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SCHOOL OF ENERGY AND ENVIRONMENT

香港城市大學
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SEE 1003
Introduction to Sustainable Energy and Environmental Engineering

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Module 4 – Urban Sustainability and Resilience

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SEE 1003 class overview

Week	Topics	Assignment issued	Key dates
Week 1	Course introduction; Climate Change and the Engineering approach		**Quiz 1**
Week 2	**MODULE I** Introduction to Sustainability Energy, Natural Resources and pollution, Electromagnetic energy; Electrical energy – Lighting, Light pollution, Policy	**Semester-long Project**	
Week 3		**Project deliverable 1.1**	
Week 4	**MODULE II** Energy and Environmental Implications– Transportation Human-Environment Impacts		
Week 5		**Project deliverable 1.2**	**Project deliverable 1.1**
Week 6	**MODULE III** Noise Pollution in Urban Environment	**Project deliverable 1.3**	**Quiz2**
Week 7	**MODULE IV** Urban Sustainability and Resilience		**Project deliverable 1.2**
Week 8	**MODULE V** Tools: Systems Analysis for Sustainability Cost-Benefit Analysis, Material Flow Analysis, Life Cycle Assessment		
Week 9			
Week 10	**MODULE VI** Advances in Environmental and Energy Engineering	**Project deliverable 1.4**	**Project deliverable 1.3; Quiz3**
Week 11	**MODULE VII** Waste management and Waste-to-Energy		
Week 12	**MODULE VIII** Economics and Policy of Energy and Environment	**Project deliverable 1.5**	**Quiz4** **Project deliverable 1.4**
Week 13	**Individual Presentations (5-mins)**		**Final Project Report**

Overview

- **Urban Sustainability**
  - Principles and strategies
  - Challenges faced by the cities ---- urban infrastructures
    - *Housing, mobility, health care, resources supply, waste management, etc.*
  - Five main challenges for making sustainable cities

- **An Introduction to Resilience**
  - Why do we need resilience thinking?
  - How does resilience relate to sustainability?
  - What are the approaches to measure and develop resilience?
  - Resilience at different scales

- **Hong Kong's Urban Sustainability and Resilience Policy**

Climate Change Mitigation

Reduce carbon emissions through traditional renewable energy sources and new ones, like tidal energy

Climate Change Adaptation

The process of adjustment to actual or expected climate and its effects

Extreme weather threat makes climate change adaptation a top priority

Implement “drawdown” measures, for removing and sequestering carbon

Cities in the 21st Century

- More than **50 percent of the world's population** lives in urban areas
  - **80 percent of the globe's economic activity**
  - **75 percent of the world's greenhouse gas** (GHG) emissions
- Spread and **continued growth of urban areas** presents a number of **concerns for a sustainable future**
  - Particularly if cities cannot adequately address the rise of poverty, hunger, resource consumption, and biodiversity loss
- Any discussion of sustainable development should **center on cities**

Definition of Urban Sustainability

“Process by which the **measurable improvement of near- and long-term human well-being** can be achieved through actions across environmental (**resource consumption with environmental impact**), economic (**resource use efficiency and economic return**), and social (**social well-being and health**) dimensions”

National Academies of Sciences, Engineering, and Medicine. 2016. *Pathways to Urban Sustainability: Challenges and Opportunities for the United States*. Washington, DC: The National Academies Press. https://doi.org/10.17226/23551 .

Urbanization and the Future of Cities

- https://youtu.be/fKnAJCSGSdk


Photo: Leung Cho Pan

Urban Sustainability: The Major Challenges

1. What are the **challenges** faced by the cities?
2. What are the **challenges** for transitioning towards sustainable cities?

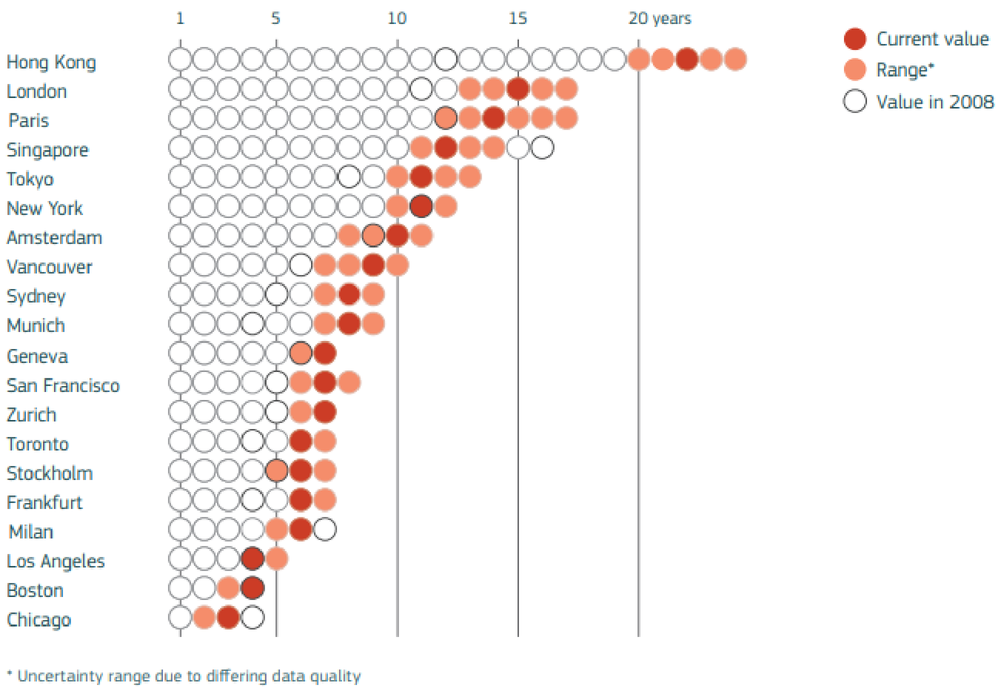
What are the challenges faced by cities?

- **Affordable Housing**
  - Cities have seen sharp increases in housing prices over the past years
- **Mobility**
  - Environmental pollution, congestion, and long commuting times are just some of the issues related to mobility
- **Ageing**
  - Strain will be put on the welfare system, as growing costs for health care, pensions and social benefits will need to be covered by a shrinking labour force
- **Urban Health**
  - High population densities in cities may facilitate the spread of infectious diseases. Emerging trends, such as ageing, and the prevalence of obesity and mental health in cities have to be tackled.
- **Resource Intensity**
  - Providing water, energy and food security for urban populations results in significant environmental pressure beyond city boundaries
- **Waste Management**
  - Large volumes of uncollected waste create multiple health hazards.
- **Climate Action**
  - Cities generate about 70% of global GHG emissions, and, at the same time, are particularly vulnerable to the impacts of climate change.

https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/future-cities

Affordable Housing

- Some of World's most in-demand cities have seen sharp increases in housing prices over the past years.
- This threatens housing affordability as prices are growing faster than earnings, and the availability of housing is low.



The number of years a skilled worker needs to work to be able to buy a 60m^2 (650 sq.ft.) near the city centre

https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/future-cities

Mobility

- Mass adoption of private vehicles in cities has led to congestion, has negatively impacted the environment (air and noise pollution), human health, personal safety, and reduced liveability and social inclusion
- Mobility in cities is one of the sectors that must change most in the future
  - Opportunity for technological innovation and behaviour changes.
- The ownership of private vehicles must decrease
  - Mobility as a service, combining multiple modes of transport, a possible solution in cities.
- Legislation and appropriate governance measures are needed to ensure new transport modes complement rather than compete with public transport.
- Autonomous electric vehicles may bring benefits to cities by reducing air pollution and congestion although they could also lead to negative socio-economic consequences as they replace existing professions.

Ageing

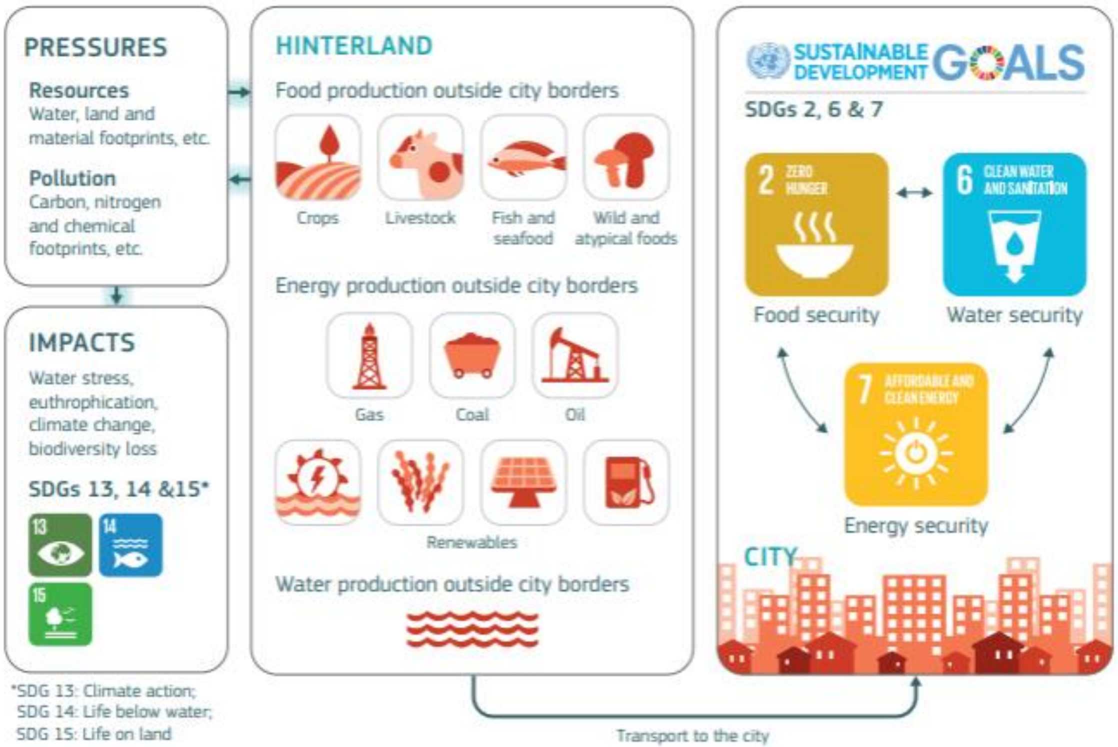
- An ageing population and changing demographic structure brings certain challenges for society as a whole and for cities in particular
  - Hong Kong women live, on average, to 87.3 years of age and men to 81.3
- A higher old-age dependency ratio puts a strain on the social system, as pensions and benefits will need to be covered by a declining labour force, potentially also affecting overall GDP and innovation
- The proportion of people needing care will rise, requiring additional investments in the current long-term care systems.
  - impact of rising pharmaceutical use on the environment
- Older populations are also more sensitive to heatwaves and pollution peaks (which often occur in cities and may become more frequent with climate change), requiring cities to be prepared to provide suitable coping mechanisms.
- Older populations are at greater risk of social isolation and the associated problems of mental well-being, requiring specific care and novel initiatives geared towards better social integration.
- Adapt the built environment, service provision and mobility within cities in a way that takes into account the needs of a changing age structure

Urban Health

- Cities have higher population and infrastructure densities, leading to:
  - Higher levels of noise and air pollution (also indoors)
  - Potential overcrowding
  - Urban heat islands
- Urban areas can pose a higher risk to personal physical and mental well-being
- Greater prevalence of diseases due to crowding and spreading of infections, lack of adequate ventilation and sanitation, and acute respiratory diseases from outdoor and indoor air pollution and mouldy housing interiors
- Mental health is also frequently poorer in cities, due to negative social and environmental determinants

Resource Intensity

- Food security, water security and energy security for cities are responsible for a large part of the total urban footprint
  - Dominant fraction of urban footprint is located outside city borders



https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/future-cities

- Cities have a strategic role to play in developing sustainable food systems and promoting healthy diets.

Waste management

- Cities have been generating an enormous amount of trash, and its proper disposal has become a major problem for them.
- Turning waste into a resource is key to a circular economy.
- Divert waste from landfills to upcycled valuable resources
- Improved waste management also helps to
  - ease health and environmental problems,
  - reduce GHG emissions (directly by cutting emissions from landfills and indirectly by recycling materials which would otherwise be extracted and processed), and
  - avoid negative impacts at the local level, such as landscape deterioration due to landfilling, local water and air pollution, as well as littering.

Climate Action

- Cities are responsible for a high level of energy consumption and generate about 70% of global GHG emissions
- City residents and the critical infrastructure on which they depend will face more frequent flooding, drought, heatwaves and intense rain events along with other climate related hazards
- Climate Change Impacts include:
  - sea-level rise affecting coastal cities,
  - impacts on built infrastructures,
  - health problems arising from higher average temperatures and extreme events,
  - an increase in energy demand and use,
  - adverse effects on water availability and resources
- Growth in the global urban population could also lead to significant increases in GHG emissions across multiple sectors and changes to the urban microclimate due to the urban heat island effect

Photo: Leung Cho Pan

Urban Sustainability: The Major Challenges

1. What are the **challenges** faced by the cities?
2. What are the **challenges** for transitioning towards sustainable cities?

What are the challenges for transitioning towards sustainable cities?

- No city can be considered sustainable.
- Focus must be on transitioning unsustainable cities in sustainable.

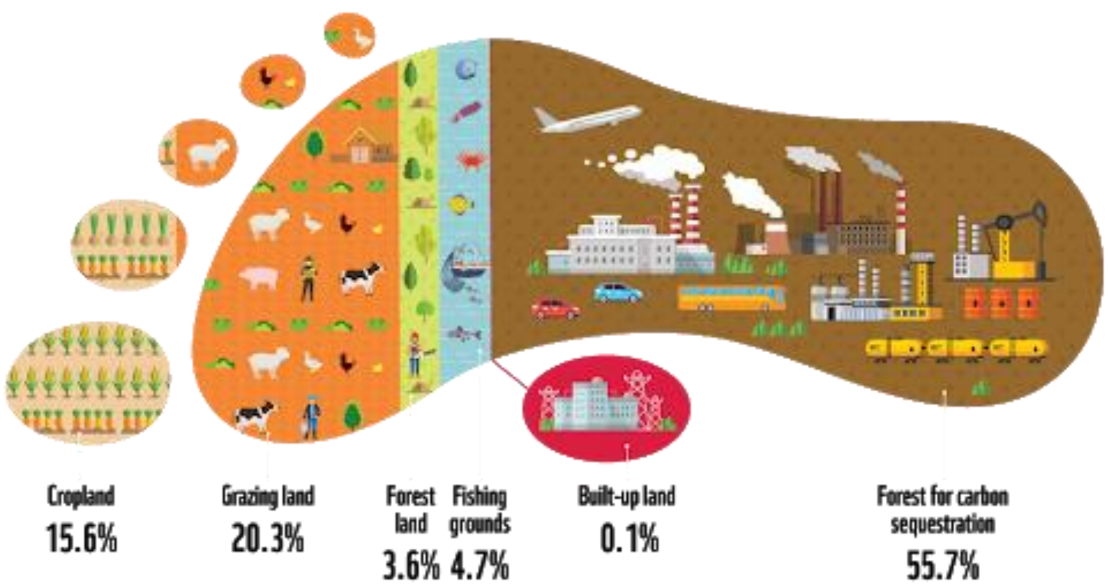
- Five Main Challenges for creating Sustainable Cities
  1. Ecological Footprint
  2. Ecosystem Services and Biodiversity
  3. Invest for Sustainability
  4. Lifestyle and Well-being
  5. Leadership and Cooperation

1. Ecological Footprint- Definitions

- The ecological footprint (EF) measures the biologically productive land and water area required both to produce the resources that are consumed, and to absorb the carbon dioxide that is generated by a population.
- An EF can be calculated for a nation, a region, a city, an organization, or individuals.
- EF is expressed in a unit called the global hectare (gha), where 1 gha represents a biologically productive hectare with world average productivity
- Biocapacity is the area of land and productive oceans actually available to produce renewable resources and absorb CO_2 emissions. It can be measured for the planet or a certain area, e.g. a country.
- Today, the global footprint exceeds the planet's biocapacity by 50 per cent.

Ecological Footprint for Hong Kong

- In Hong Kong, the average per capita footprint is 7.14 global hectares (gha), while the globally available area per person is just 1.7 gha.
- If everyone in the world adopted a Hong Kong lifestyle, it would require 4.2 planets to produce all the required resources and absorb the produced carbon dioxide emissions
- Hong Kong's ecological footprint needs to decrease considerably to reach a sustainable and equitable level



https://www.wwf.org.hk/en/whatwedo/biodiversity_and_sustainability_in_hong_kong/ecological_footprint_2019/

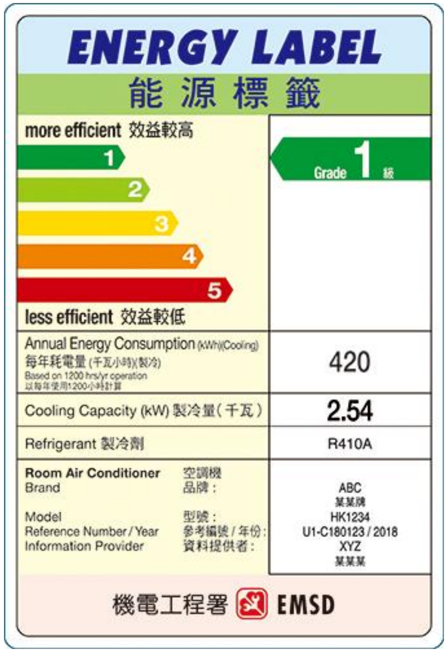
Ecological Footprint – Key Sectors

- The transition to an economy that is free of fossil fuels is essential to a substantial reduction of cities' ecological footprints.
- This requires priority actions in four key sectors:
  - Energy
  - Transport
  - Food
  - Housing

- Cities can develop resource-efficient infrastructure based on renewable energy sources.
- Cities can provide opportunities and incentives for their citizens to make climate-smart and sustainable choices that can improve their quality of life.

Ecological Footprint – Energy Sector

- About half of the ecological footprint consists of carbon dioxide emissions from the combustion of fossil fuels.
- Need to transition to an economy that is based upon 100 per cent renewable and sustainable energy.
- This involves a double challenge: high energy efficiency and a conversion to renewable energy sources.



Carbon Footprint

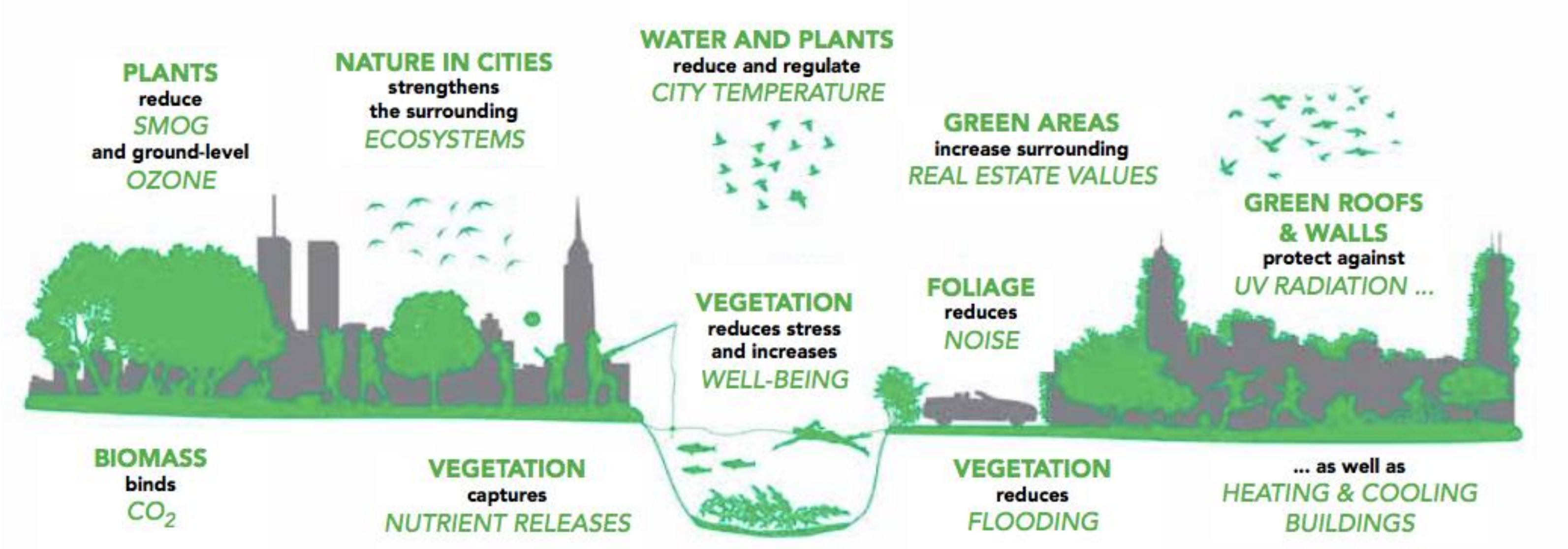
- The carbon footprint (CF) registers the carbon dioxide emissions caused by a population's total consumption.
- CF is the sum of all direct emissions, e.g. from heating and transport, plus all indirect emissions along the entire production chain for those goods and services that are consumed.
- A CF can be calculated for a nation, a region, a city, an organization, or individuals.
- CF is expressed in units of tons of carbon dioxide. Sometimes additional greenhouse gases are included, and then the unit is expressed as carbon dioxide equivalents (CO2e).
- Decision-makers must create conditions – for example by promoting stricter building standards, upgrades of existing buildings, mass transport systems free of fossil fuels, consumer education, as well as campaigns and support for more vegetable-based, locally produced, and seasonal food.

2. Ecosystem services and biodiversity

- Ecosystem services stands for all the products, processes, services and values that are provided by nature.
    - Products such as food, medicines, timber, biofuel
    - Processes such as photosynthesis, soil formation, water purification and pollination
    - Emotional values such as recreation, beauty, and spiritual experiences
- For sustainable cities, ecosystem services in and outside the city are key assets that provide a wide range of values: environmental, economic, social, and cultural.
- High quality urban greenery and urban water bodies produce multiple benefits in biodiversity, climate regulation, improved public health, and quality of life – thereby raising both the attractiveness and sustainability of the city.

Ecosystem services and biodiversity

- In growing cities there is a continuous conflict between conservation and development.
- Decision-makers must act effectively to preserve, restore and even create urban greenery and urban water bodies.
- This requires them to implement tough, innovative and proactive planning, with a holistic perspective and cooperation across sectors.



Ecosystem services and biodiversity

- Cities should invest in ecosystem services and in the landscape's ecological infrastructure:
  - Air quality
  - Aquatic ecosystems (e.g. seas, lakes, watercourses)
  - Farming and forestry
  - Pollination
  - Green corridors and migration routes
  - Microhabitats such as edge zones and wetlands
  - Protection of highly vulnerable species

3. Invest for Sustainability

- The transition to sustainable development in the world's cities demands huge investments.
- In the fast-growing cities of developing economies, it is vital that basic infrastructure is built in a sustainable way.
- In the industrialized world, existing infrastructure needs to be updated with climate-smart and resource-efficient systems.
- To break the heavy dependence on fossil fuels, innovations and new technologies on a broad front are needed.
- Innovation need not only involve technology. Financial, social and institutional innovations are equally important, such as new ways to think, organize and cooperate in order to meet human needs in a smart and resource-efficient way.
- Connect solutions with markets
  - Many technical innovations with the potential to radically reduce CO2 emissions are already on the market but are not applied at the scale necessary to reach climate goals.

4. Lifestyle and Well-being

- Sustainable urban development should take its starting point in promoting citizens' wellbeing.
- Even if 'the good life' cannot be easily measured or planned, city planners can provide citizens with the preconditions for living well and sustainably.
- A sustainable city should therefore provide the preconditions for its citizens to enjoy a climate-smart, resource-efficient and high-quality lifestyle.
- A truly sustainable city would thus typically involve a dense, integrated and green environment with attractive housing, working and living conditions for all sectors of society.
- The provision of public spaces and meeting places are immensely important and can help a city provide its inhabitants with a sense of identity and place.

5. Leadership and Cooperation

- Shifting to sustainable urban development requires new ways of thinking.
- Need to go from one-dimensional perspectives – based on sector, competition, or growth – to thinking in terms of holistic, sustainable systems.
- Transformational leadership
  – Sustainable cities require creative and visionary ideas about the future city.
- Broader perspectives
  – Cities should complement a local perspective with a global resource and sustainability perspective by using consumption-based indicators, for example, ecological footprint, carbon footprint, and water footprint, together with local indicators for the city's development.
- Complementary indicators
  – Challenge is to combine ecological, social, and economic aspects, to provide a nuanced picture of the city's development.

Urban sustainability strategies should be:

- Multi-issue (solve more than one problem)
- Multidimensional (improvement on more than one indicator)
- Integrative (consider multiple layers of complexity)
- Collaborative (brings people with different expertise together)

Introduction to Resilience

Overview

- *What is resilience?*
  - Definitions of resilience: Engineering resilience, ecological resilience and social-ecological resilience
- *Why do we need resilience thinking?*
  - *Fail-safe* vs. *Safe-to-Fail*
- *How does resilience relate to sustainability?*
  - Relationship between resilience and sustainability
- *What are the approaches to measure and develop resilience?*
  - Systems thinking for resilience engineering: Methods
- *Resilience at different scales:*
  - 2001 North-East blackout (infrastructure scale)
  - Hurricane Katrina (urban scale)
  - Colony Collapse disorder (ecosystem scale)
  - 2014 Ebola epidemic (Global scale)

Large Scale Disasters

2003 North-east Blackout

55 million people affected in north-east US and Canada

2011 Fukushima Daiichi nuclear disaster

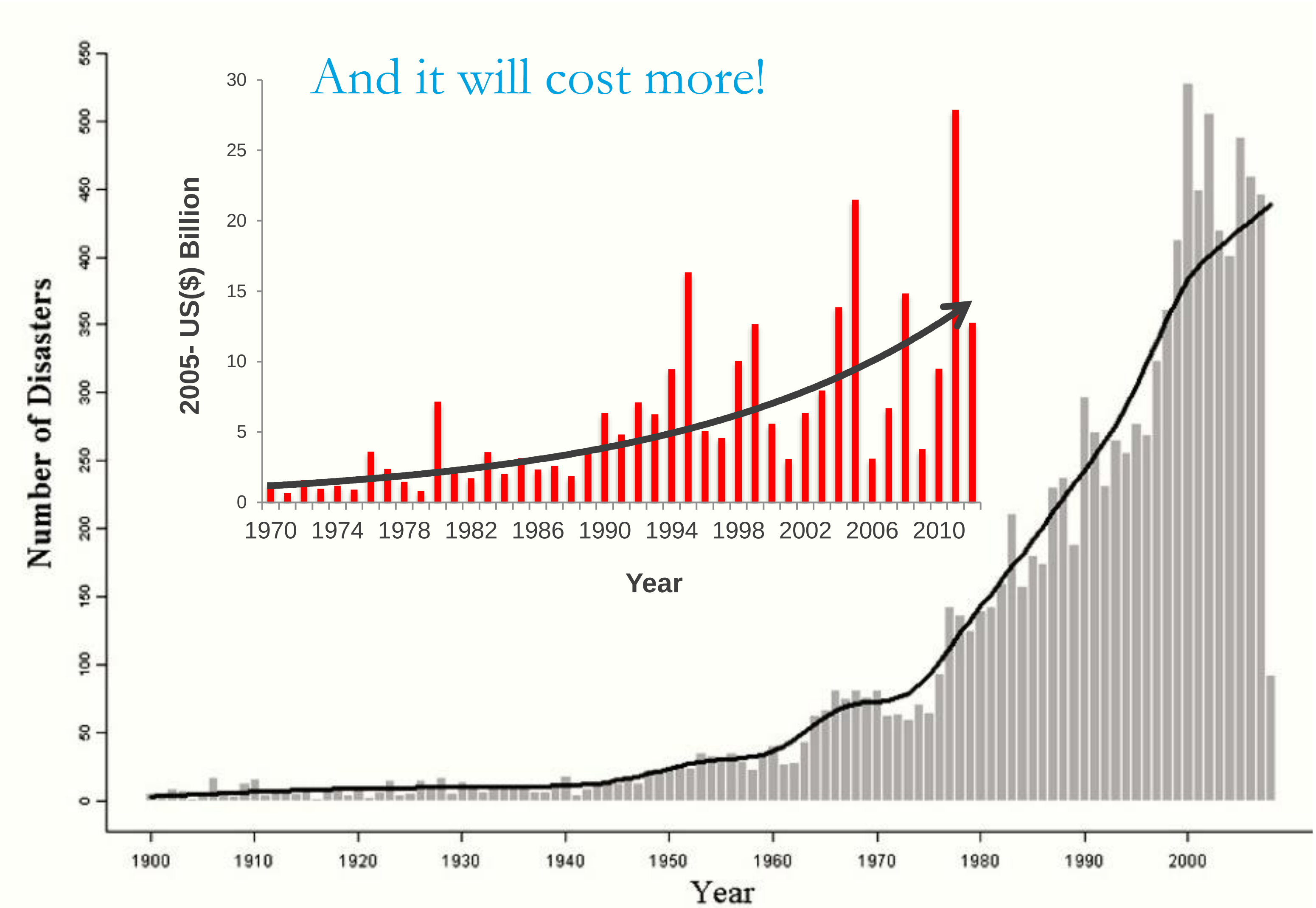
300,000 evacuated, 1600 deaths

2012 Hurricane Sandy

8.2 million people without power

Image Source: National Geographic

It's only getting worse



Source: UN ESCAP

Source: Emergency events database, 2008

Year in Disasters 2019

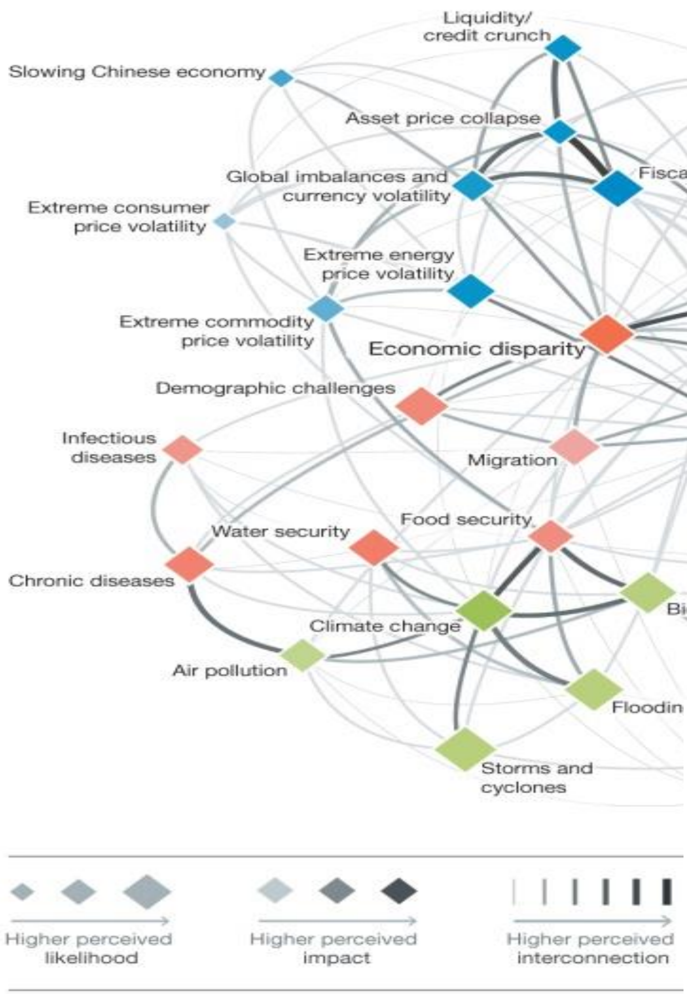
https://youtu.be/BZXNcli9suo

Large-Scale Disasters

- Have we learned from these past experiences?
  - Exemplify *lack of preparedness and resilience*
- Need to rethink our strategy in the face of extreme events
  - Move from *"disaster management"* to *"disaster adaptation"*

Image Source: National Geographic

Growing complexity



PERSPECTIVE

doi:10.1038/nature12047

Globally networked risks and how to respond

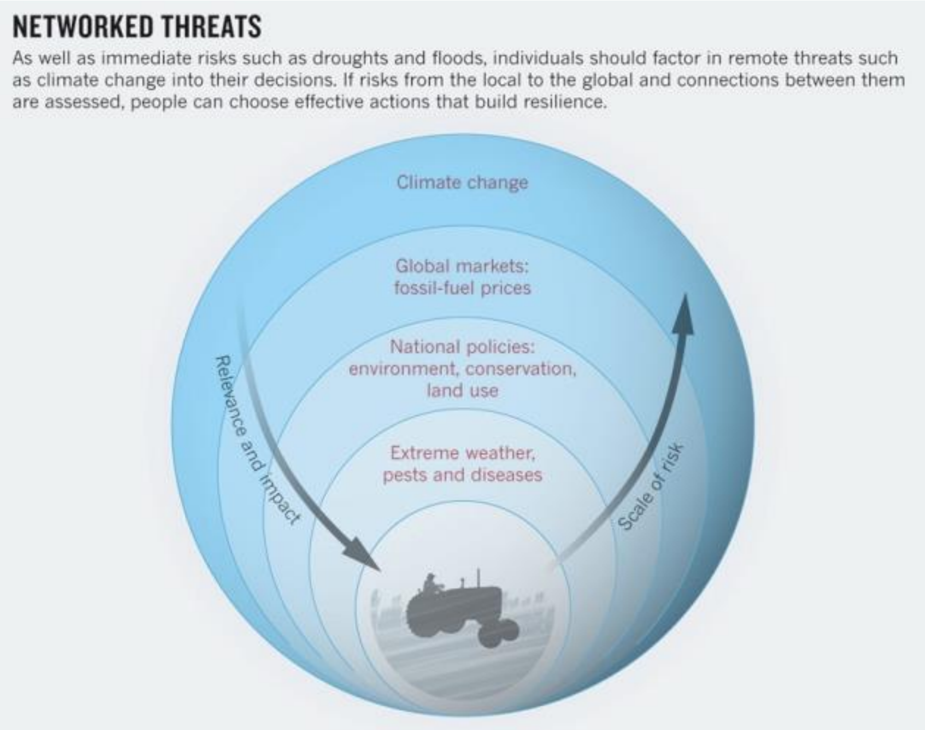
Dirk Helbing[1,2]

Dirk Helbing. Globally networked risks and how to respond. Nature 497(7447):51–59, May 2013.

Understand Interdependencies

Put people at the centre of global risk management

An individual focus is needed to assess interconnected threats and build resilience worldwide, urge **Jan Willem Erisman** and colleagues.



Erisman et al., Global change: Put people at the centre of global risk management. Nature (2015) pp 151-153

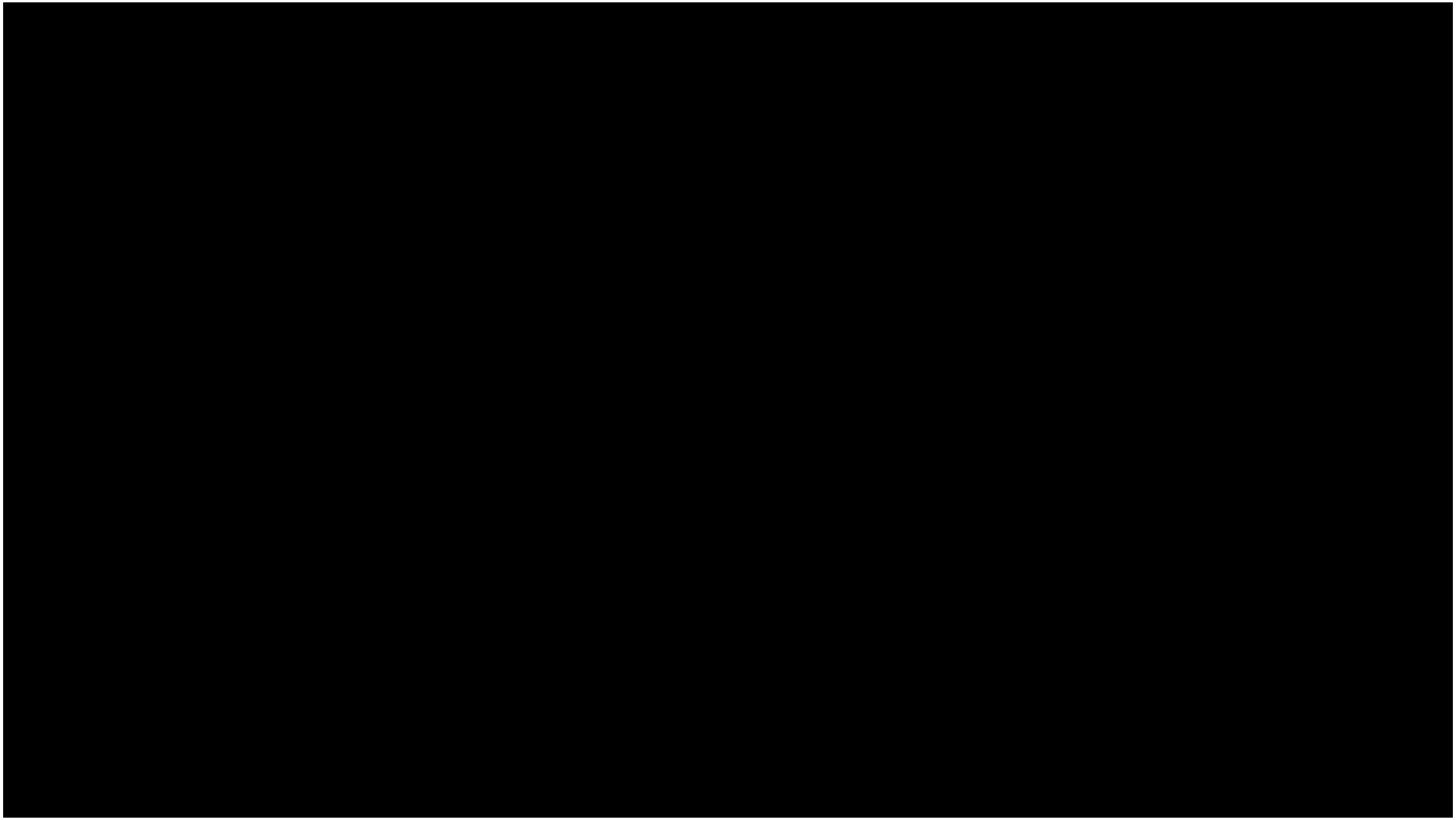
Implications of Interdependencies

- Interdependencies in our highly connected world establish *high vulnerabilities*

- "System of systems" make the system more *vulnerable to abrupt failures*

- Patterns of interdependencies *cause cascading impacts by amplifying the effects of disruptions*

THE WOLVES OF YELLOWSTONE



https://youtu.be/ysa5OBhXz-Q

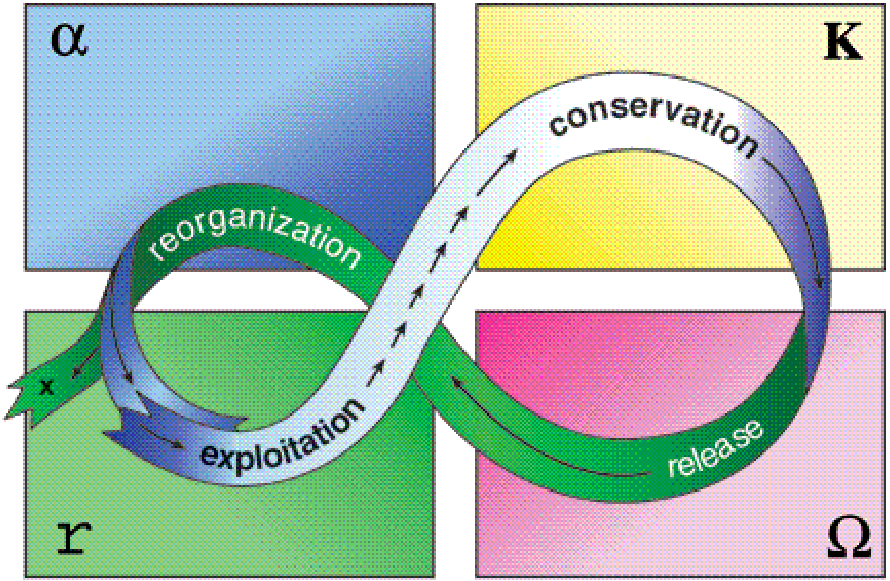
Resilience- its history

In 1973, Holling introduces the concept of resilience in the field of Ecology

Resilience is the "magnitude of disturbance that can be absorbed before the system changes its structure"…

- The adaptive cycle consists of 4 phases:

1. Growth or exploitation (r)
2. Conservation (K)
3. Collapse or release (Ω)
4. Reorganizations (α)

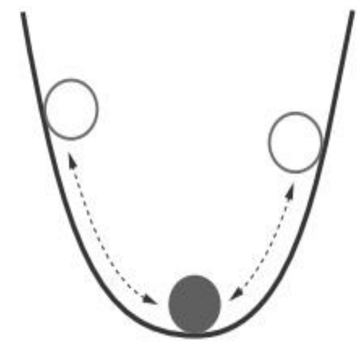


Resilience definitions vary

Ex. Failure in an assembly line

Engineering resilience:

concentrates on stability near an equilibrium steady state, where resistance to disturbance and speed of return to the equilibrium are used to measure the property

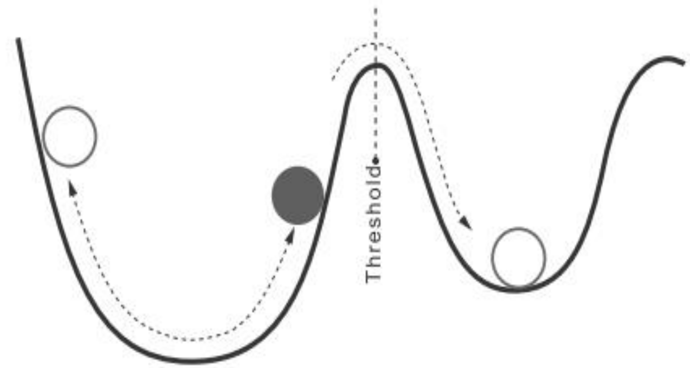


Engineering resilience concept

Ecological resilience:

the magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that control behavior

Disturbance can trigger a regime change—to another stability domain



Ecological resilience concept

Social-ecological resilience:

capability of the system to absorb disruptions while maintaining the structure, function and control components

Ex. Disappearance of wolves from the Yellowstone National Park

More recent developments of definitions

Resilience as defined by the U.S. government:

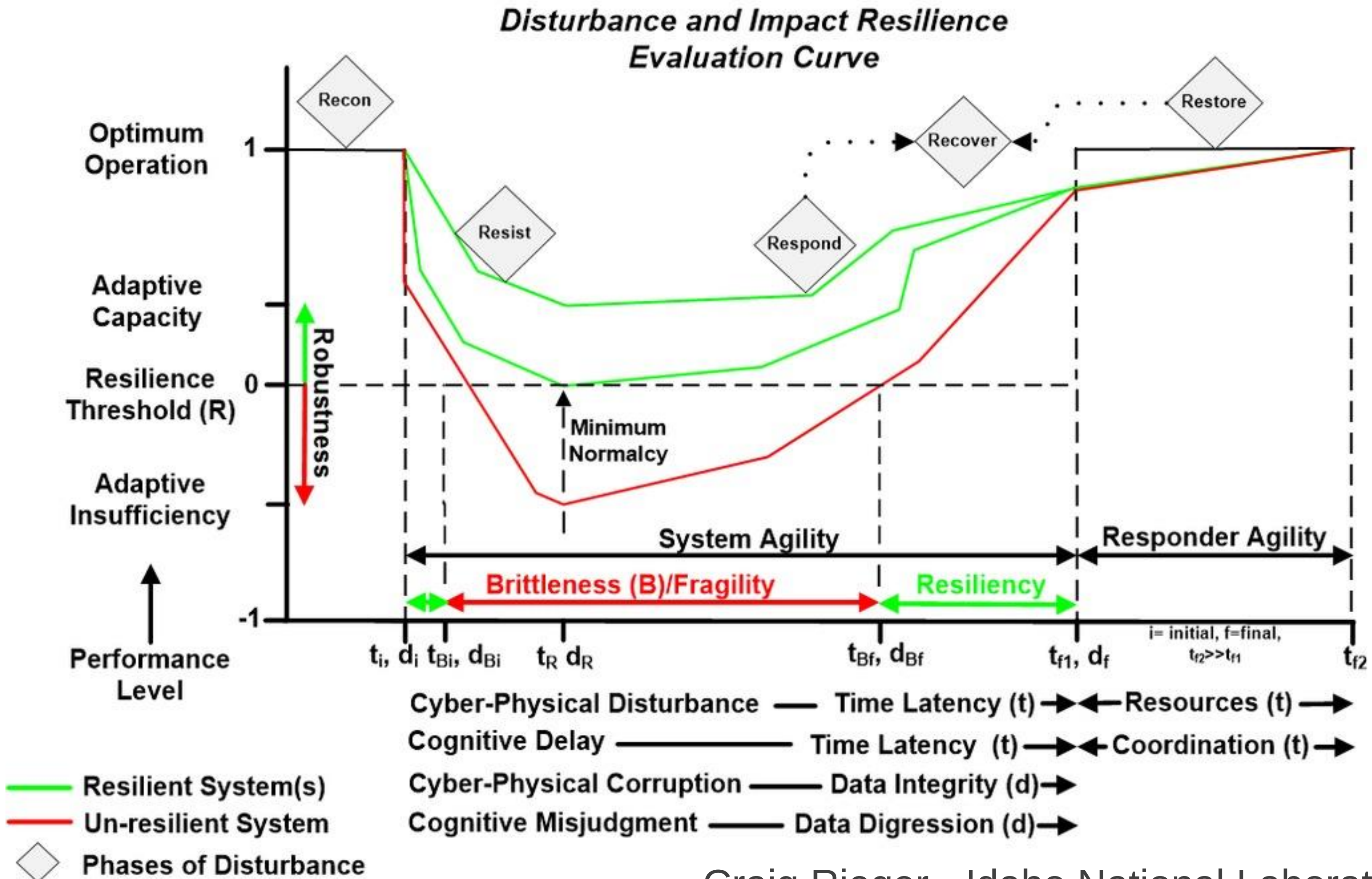
“The term "resilience" means the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents.”

In the context of Critical Infrastructure sectors

Critical Infrastructure Sectors

There are 16 critical infrastructure sectors whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof.

Disturbance and Impact Resilience Curve

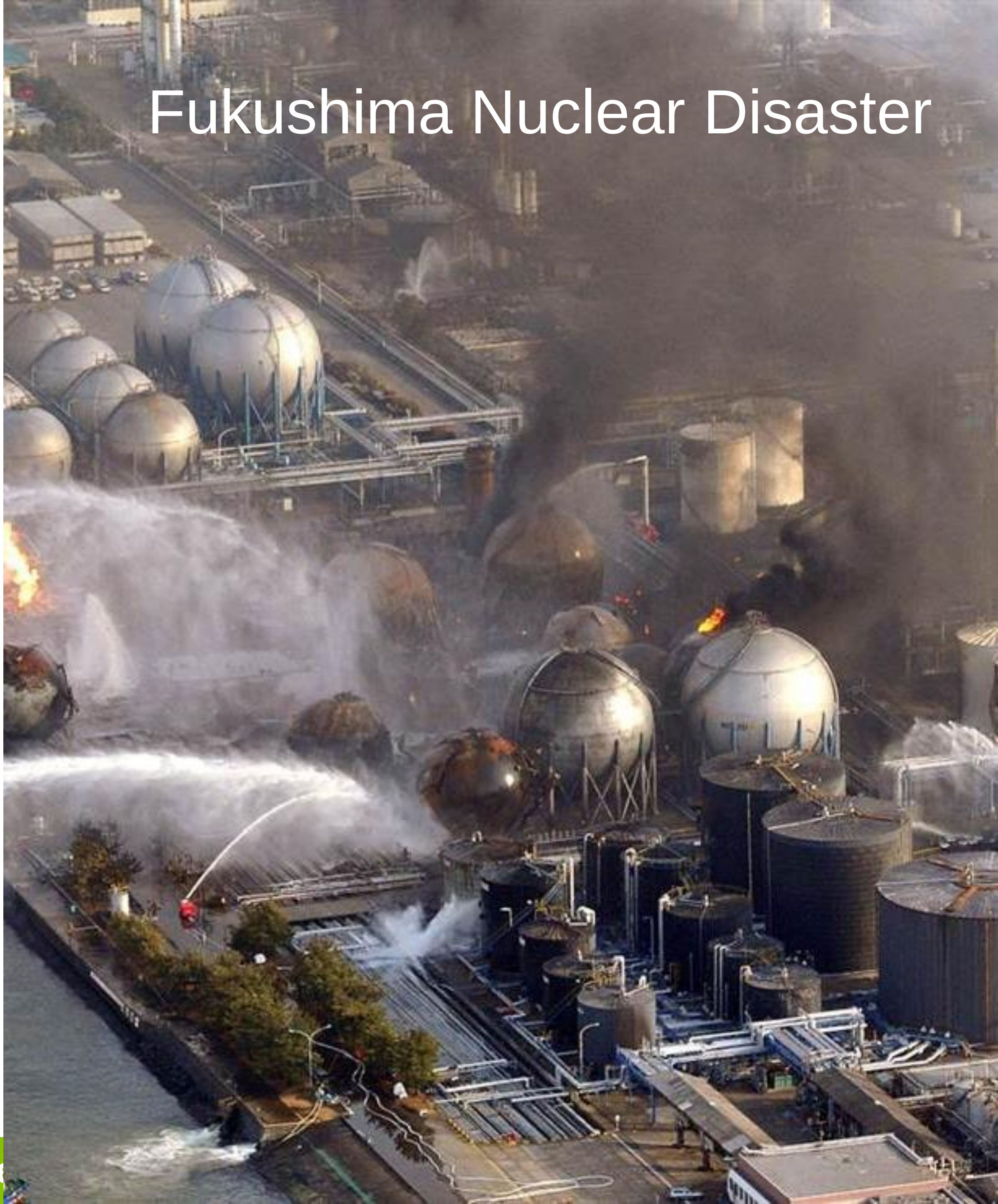


Craig Rieger - Idaho National Laboratory

Why do we need Resilience thinking?

Fail safe

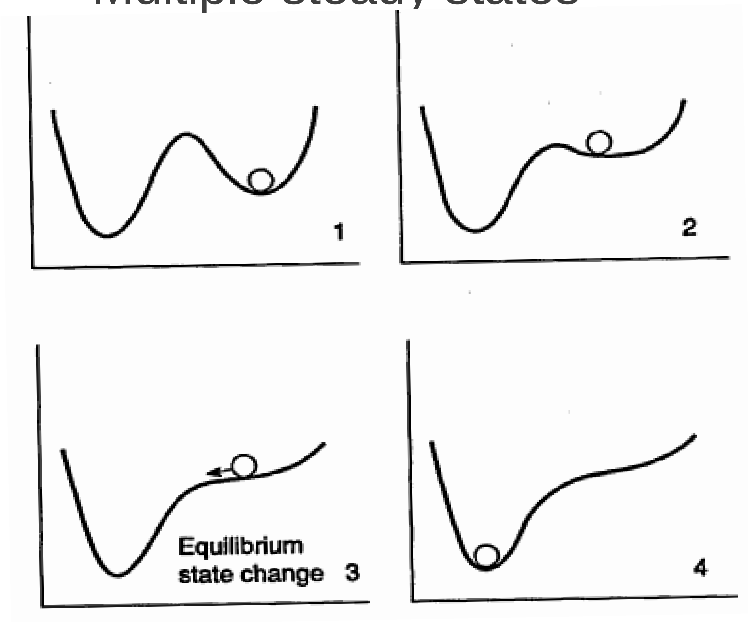
Design for perfection
- Assumes stable environment
- Assumes components can be made 100% reliable
- Neglects ”black swan” events



Safe-to-fail

Design to survive, adapt and evolve

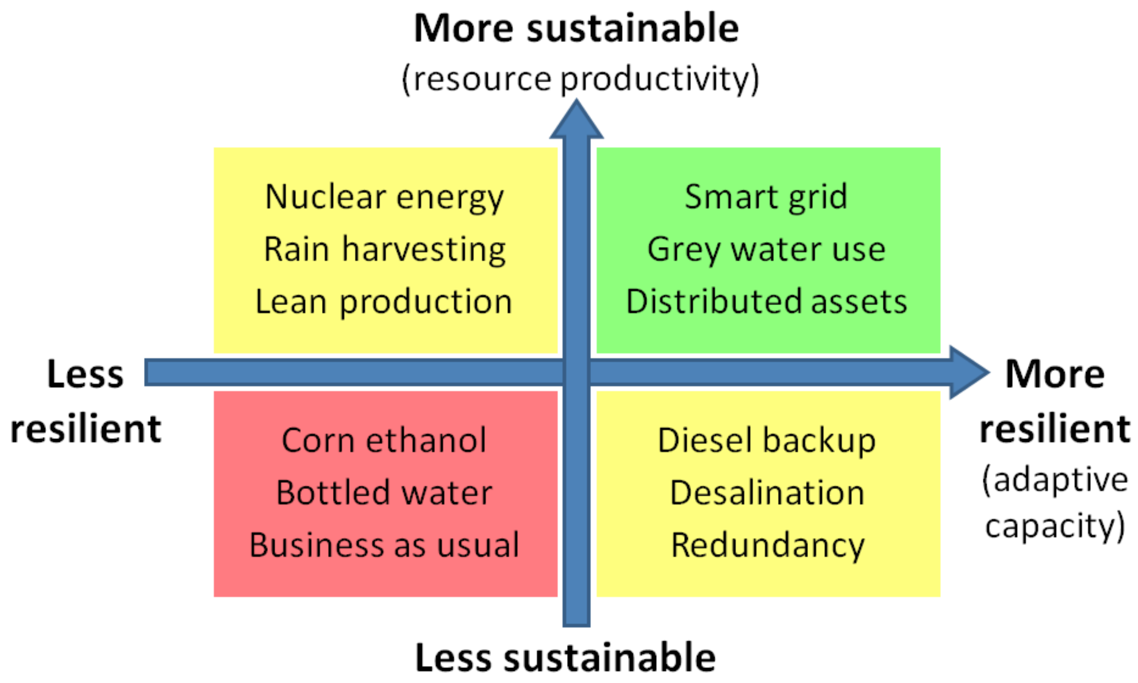
- Assumes turbulent environments
- Multiple steady states



The system modifies its states as it changes from 1-4. From 1-4, a smaller perturbation is needed to change the state[1]

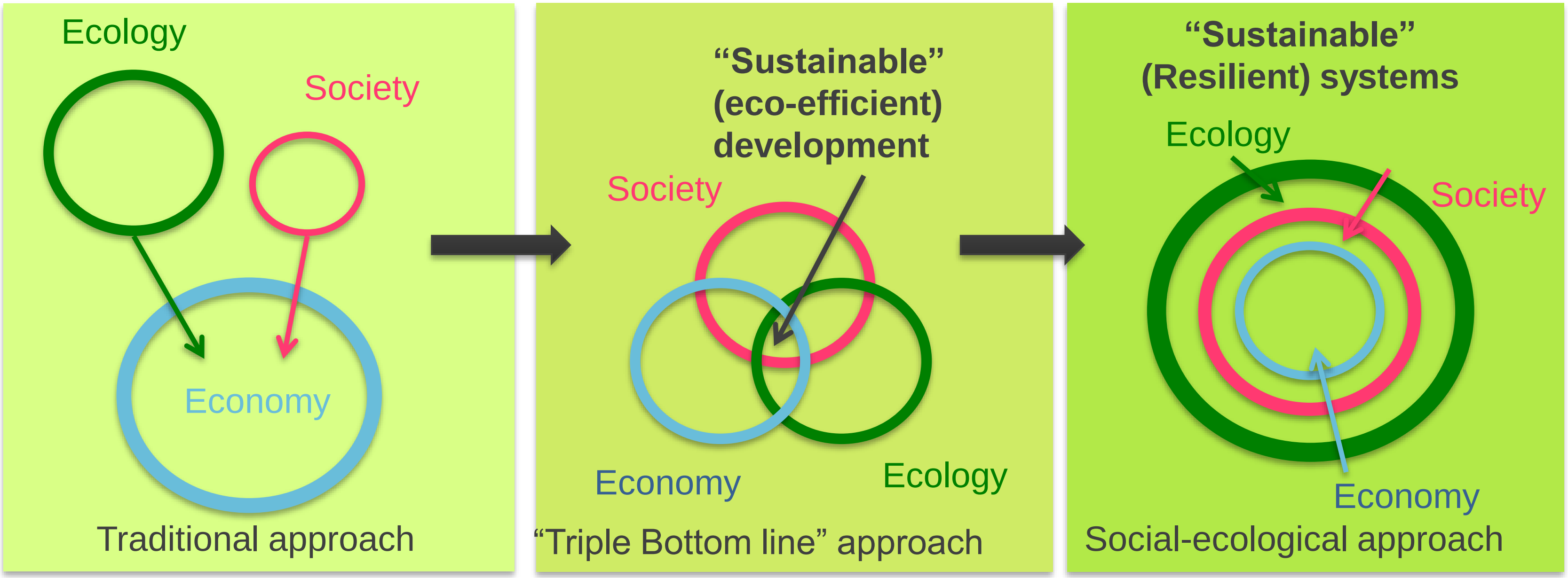
Combination of different

1: "Engineering Resilience versus Ecological Resilience." Engineering Within Ecological Constraints. Washington, DC: The National Academies Press, 1996.



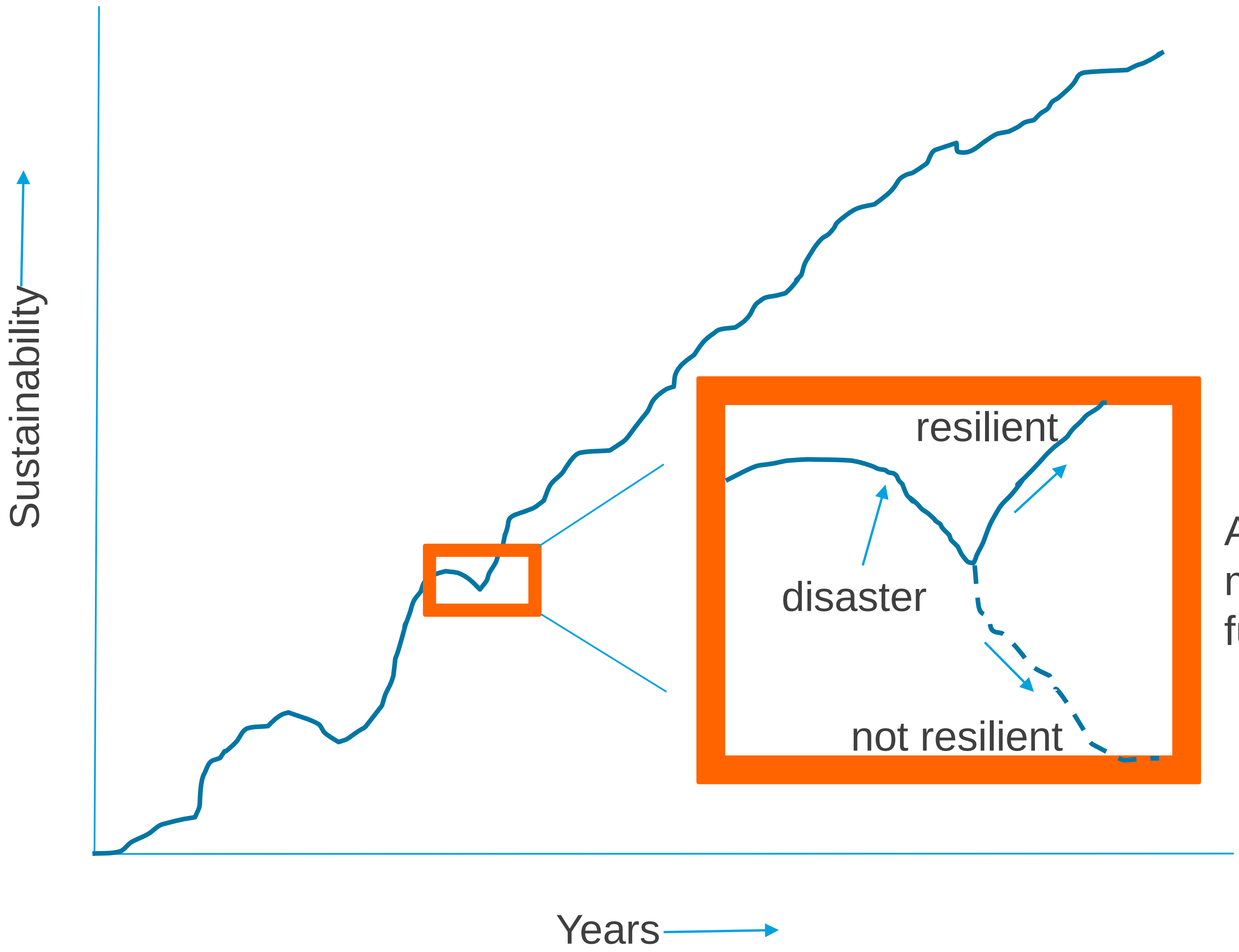
How does resilience relate to sustainability?

System unable to maintain its structural cohesion can hardly be sustainable



Evolution of the perspective on Sustainability

Hypothetical trajectory of sustainability



Ability to maintain the functionality

Resilience of Engineered Systems

Bulk of literature has taken a *qualitative approach* to understand resilience

Challenge to *measure resilience quantitatively*

Consider *engineered systems as complex systems* to quantitatively understand resilience

Underlying structure of the complex system is *indicative of emergent properties* like resilience

Modeling approaches to study emergent properties

Top-down modeling: Modeler starts with a general model and organizes data into it to understand how the system behaves.

Ex. System dynamics models of water systems

Bottom-up modelling: Modeler starts by modeling decisions at the individuals scale, and their interactions allow understanding the properties of the system.

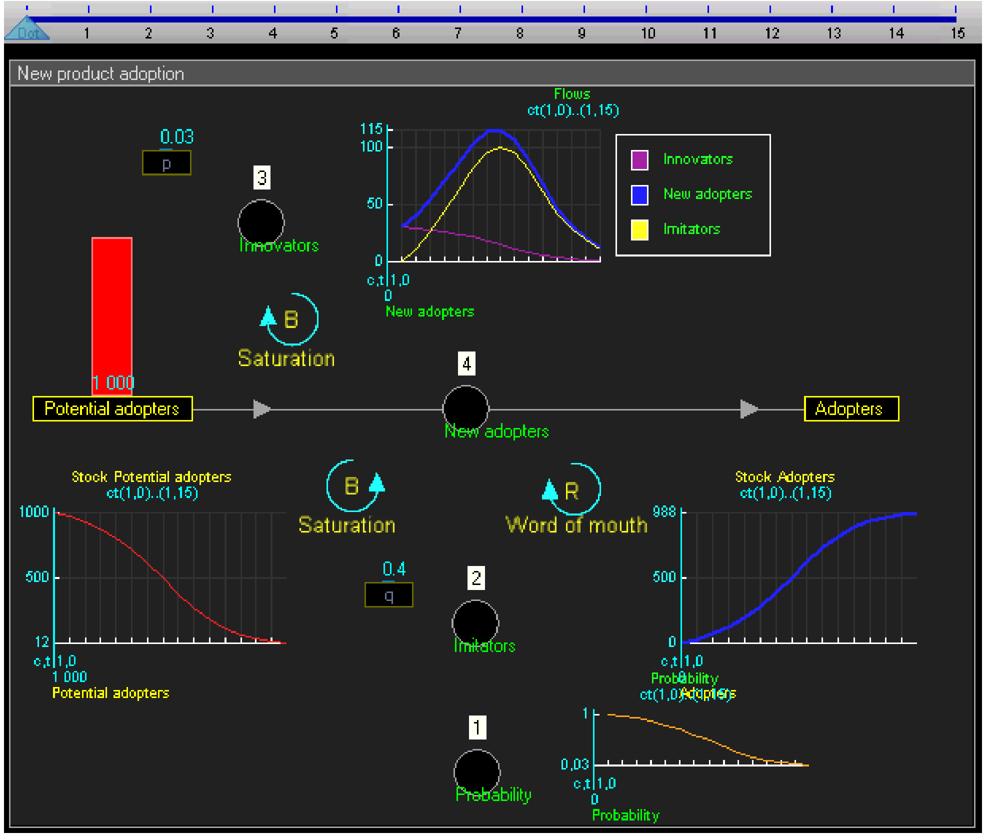
Ex. Agent-based models of traffic flow in cities

System Dynamics

- System dynamics (SD) is a method for understanding, designing, and managing change
- It models the relationships between elements in a system and how these relationships influence the behavior of the system over time.
- We often find that many of the causes of resilience problems have their roots in well-intentioned policies that have unintended consequences, ignore the implications of feedback, nonlinear interactions, delays, and accumulations over time.
- Using system dynamics, we can help people frame problems, visualize the system, identify potential leverage points, develop skills for communicating system insights, analyze policies, and ultimately design more effective and sustainable solutions.

Example of System Dynamics

The dynamic simulation results show that the behaviour of the system would be to have growth in *adopters* that follows a classic s-curve shape.



The increase in *adopters* is very slow initially, then exponential growth for a period, followed ultimately by saturation.

Agent-based Model

- Agent Based Models are computer models that attempt to capture the behaviour of individuals within an environment.

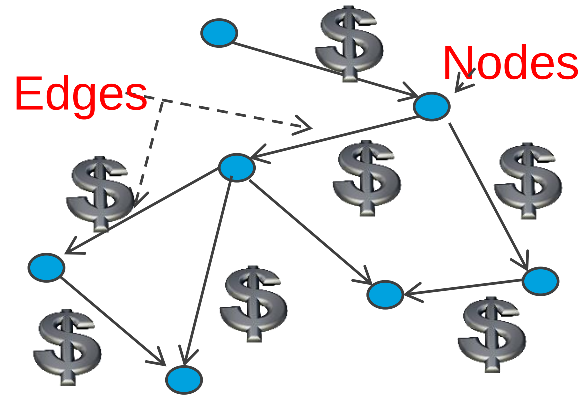
- Agent Based Models aim to provide a *in silico* lab, where we can:
  1) Capture our understanding of systems.
  2) Test that understanding of the systems for coherence and comprehensiveness.
  3) See how theory at the individual level creates aggregate patterns.
  4) Validate that theory against real data at the aggregate and individual scale.
  5) Make predictions about the system.
  6) Test "what if?" scenarios to inform planning

Agent based modeling

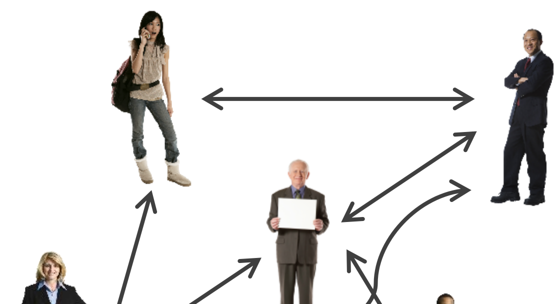
https://youtu.be/TfzZxJ46-z8

Complex Systems as Networks

- Network- a collection of objects
  - *Directed, undirected and weighted*
- Network analysis widely adopted across disciplines
  - **Engineering:** Transportation networks, power grids
  - **Life sciences:** Metabolic network, Brain mapping, Systems biology
  - **Social Sciences:** Social network analysis- friendship network
  - *Lacking in Sustainability*



Example of a weighted-directed network



Network	Node	Edge
Metro network	*Station*	Metro rail line
Metabolic network	Metabolite	Metabolic reaction
Friendship network	Person	Friendship
Economic network	Industrial sector	Monetary transaction

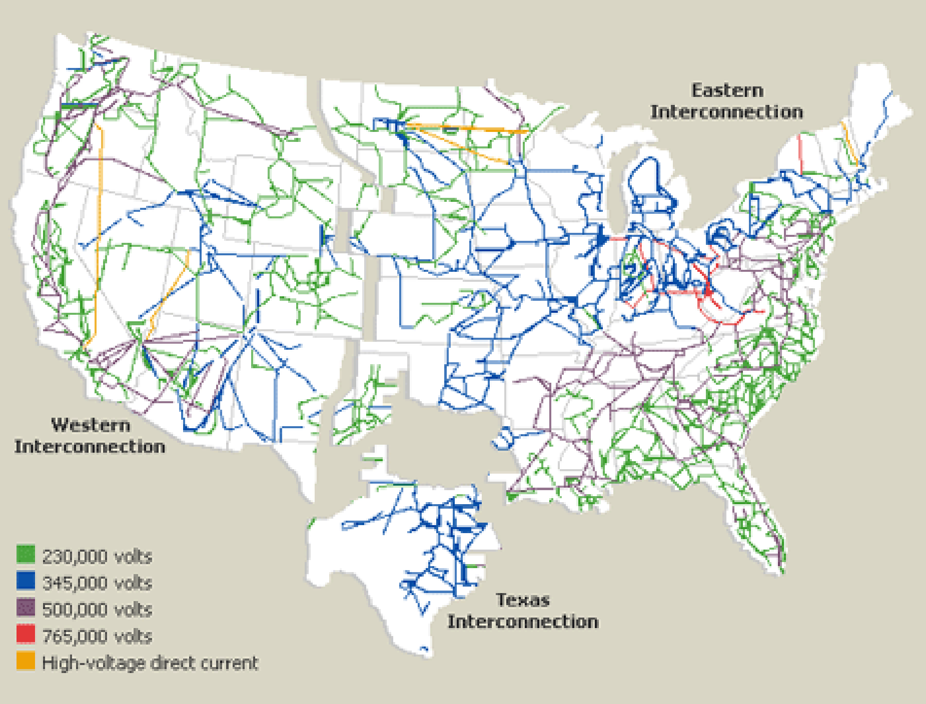
Urban

Ecosystems

Resilience at different scales

Global

Infrastructure

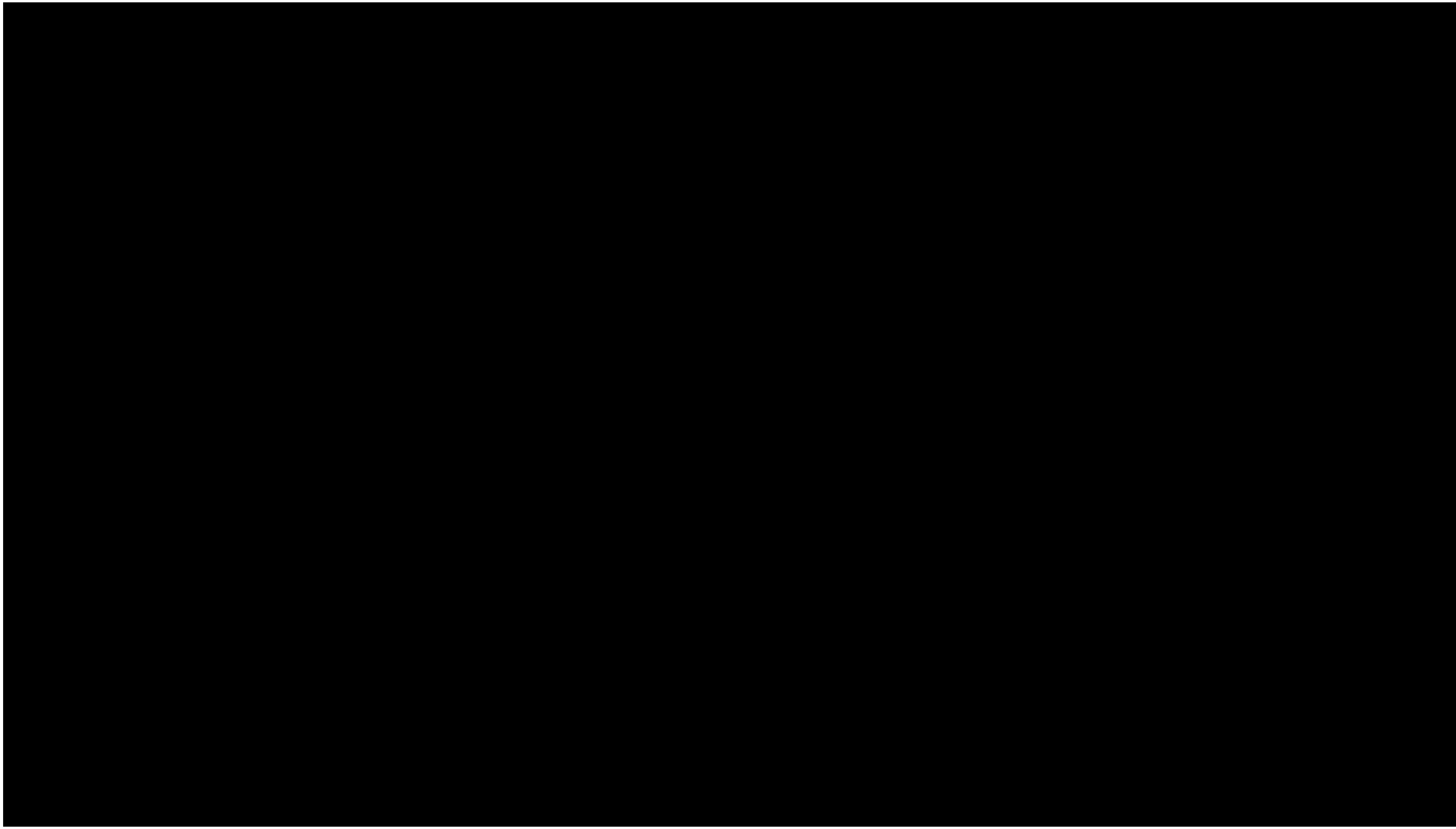


Infrastructure scale

Highly dependent on transportation, electric, water etc. critical for modern society

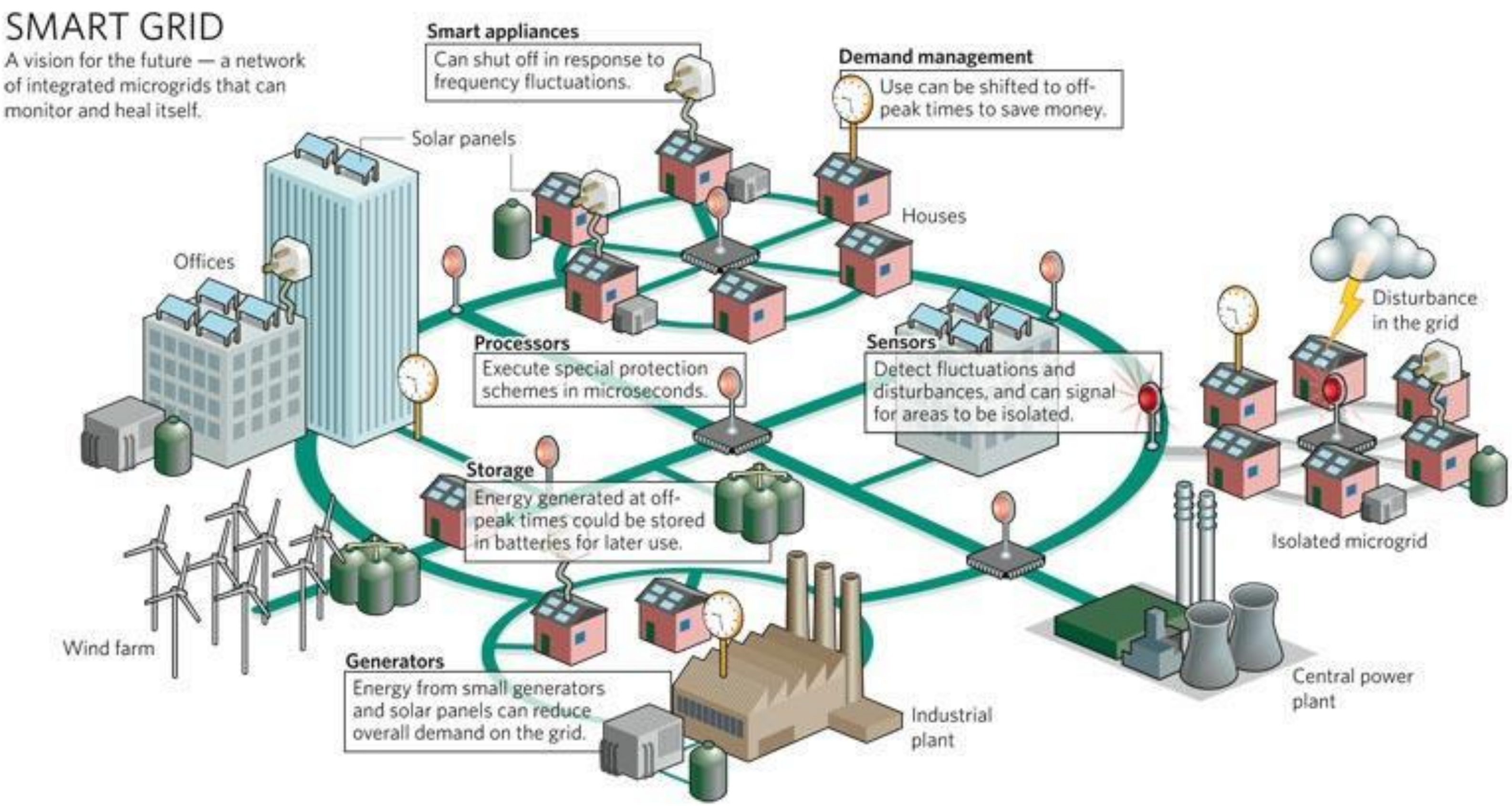
Large-scale Disaster:
2001 North-East Blackout

Blackout



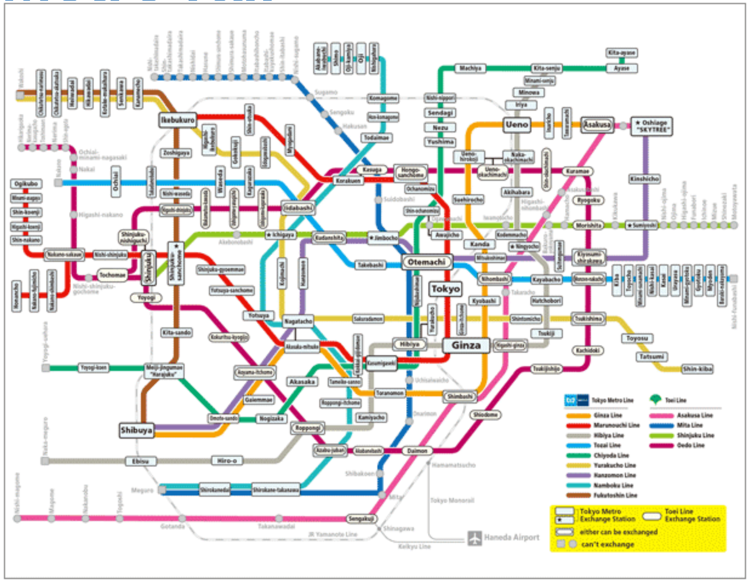
https://youtu.be/nd3teNgUq8E

More Resilient electric grid:

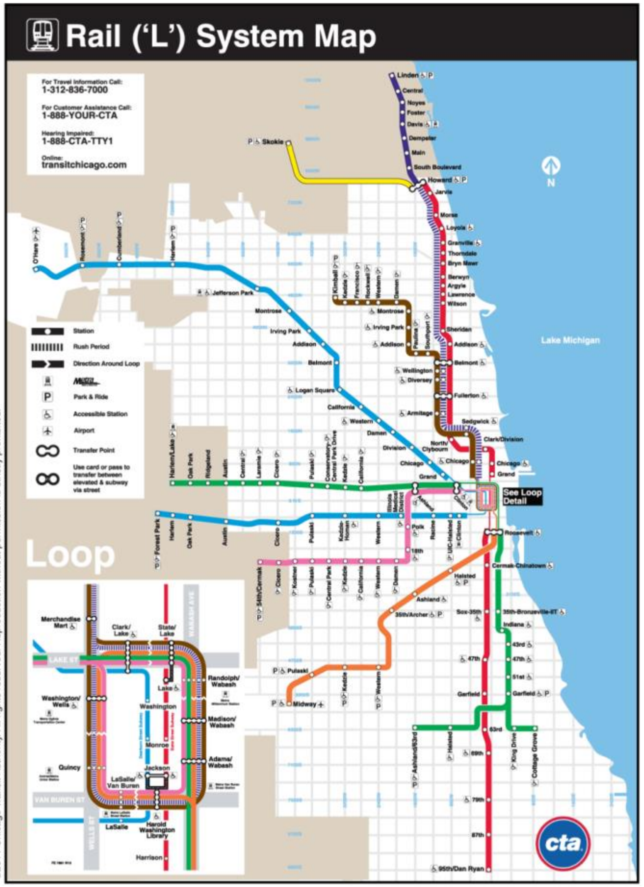


Transportation systems- Metro rail

Tokyo Metrorail



Chicago Metrorail



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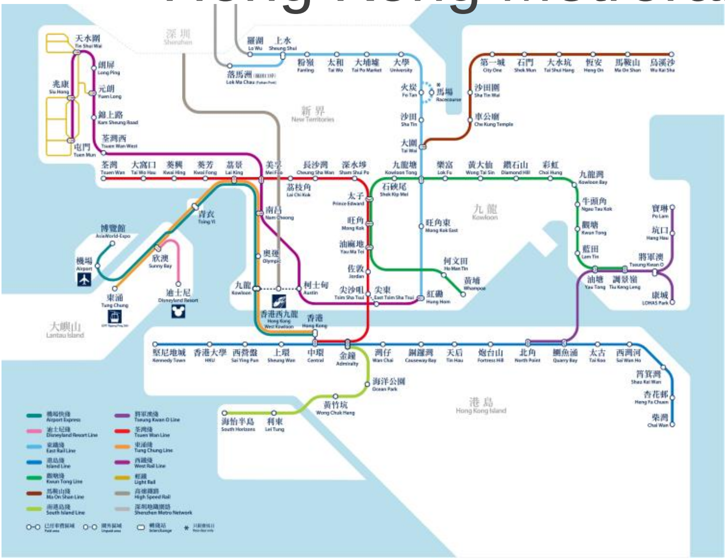
Hong Kong Metrorail



Urban scale

Combination of systems support urban lifestyle

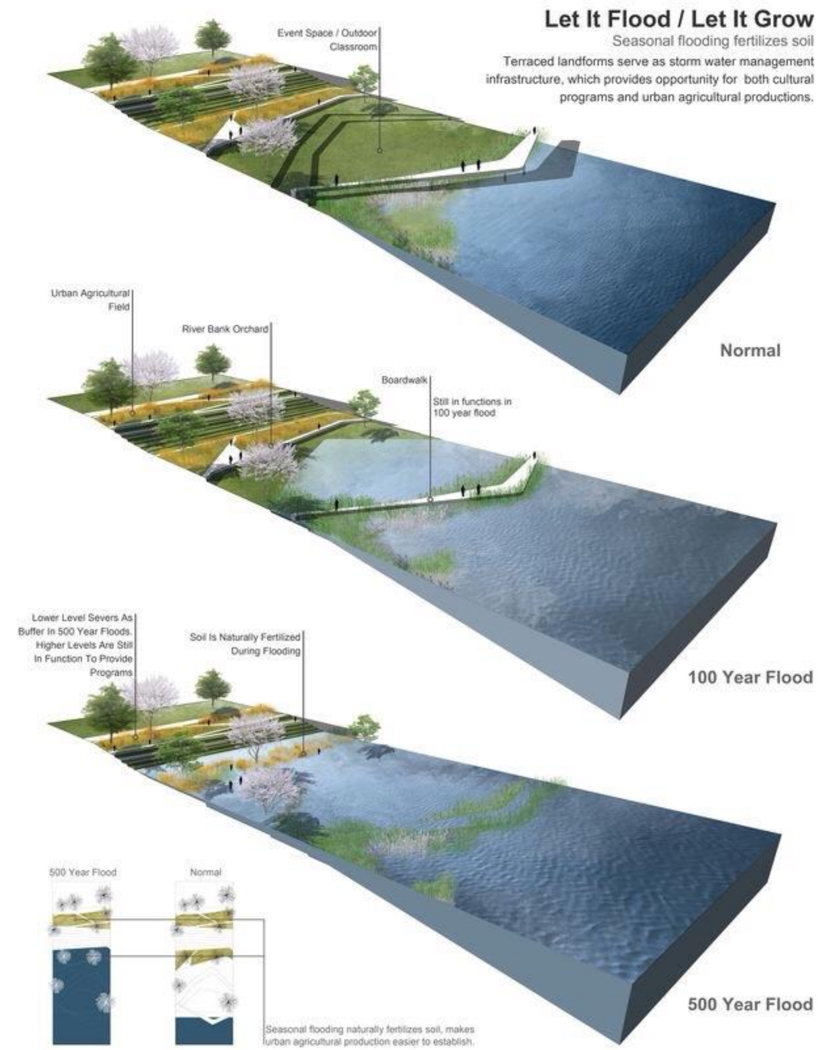
"System of systems" approach

Large-scale Disaster: 2006 Hurricane Katrina

Multifunctional Infrastructure

Resilient Stormwater management

Green infrastructure provides many co-benefits, with one of the benefits being resilience



Ecosystem scale

Human systems embedded within Natural systems

Essential to value ecosystem goods and services

- Provisioning services
- Regulating services
- Cultural services
- Supporting services

Large-scale disaster:

Degradation of pollination services, including Colony collapse disorder (CCD)

Resilient ecosystem services

The Supertree Grove, Singapore

Alternate pollinator species:

Lurie Garden, Chicago

Global scale

Growing complexity in the world means growing vulnerability to epidemics

What is *Fail-safe* vs *Safe-to-fail* solution?

Large-scale disaster:
2014 Ebola outbreak

Spread not restricted to diseases alone.

- Economic collapse (*2008 Global economic recession*)
- Political turmoil (2010 *Arab spring*)

Building Resilient Cities

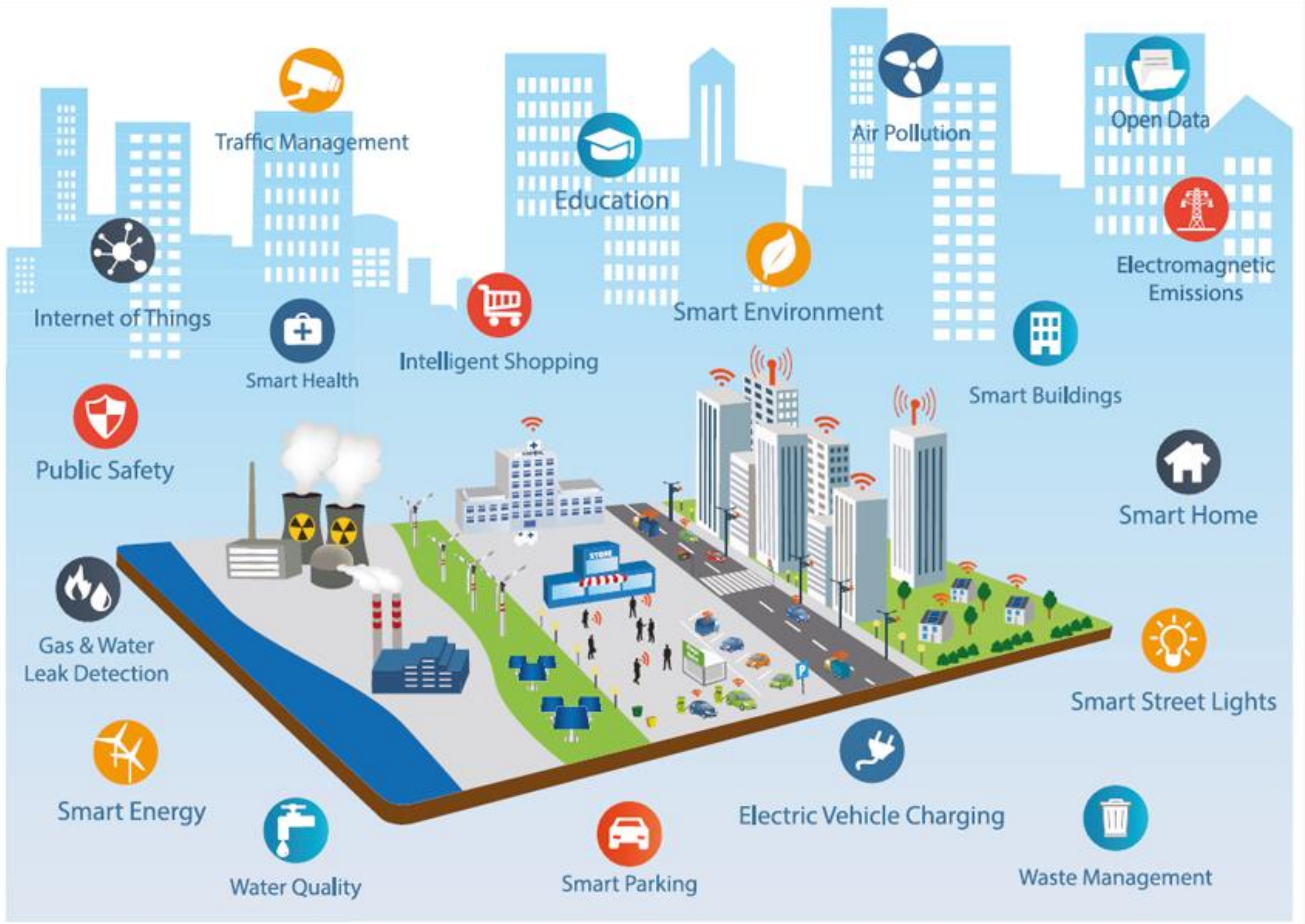
https://youtu.be/BrjIL---08Y

Hong Kong’s Urban Sustainability Policy:
Hong Kong 2030+: A Smart, Green and Resilient City Strategy

- Smart, Green and Resilient (SGR) city strategy focuses on **promoting sustainable land use planning and urban design**, **fostering smart mobility and devising an integrated smart**, **green and resilient infrastructure system**.

Hong Kong 2030+: A Smart, Green and Resilient City Strategy https://www.hk2030plus.hk/document/Hong%20Kong%202030+%20A%20SGR%20City%20Strategy_Eng.pdf

Smart Cities are NOT the same as Sustainable Cities



Source : Adobe Stock

Promoting Sustainable Land Use Planning and Urban Design

Key feature:

Minimise Demand for and Use of Land Resources	➢ Optimise opportunities for low-carbon living and business at an early planning stage for NDAs and comprehensive redevelopment areas ➢ Promote comprehensive mix-use developments for better synergy ➢ Optimise the use of scarce land resources (e.g. cavern/ underground space developments, brownfield sites and land use reviews) ➢ Bring jobs closer to homes to reduce/ shorten trips ➢ Concentrate population and economic activities within walkable distance of public transport stations and nodes to reduce the need for commuting and private car trips ➢ Integrate recreational and community farming into the built environment
Smart and Green Planning and Design at Different Scales	➢ Smart homes and smart living ➢ Incorporate smart measures for ageing in place more safely with greater independence ➢ Promote smart and green measures in new buildings and retrofitting existing buildings for various uses ➢ Promote the development of smart and green communities/ districts for incorporating various SGR measures

Hong Kong 2030+: A Smart, Green and Resilient City Strategy https://www.hk2030plus.hk/document/Hong%20Kong%202030+%20A%20SGR%20City%20Strategy_Eng.pdf

Promoting Sustainable Land Use Planning and Urban Design

Key feature:

Promote Low Carbon Economy	➢ Further utilise innovation and technology and ICT for smart production and development of smart products and services, and improving work process ➢ Create a supportive tech-ecosystem with sufficient land and space at strategic locations to promote the growth of innovation and technology ➢ Make use of prototypes to demonstrate the positive impacts of the new technologies to facilitate further refinement
Promote Climate Resilient Planning	➢ Create robust, green and resilient communal facilities (e.g. community green stations and recreational and community farming in public parks/ amenity areas) ➢ Promote urban greenery (including the provisioning of urban green space with the use of native trees and other plants), blue spaces and nature conservation to enhance biodiversity ➢ Develop urban design and greening measures to improve air ventilation conditions and reduce heat island effect at the early stage of the strategic planning process ➢ Integrate environmental and urban climatic consideration in planning and building design ➢ Explore the multiple uses of public space for resilience purposes (e.g. emergency assembly points, city cleansing, stormwater retention, etc) ➢ Integrate green buildings, green neighbourhood and green infrastructure initiatives in planning

Hong Kong 2030+: A Smart, Green and Resilient City Strategy https://www.hk2030plus.hk/document/Hong%20Kong%202030+%20A%20SGR%20City%20Strategy_Eng.pdf

Fostering Smart Mobility

Key feature:

Transport Infrastructure	➢ Promote a rail-based and multi-modal public transportation network with emphasis on green mobility ➢ Expand rail options and services to formulate a resilient transport network system that is capable of accommodating disruption and changing circumstances ➢ Enhance walkability, age-friendly/ inclusive pedestrian space, easily accessible daily necessities and direct links to transport nodes ➢ Foster a cycle-friendly environment through comprehensive cycling network with supporting facilities such as underground cycle parking areas and cycle sharing facilities ➢ Foster a seamless integration of walking, cycling and public transport system
Transport Management and Operation	➢ Promote an integrated intelligent transport system in a single platform for managing real time traffic flow, pedestrian flow and cargo flow ➢ Encourage a traffic adaptive control system ➢ Disseminate real time traffic information through the use of ICT and sensors ➢ Promote walking, cycling and feeder services to facilitate first and last mile travel ➢ Promote inclusive mobility for the aged and the disadvantaged

Hong Kong 2030+: A Smart, Green and Resilient City Strategy https://www.hk2030plus.hk/document/Hong%20Kong%202030+%20A%20SGR%20City%20Strategy_Eng.pdf

Devising an Integrated Smart, Green and Resilient Infrastructure system

Key feature:

Integrated Smart and Green Infrastructure	➢ Promote energy saving, land saving, and synergy between different infrastructures (e.g. effluent reuse, waste-to-energy approach) ➢ Promote sustainable urban drainage ➢ Promote smart waste management ➢ Enhance total water management (i.e. contain growth of water demand through water conservation and smart network management and strengthen water supply by developing new water sources such as desalinated water, treated sewage effluent or recycled water from grey water and rainwater harvesting) ➢ Foster the development of ICT Platform for a smart city
Resilient Infrastructure Consideration	➢ Sustainable drainage system and flood protection system ➢ Retrofit city infrastructure (e.g. drainage and stormwater retention facilities, blue-green infrastructures, transport system, etc) to address climate change ➢ Promote climatic defensive and hazard proof infrastructure with due consideration to their locations, potential for co-location, design and operation requirements ➢ Ensure appropriate siting of critical facilities and infrastructure (e.g. hospitals, major transport routes and utility pipelines) to enhance resilience towards extreme weather conditions and other hazards

Hong Kong 2030+: A Smart, Green and Resilient City Strategy https://www.hk2030plus.hk/document/Hong%20Kong%202030+%20A%20SGR%20City%20Strategy_Eng.pdf

Project Deliverable 3- Due at 9:00 am Mon, Mar 21

1. There is a close relationship between resilience and sustainability. However, there is some uncertainty surrounding the nature of this relationship. Some researchers consider resilience a prerequisite for sustainability, while others have defined resilience equivalent to sustainability, and then there are those who find resilience inadequate for attaining sustainability.

- How do you explain the relationship between resilience and sustainability?
- **1) Contrast these concepts in the context of the four types of car technologies: a) Biofuel-based cars, b) Electric Cars, c) Hybrid Cars and d) Hydrogen Car** (12 pts)
- **2) Examine whether resilience and sustainability are synonymous, complementary, or in conflict** (3 pts)
- NOTE: You may consider this issue **in general** or **focus on one of the 16 critical infrastructure sectors** identified by the Department of Homeland Security (https://www.dhs.gov/cisa/critical-infrastructure-sectors) at the *urban* scale.
- You are expected to demonstrate clear understanding of key concepts as well as an ability to deal with complexity of issues, rather than provide simplistic answers.

Project Deliverable 3- Due at 9:00 am Mon, Mar 21

2. A motorcyclist is warming up his racing motorbike at a racetrack approximately 200 m from a sound level meter. The meter is reading 56 dBA. What meter reading would you expect if 15 other motorcyclists with similar sound emissions were participating in the race as well? You may assume that the sources may be treated as ideal point sources located at the same point. (5 pts)

3. Using the Fletcher-Munson curves of equal loudness, determine the loudness level in phons of each of the following tones. Remember that the horizontal axis is marked as a logarithmic scale.

3.a What must be the sound intensity of a 100 Hertz sine wave, if it is to sound as loud as a 1000 Hertz sine wave of 60 dB intensity?
(3 pts)

3.b How loud must a 4kHz sound be, to sound as loud as an 80 dB sine wave at 400 Hertz?
(2 pts)