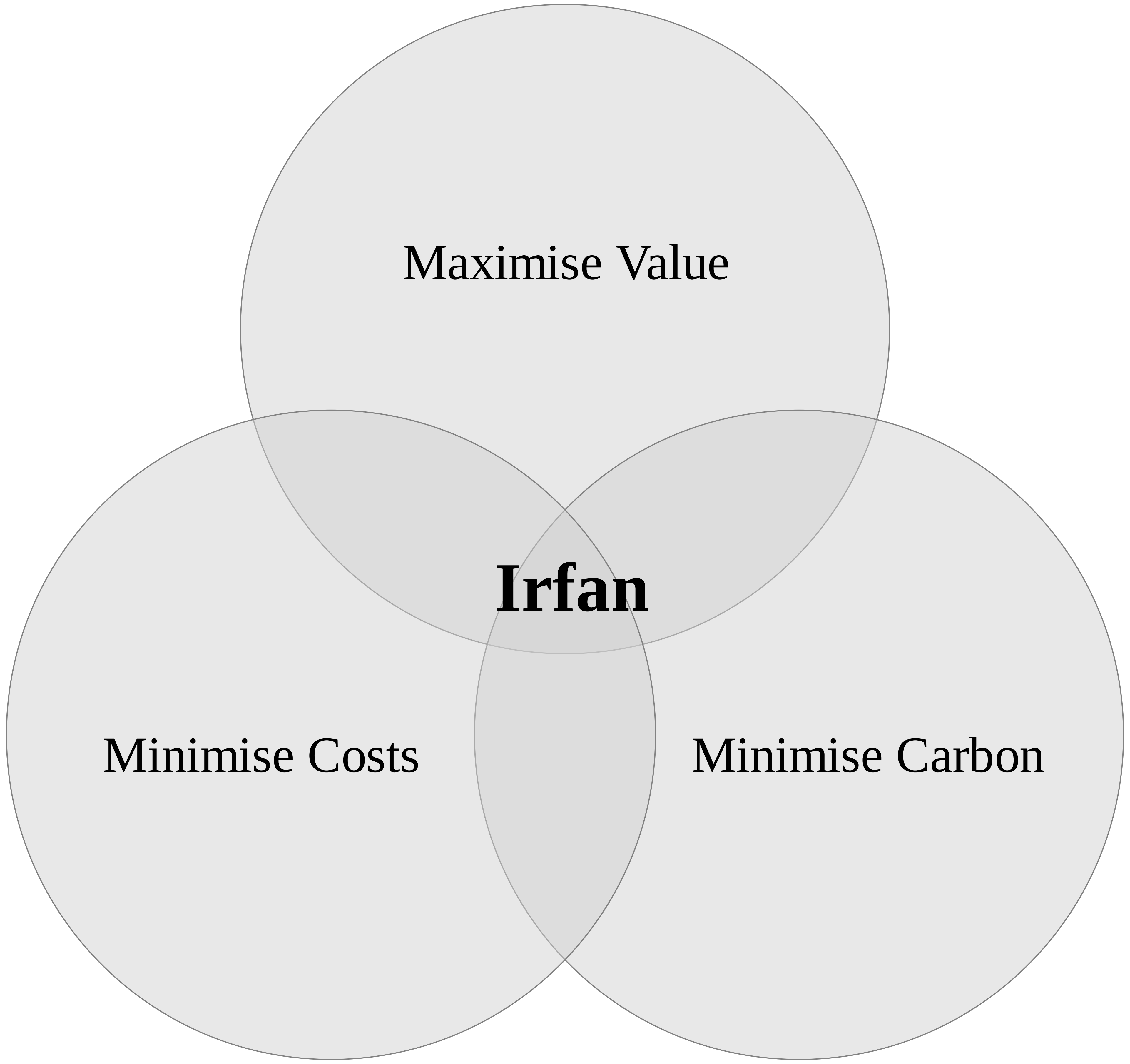
1.PRODUCE A MASTERPLAN THAT BOTH MAXIMISES:

- The value of the site
- The sustainability of the development

2. QUANTIFY THE COSTS AND BENEFITS IN TERMS OF:

- Value
- Cost
- Carbon



Irfan

The challenge

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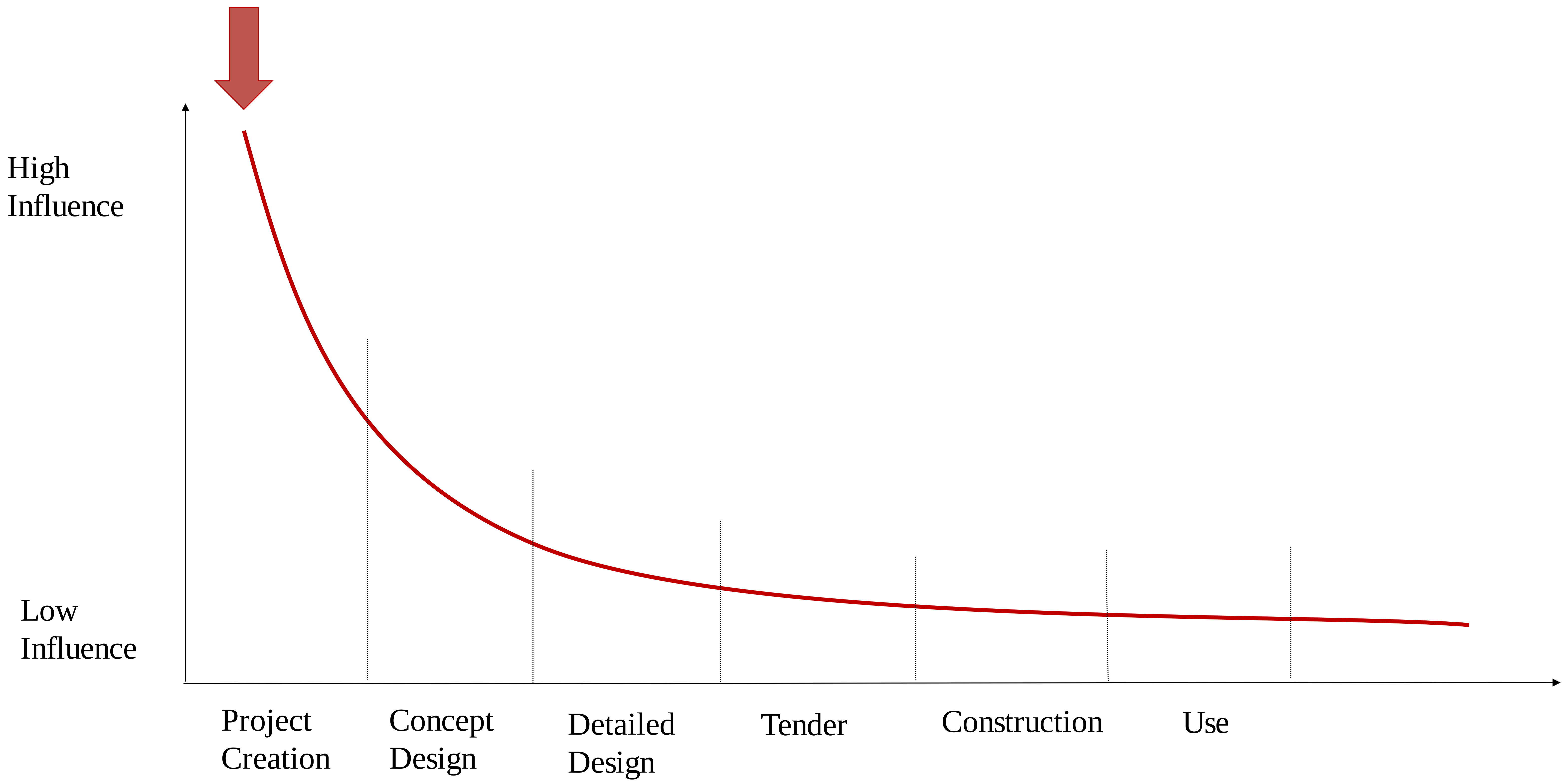
PROJECT CREATION STRATEGIC MOVES:

- Site Selection
- Development Use
- Density of development
- Connections to Muscat



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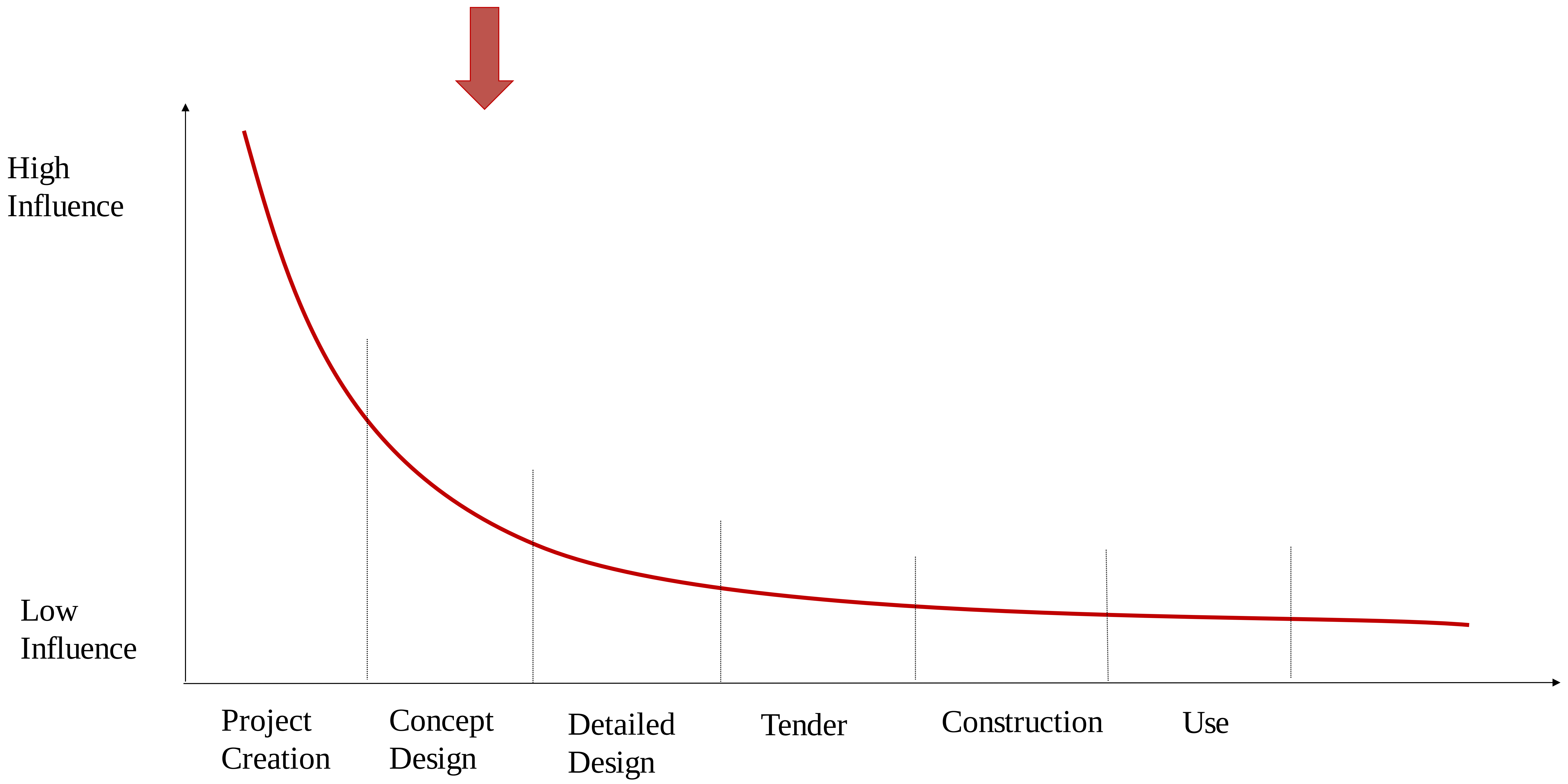
The challenge

STAGE 2 DESIGN MOVES:

- Masterplan
- Building Efficiency
- Sustainable infrastructure
- Resource Demand Reduction



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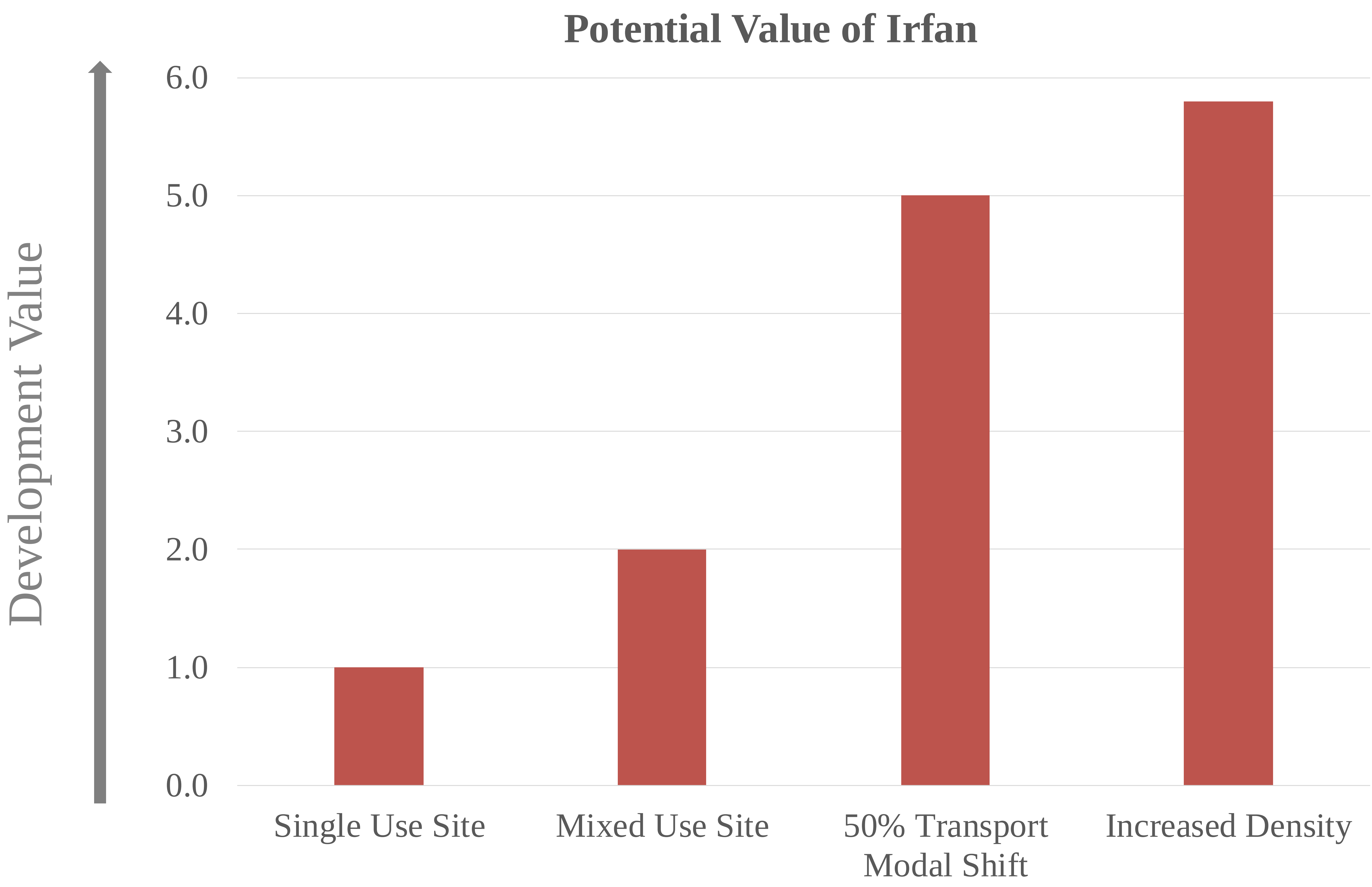
Strategic moves



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Infrastructure Systems

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- Earthworks and Flood Management
- Transport
- Water Supply
- Energy | Cooling
- Digital and Smart
- Governance

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Earthworks and Flood Management

Potential benefits of working with existing landform and geology include:

- Visually part of the natural environment – sense of place;
- Reduced cost – minimises cut and fill;
- Inherent flood risk protection – fluvial flood risk study indicates that the wadi can readily accept 100-year flood including climate change allowance;
- Use of sustainable urban drainage – limestone appropriate for infiltration drainage (testing dependant). Retaining landform and central wadi make conventional pipe system efficient if limestone not suitable for infiltration;
- Resilience to flooding - Slopes and natural landform to create a levels hierarchy with buildings at the highest levels, landscape at the lowest levels and all falling towards the wadi

Irfan wadi

Irfan

Transport

50% MODAL SHIFT

- Walking and cycling
- LRT (Light Rail Transit)

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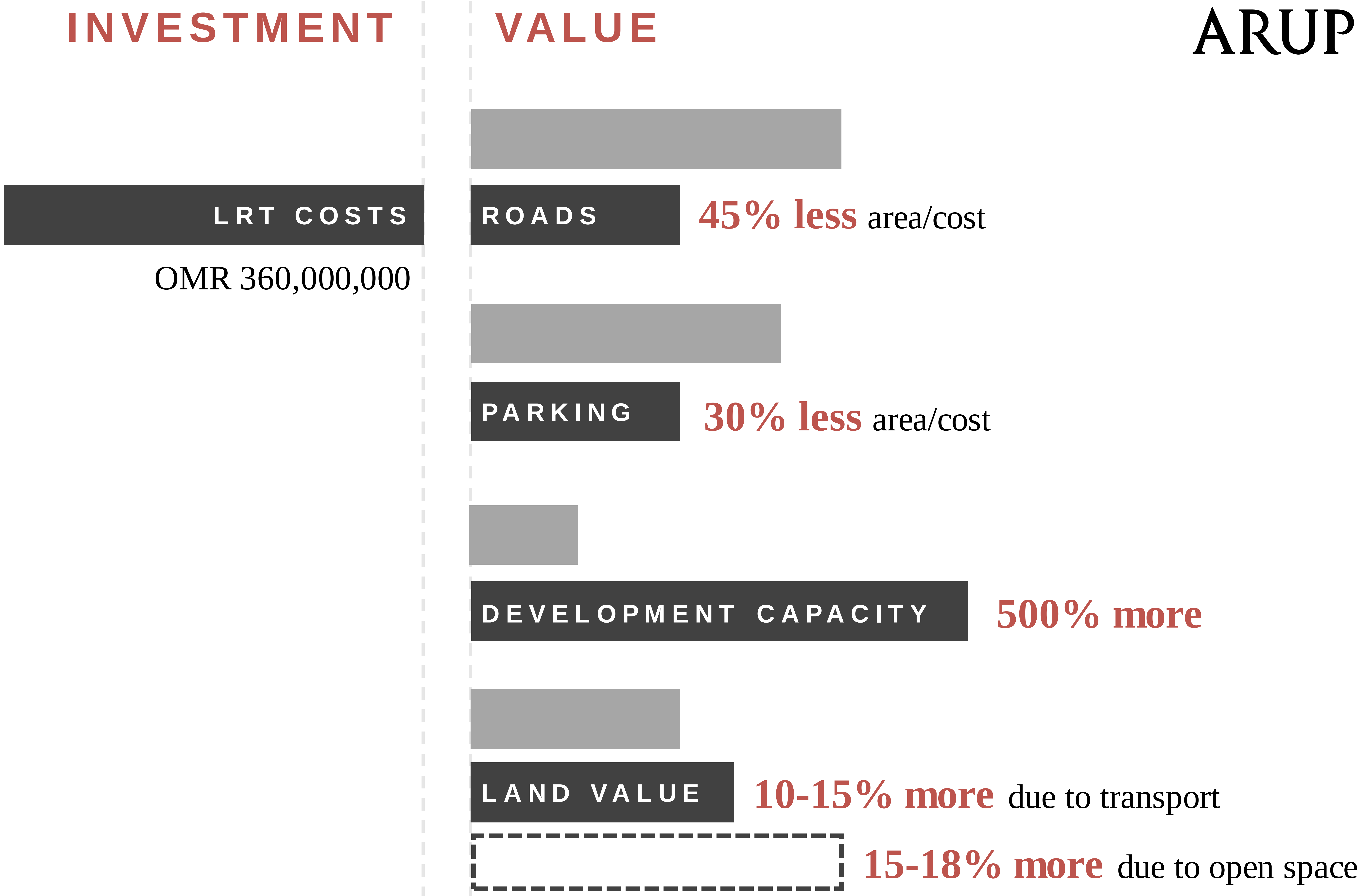
Transport



Other benefits/value:
Less commute
Productivity
Walkability
Shading
Air quality
Health

Business-as-usual

Irfan: Catalyst for Change

Irfan

Water supply

Key elements of providing resilience for the water supply systems include:

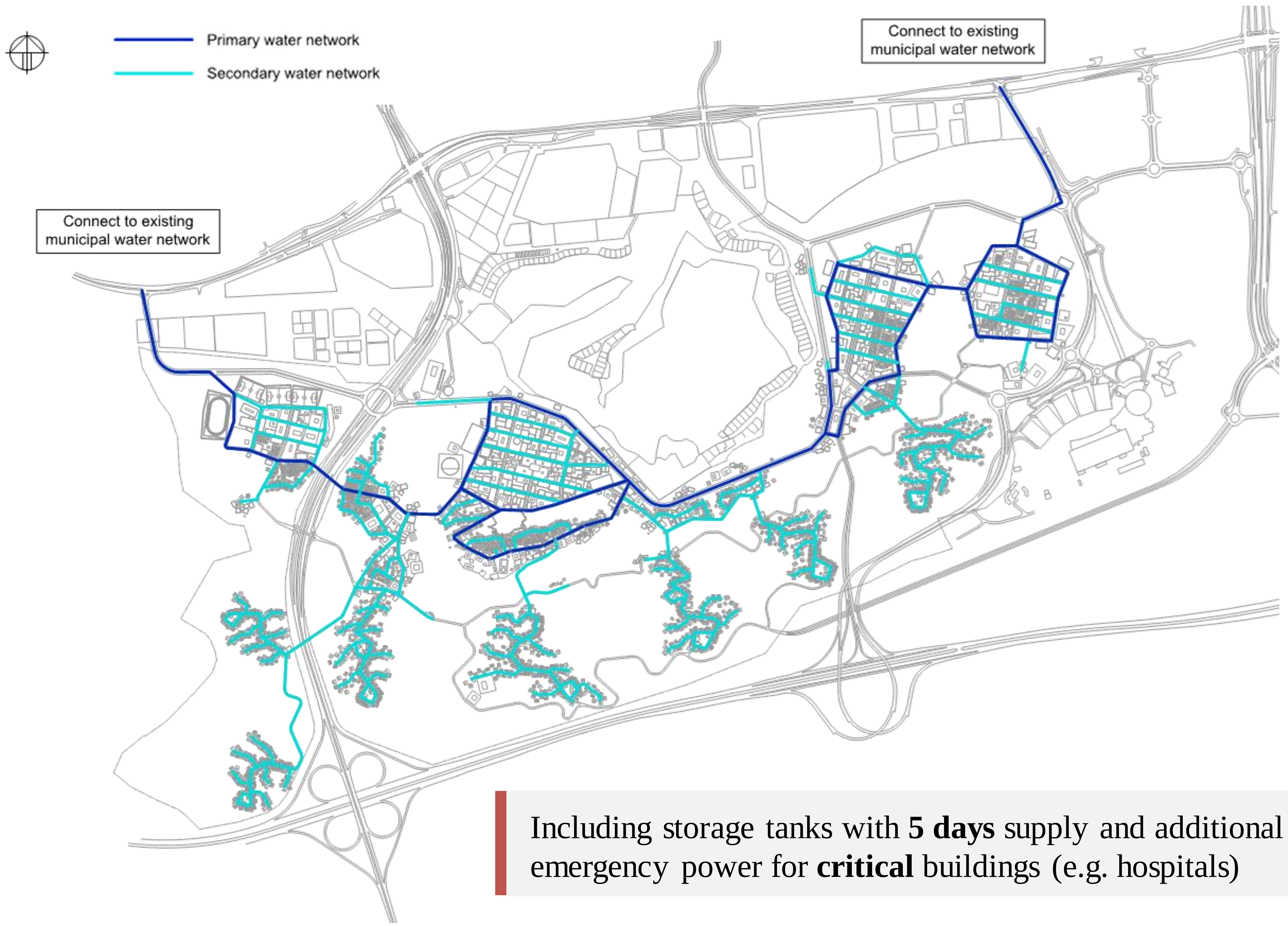
- Demand Reduction;
- Multiple supply into the City Network;
- Site supply from multiple connections to the mains;
- Ring main option for site distribution where appropriate;
- Size site ring main for potential increase in density;
- Provide critical plant such as pump stations with:

    Multiple pumps - duty and standby

    Emergency power supply

    Full set of replacement parts

Proposed water network



Including storage tanks with **5 days** supply and additional emergency power for **critical** buildings (e.g. hospitals)

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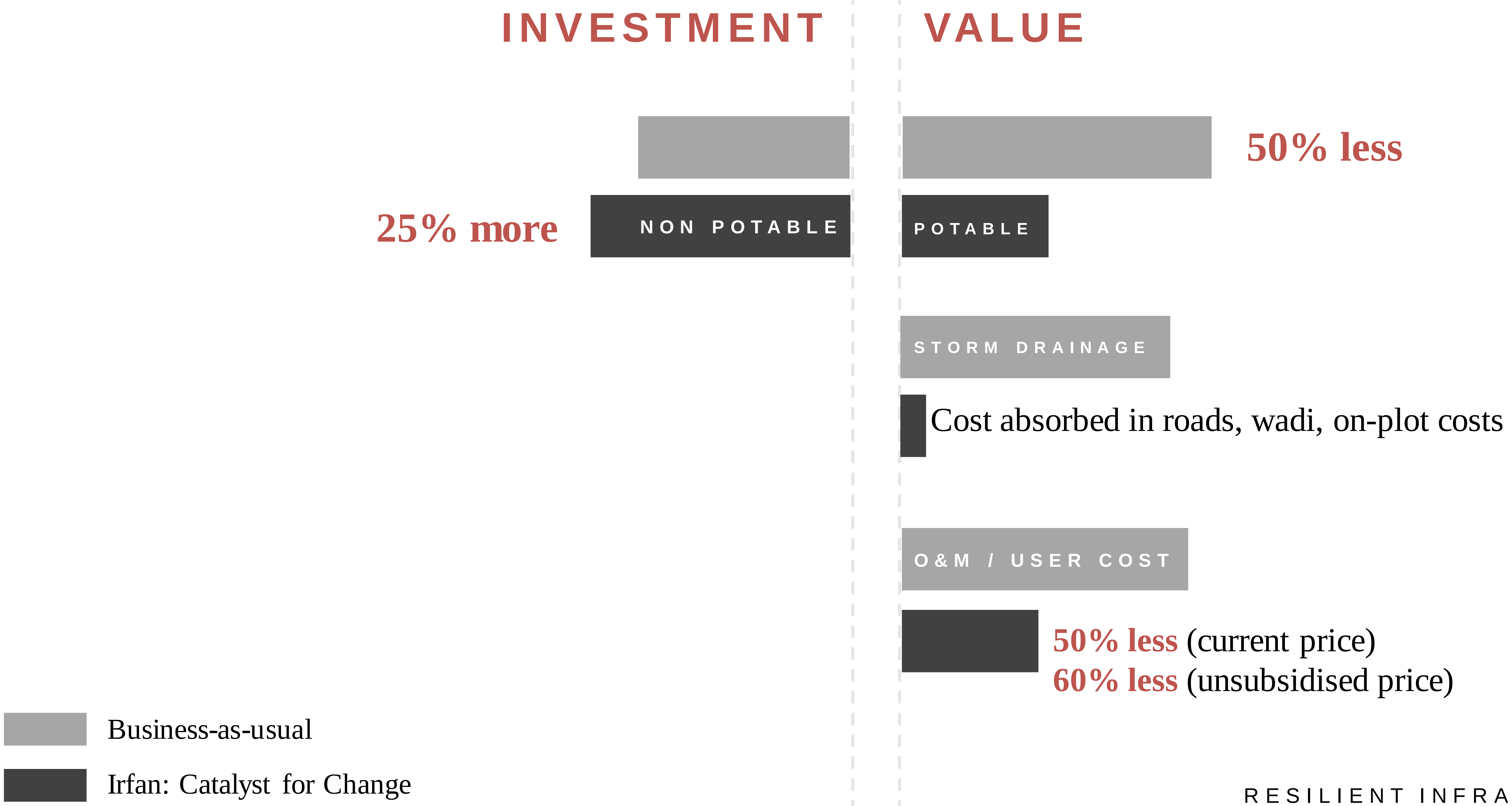
Water supply



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Energy

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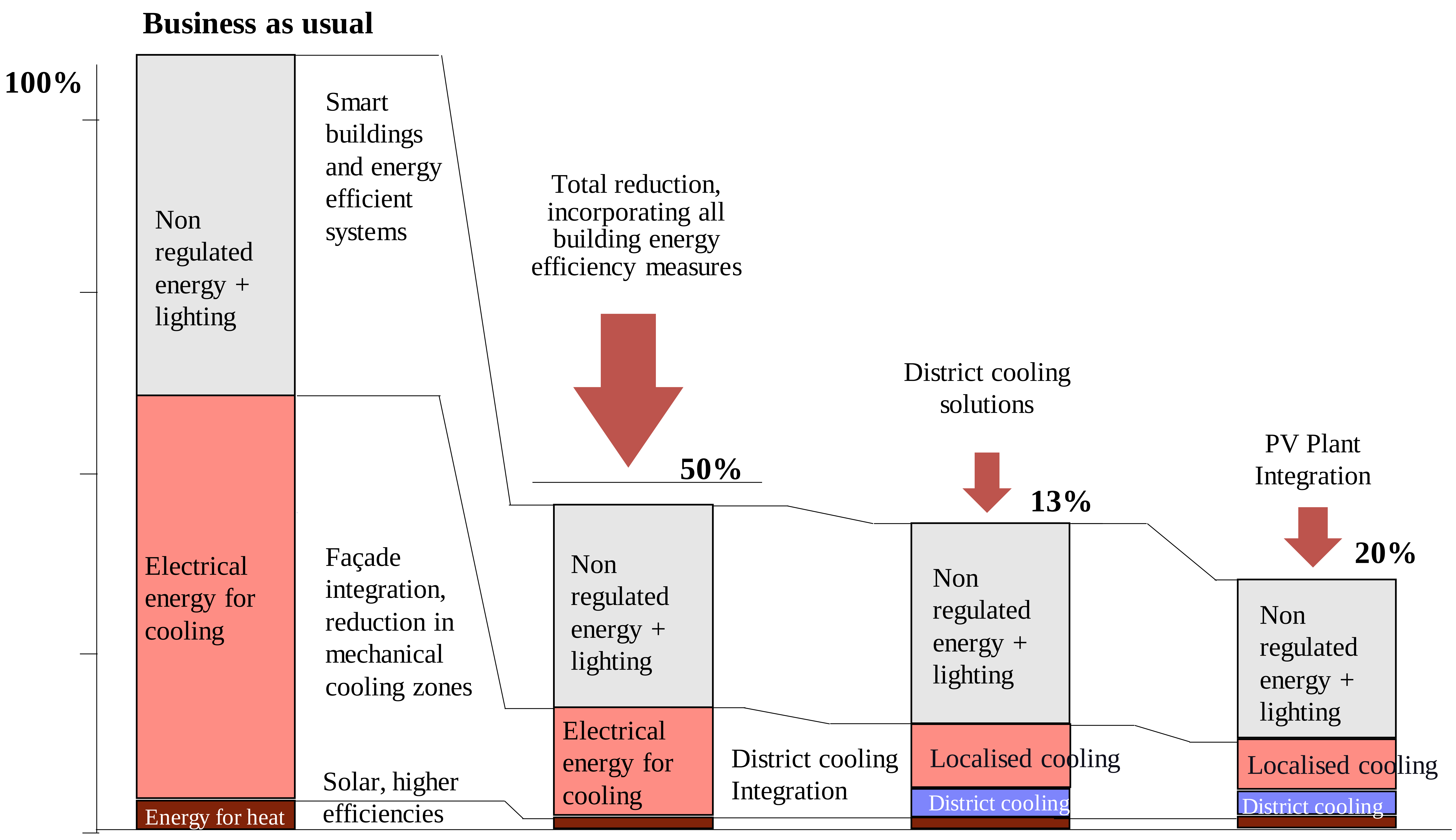

Irfan
Energy

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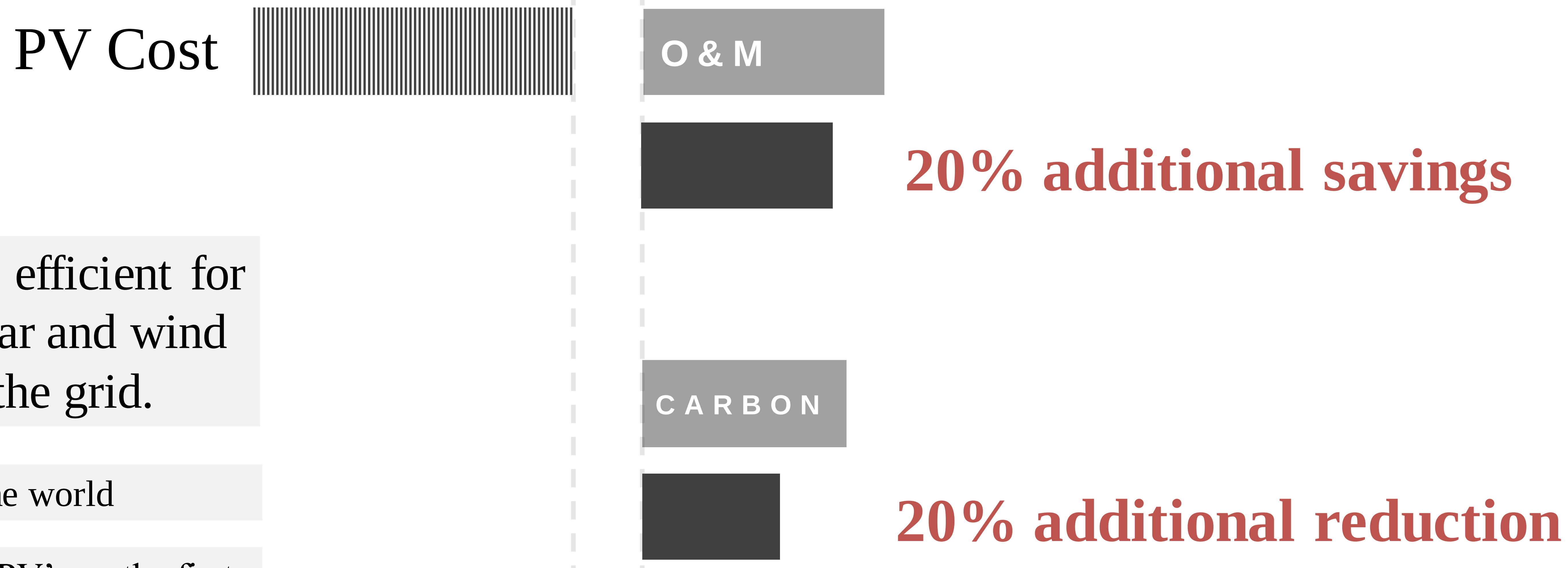
MORE INFO

INVESTMENT | VALUE



In the *long-term*, it may be more efficient for Oman to develop large-scale solar and wind power to supply power through the grid.

- Oman the **highest** solar irradiance in the world
- Launched a pilot programme to install PV's on the first **1,000 homes**

Business-as-usual

Irfan: Catalyst for Change

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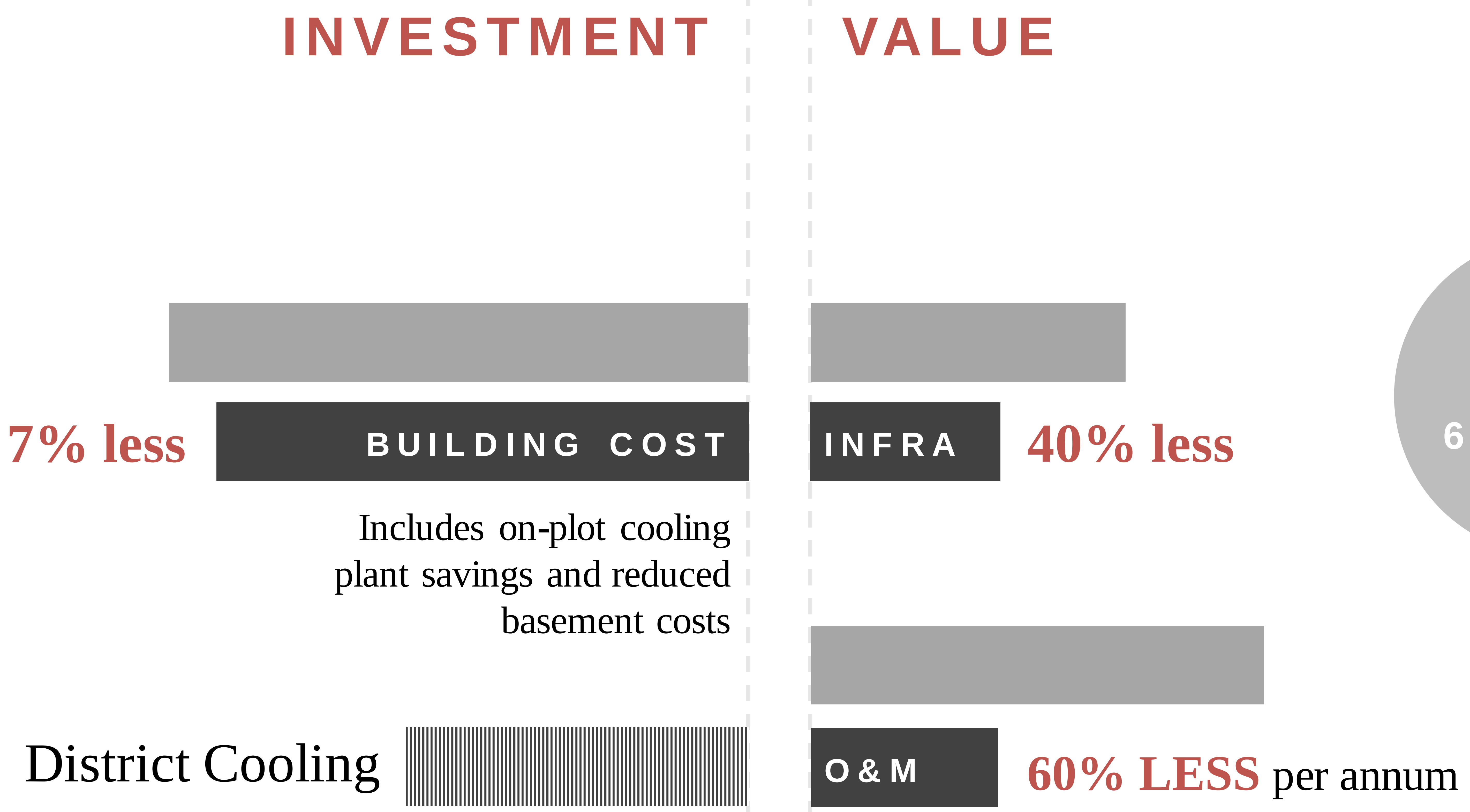

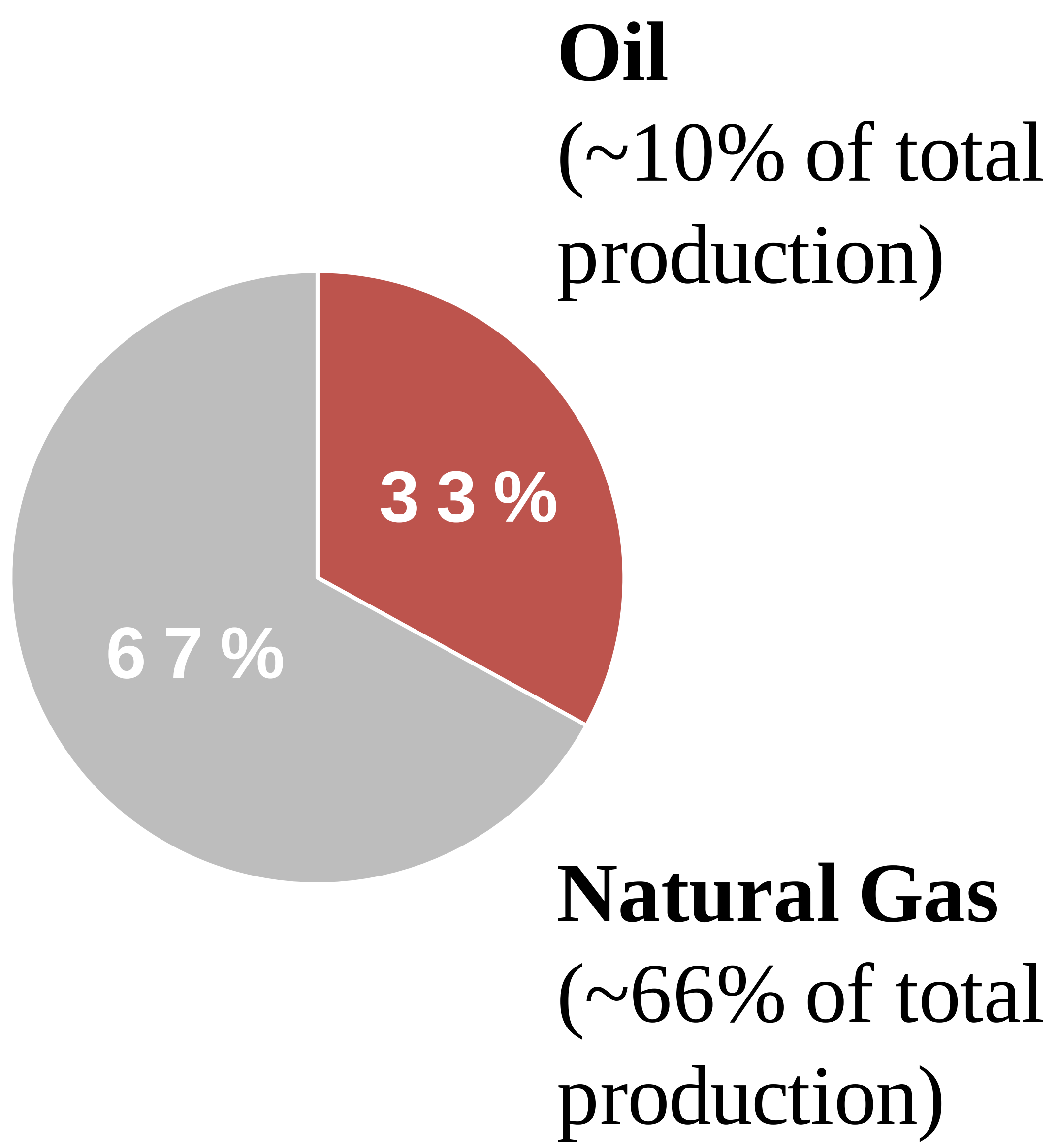

Business-as-usual

Irfan: Catalyst for Change

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Digital and Smart

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All infrastructure systems will have digital monitoring and data collection. This data will be used to inform:

- Smart demand management systems to reduce overall demand and peak demands;
- Predictive maintenance: Unusual behaviour in the system such as leaks, and the location to aid focus maintenance and repair.

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General Strategies

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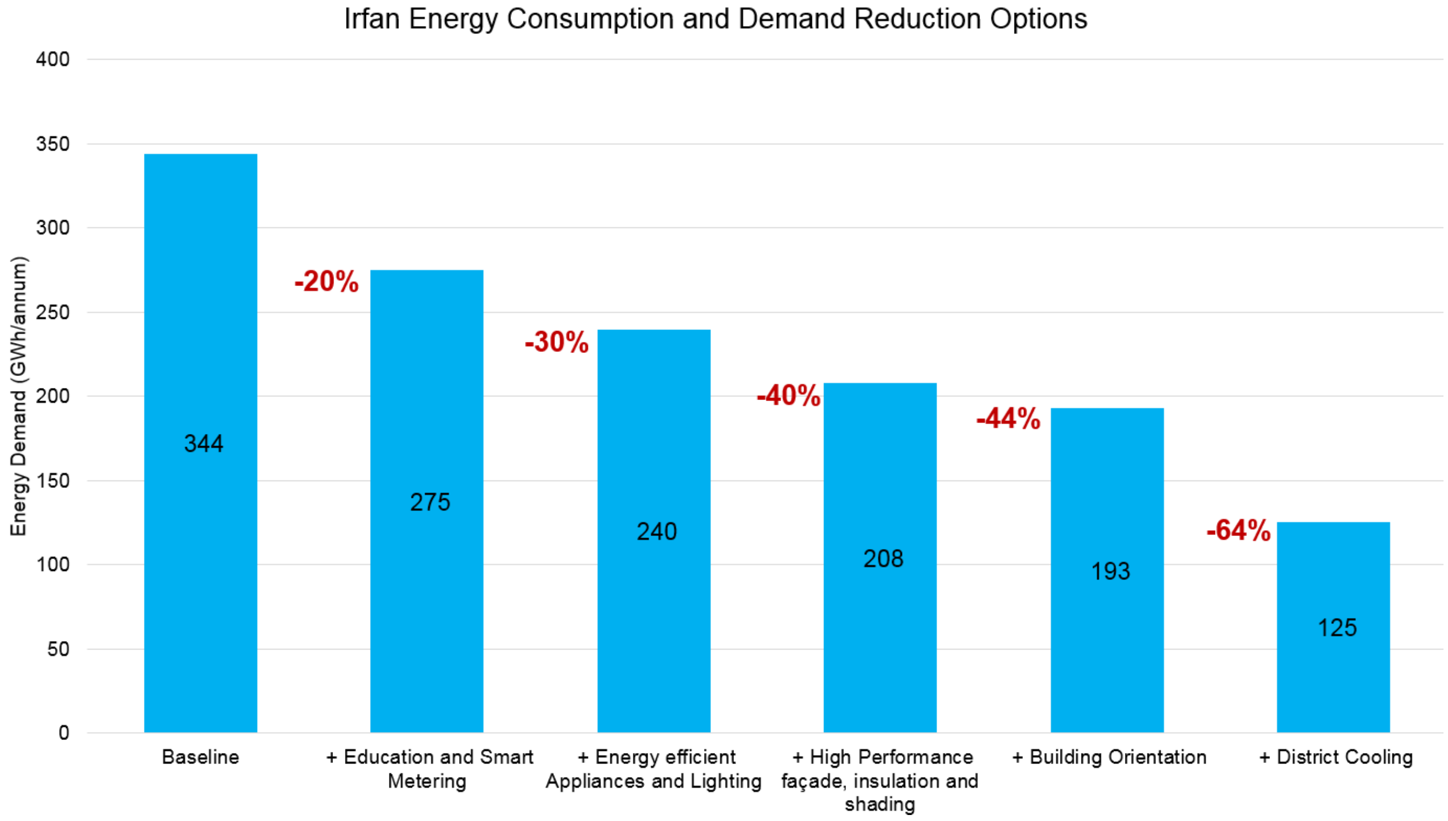
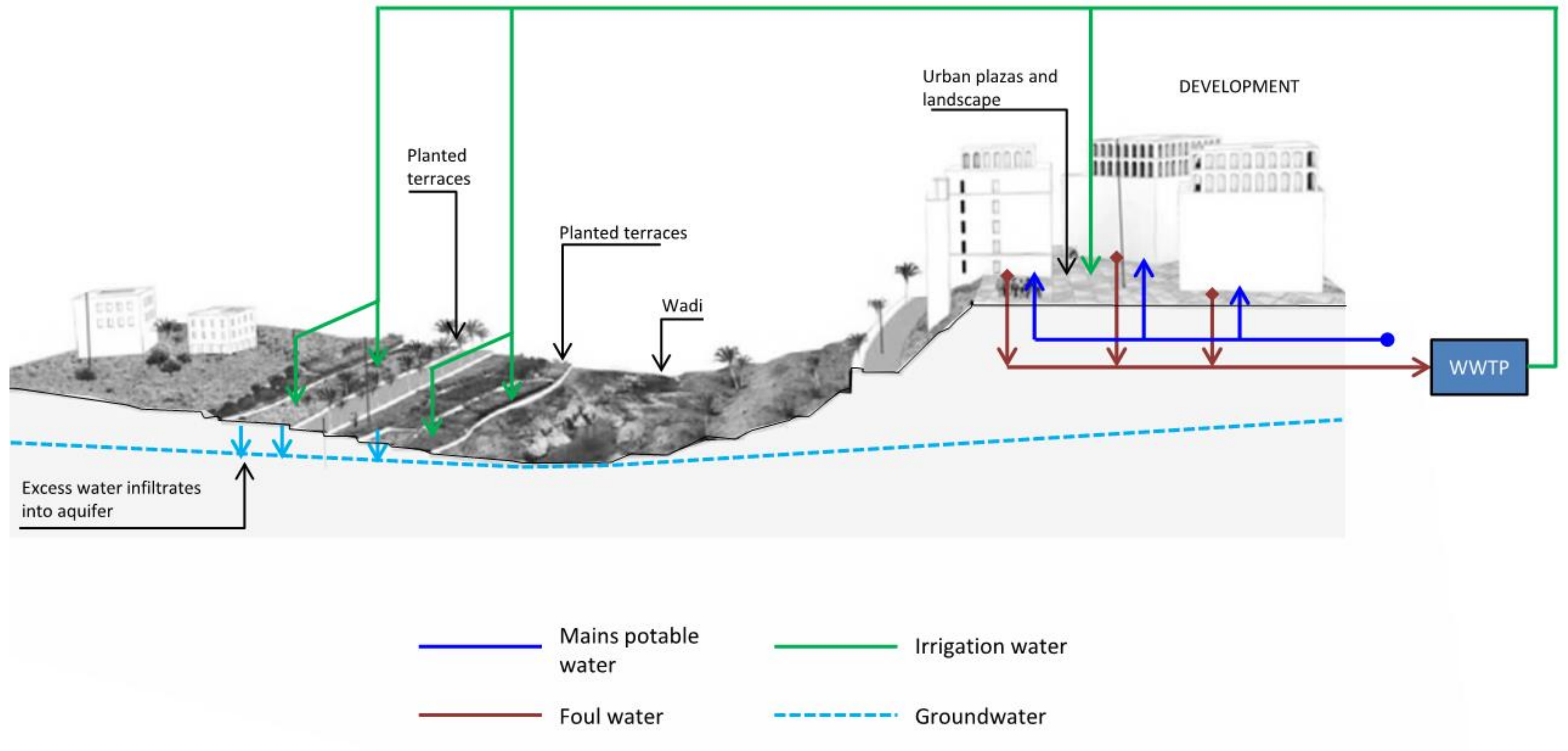
DENSE DEVELOPMENT

DEMAND REDUCTION



RECYCLING AND REUSE



EFFICIENT GENERATION

Irfan

Governance

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Critical to the success of the project, governance framework would include responsibility for:

- Maintaining the project vision;
- Reviewing the project density and mix of uses;
- Maintain the quality of design;
- Operation and maintenance of the main landscape and infrastructure systems;
- It is proposed that the O&M team would utilise the enhanced infrastructure resilience; model which would have the following characteristics:

  Reduced Risk of Failure – through planning, design and smart O&M;

  Rapid Recovery - in the event of failure through contingency planning;

  Transforming Performance - through reflection, learning and understanding of interdependencies with other systems.

INVESTMENT VALUE

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15-18% more

25 km of Wadi frontage plots

58% of plot area in Irfan has a direct Wadi or park aspect

Direct views over green space can result in **25%-30%** uplift in value

- Business-as-usual
- Irfan: Catalyst for Change

Irfan

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The Integrated Approach

	Masterplan / Buildings	Landscape	Microclimate	Transport	Energy	District Cooling	Water	Surface Drainage	Foul Drainage	Solid Waste	Operations	Governance	Policy
	DESIGN			TRANSPORT	INFRASTRUCTURE						GOVERNANCE		
50% journeys on public transport	■	■	■	■							■	■	■
50% less energy demand	■	■	■		■	■					■	■	■
20% energy from on-site renewables	■				■						■	■	■
50% less potable water demand		■					■		■		■	■	
100% irrigation with non-potable water		■	■				■				■	■	
80% storm water managed through SuDS		■						■			■		
100% wastewater network connectivity	■						■		■				
95% waste diverted from landfill		■								■	■	■	■
95% wadis conserved as open space	■	■	■				■					■	
80% use of native or adaptive plants		■	■				■					■	

SuDS = Sustainable Drainage Systems

Irfan

Carbon Overview

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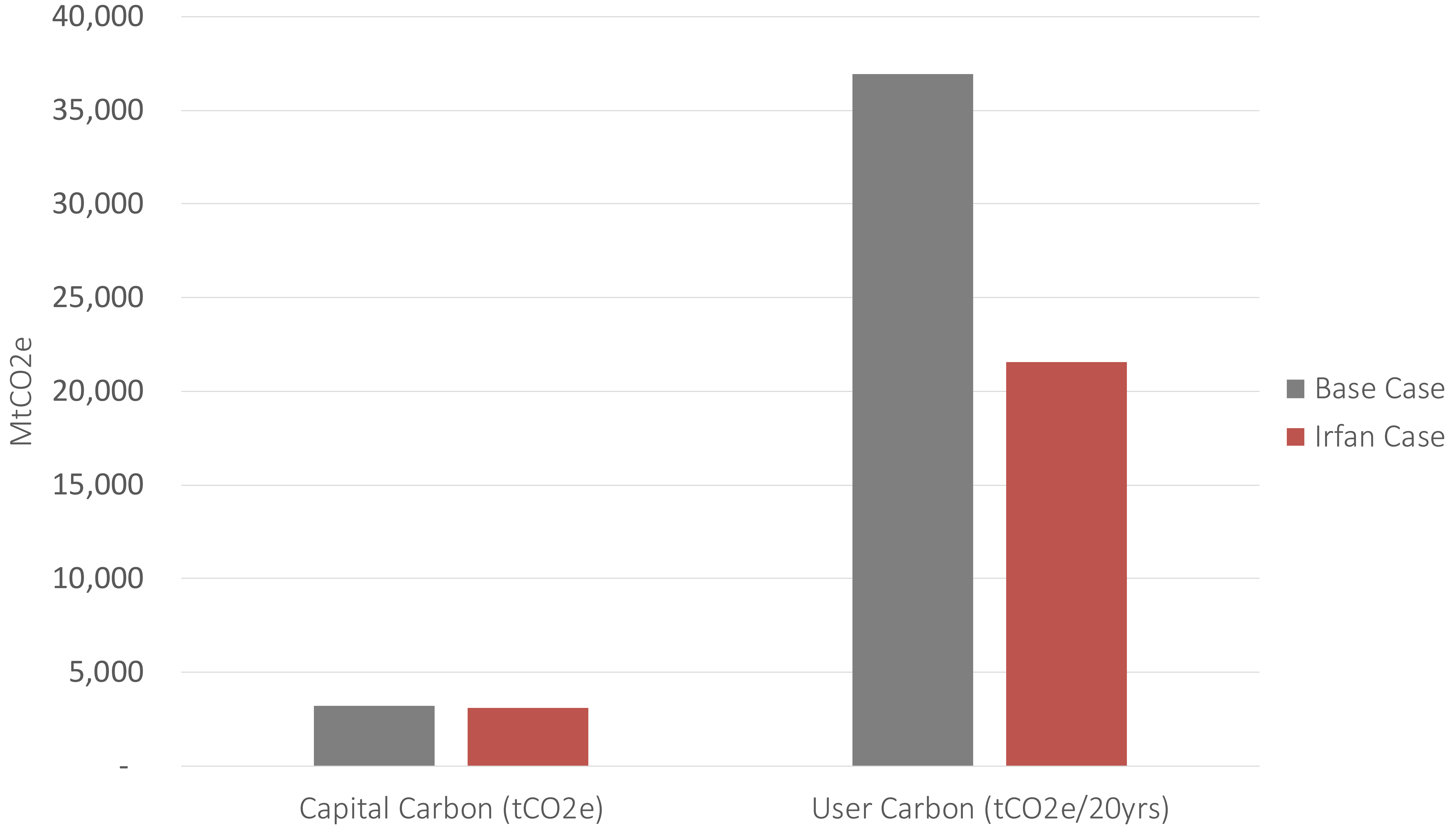
FULL BUILD OUT MASTERPLAN OVER 20 YEAR TIMEFRAME

For the base case, over a 20 year timeframe User Carbon is **12** times greater than Capital Carbon.

Over a 20 year timeframe the total carbon emissions associated with the Irfan Case are 40% fewer than the Base Case.



SUMMARY

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1. Context of why resilience is important;
2. International guidance and latest thinking;
3. Definitions of resilience and sustainability; and
4. Design Guidance and an example project (Irfan).

KEY LESSONS

1. Resilience and Sustainability can be achieved through good design;
2. A systems approach provides a good methodology particularly if :
    - It includes an integrated design approach;
    - It takes account of policy, governance and operations; and
    - We actively look for synergies between systems.
3. Pathways to resilience (Prevention, Recovery and Transformation) apply to Pandemics; and
4. Resilience and Sustainability can be achieved economically.

Pandemics and Infrastructure Resilience

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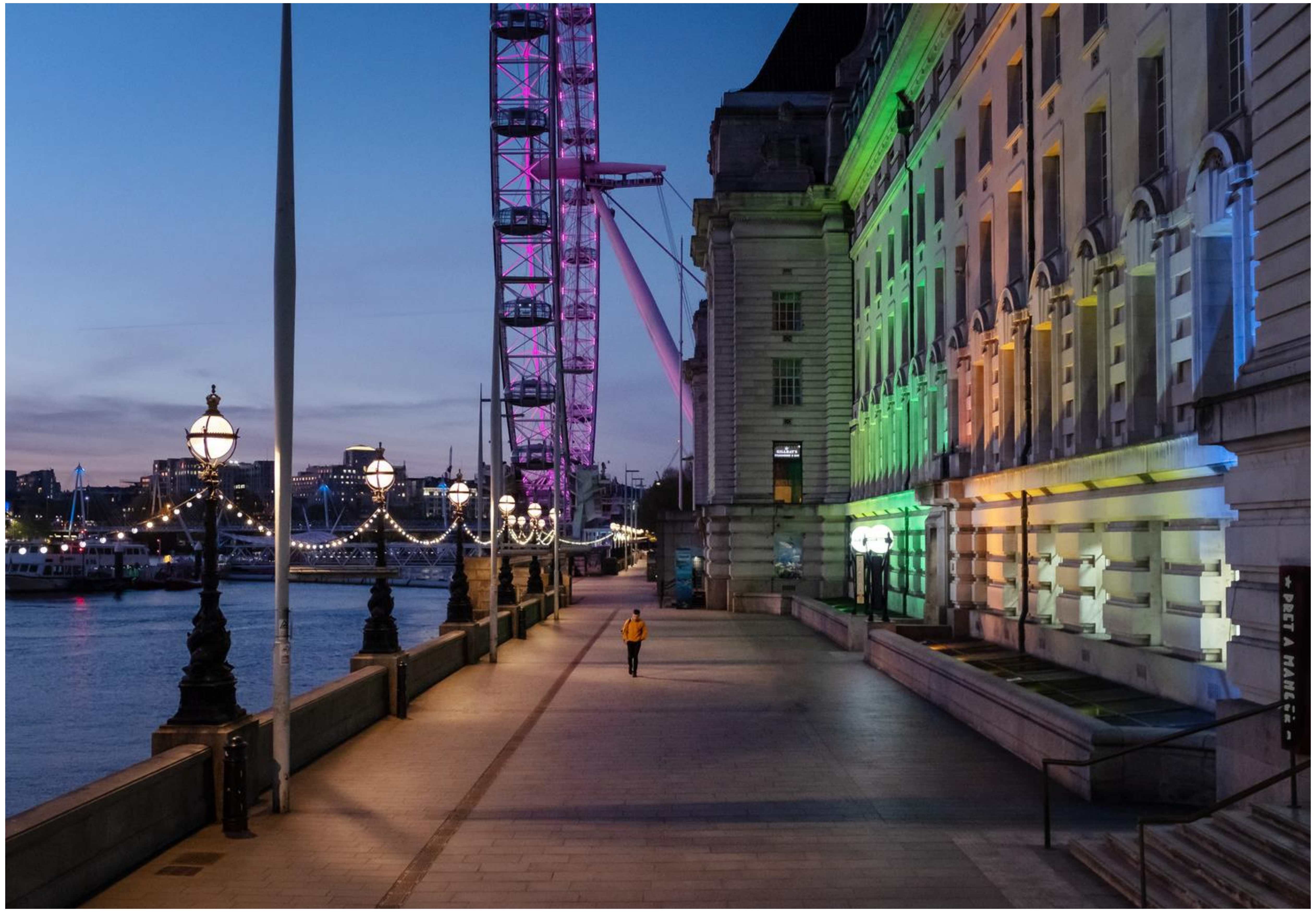
Context

- Pandemics alongside climate change have been recognised for several years as the **biggest threat to human existence**
- Important observations relating to resilience based on early stages of Covid-19:
  - Age Distribution;
  - Inherent health of the population;
  - Population density;
  - Equity and access to opportunities;
  - Climate;
  - Health Care System;
  - Country’s (geographical) Isolation;
  - Leadership; and
  - Level of preparedness and anticipation.



London Eye area during Covid-19 lockdown, London – UK (April 2020)

Pandemics and Infrastructure Resilience

Systems Approach

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?

HOW

SHOULD WE DESIGN INFRASTRUCTURE SYSTEMS TO ALLOW US TO **OPERATE IN A PANDEMIC EVENT**?

HOW

SHOULD WE DESIGN CITIES TO **REDUCE THE RISK** OF AN EVENT OCCURING?

Mobile data to re-trace steps of infected citizens, South Korea (March, 2020)

Pandemics and Infrastructure Resilience

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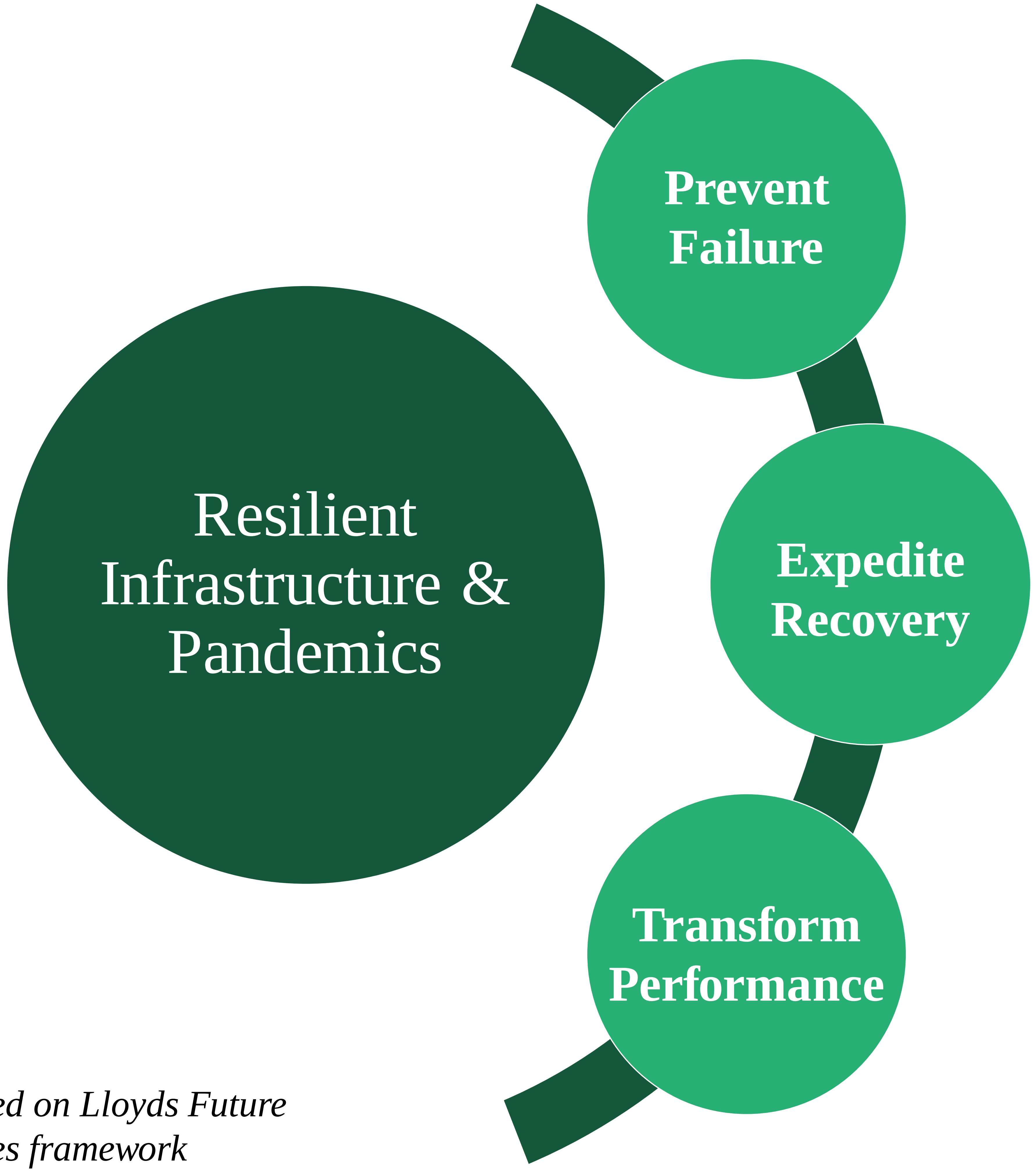
Systems Approach Framework



Based on Lloyds Future Cities framework

WITHSTAND AND MITIGATE IMPACTS

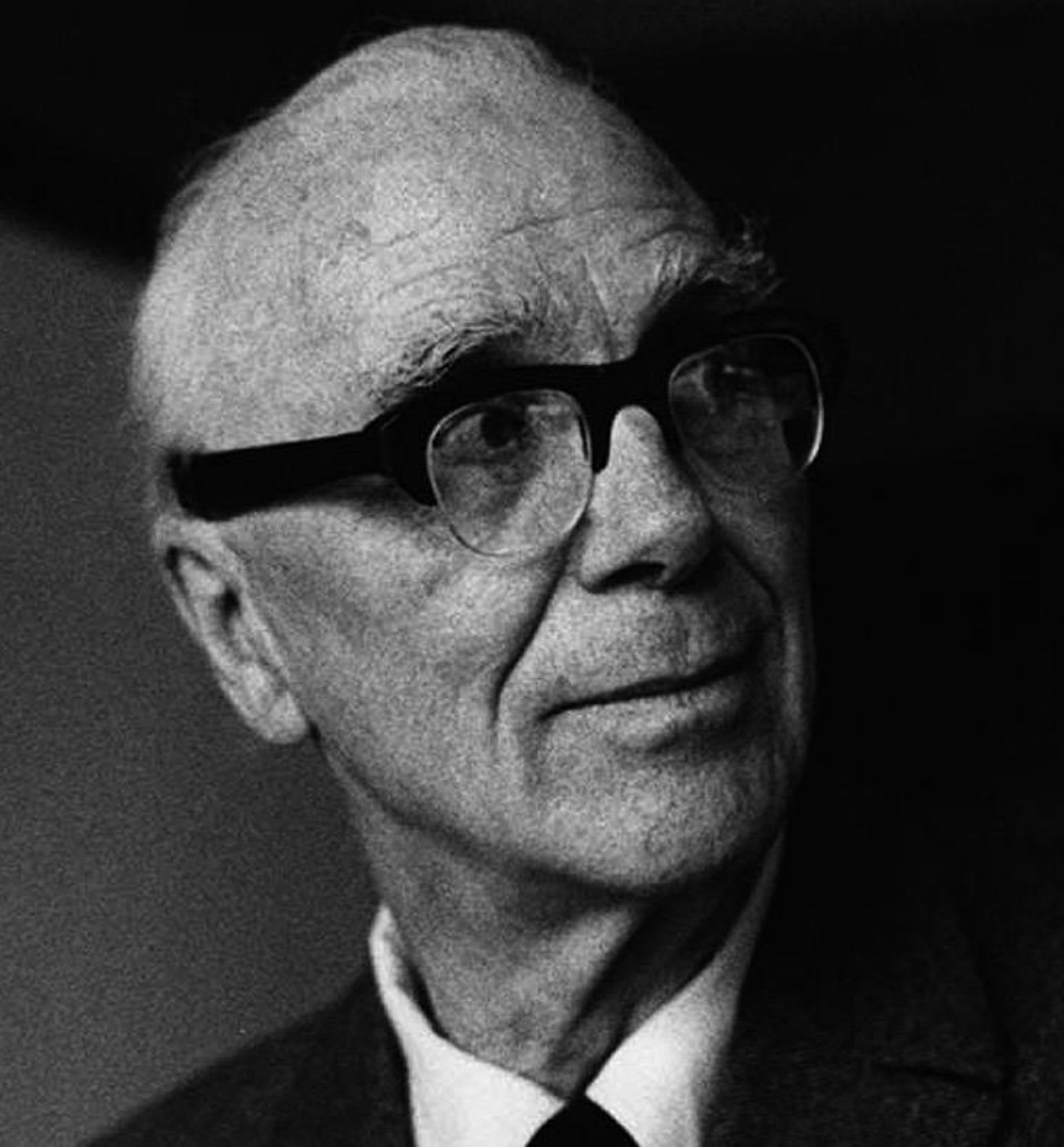
- Public transport: still running, but financial model failed
- Active travel: temporary cycling facilities
- ICT and communications: change working patterns and support companies to keep business going
- Redundancy and alternatives

FUNCTIONAL ASAP

- Systems continue to operate: clean water, sanitation, reliable energy, transport operation, communications
- Digital solutions to support test, trace and isolate system
- Schemes to support cycling to work

THE 'NEW NORMAL'

- Public transport: monitor capacity to reduce overcrowding and provide real-time information of network
- Reconsider space allocation on streets for active travel
- Food system: nutritious foods to improve individual's health
- Materials with natural disinfectant properties (e.g. copper door handles)



THANK YOU!

CO-AUTHORS

CLAIRE HICKEY
LUIS STRENGARI

PICTURE: SIR OVE ARUP, ARUP FOUNDER

Commonwealth Association of Architects

Engaging with the UN 2030 Sustainable Development Goals

We hope you found this lecture of interest and that you will be interested in the other lectures in this series:

1. **Introduction to the UN 2030 Sustainable Development Goals**
2. **Planning for Rapid Urbanisation**
3. **Planned City Extensions**
4. **Resilient Infrastructure**
5. **Climate Responsive Design**
6. **Heritage-led Regeneration**
7. **Sustainable Outcomes Guide**

The Commonwealth Association of Architects would like to extend its thanks to all the contributors for their support in the creation of this pilot programme. The CAA welcomes feedback together with suggestions for future topics and would be pleased to hear from subject matter experts from around the Commonwealth who may be interested in contributing future material.

For this or any other issue, please contact: admin@comarchitect.org

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@comarchitect
www.comarchitect.org
admin@comarchitect.org

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