

## Introduction

We are developing and demonstrating the world's first open-source, integrated human-ecology-economics systems platform that enables resilient disaster risk sensitive planning, policy-making, investment and procurement for city-regions globally.

**resilience.io** is designed as a computer-based platform that provides an integrated systems view of a city-region. It will be an analysis and decision-support tool for collaboration and resilience decision-making.

The **resilience.io** platform combines computer representations of resource flows, human and business activities and infrastructure systems. The platform contains a growing library of process models of typical human, industrial and ecological systems, the relevant ones of which are used in a local instance to create a tailored integrated systems model for a city-region.

It is designed to connect to many data sources, including from earth observation satellites, government and private sector data, local sensor networks, smart phones, tablets and local survey data. This data is processed by the systems model and visualized to give an improved understanding of the human, economic and ecological systems within a region including how these are interlinked.

Installing a local version of the model allows communities to manage both their economy and its critical supporting ecosystems on the basis of integrated systems insights. It allows city-regions globally to assess their current development path, taking account of the risks of climate change, resource scarcity and events and map out a more sustainable and resilient pathway. It is a tool for testing possible scenarios and driving towards a holistic set of social, environment and economic goals.

**resilience.io** is designed and created to support regional investment and performance based procurement in resilient growth of sustainable city-regions with the governance and metrics that planners, designers and investors need. Utilities, services and transport infrastructure, construction, water and energy supply, clean technology, climate adaptation, agriculture and forestry, health and education are all part of this and together are vital components of resilient urban growth. The platform will build evidence to attract public and private investment to climate adaptation and mitigation projects that achieve economic, social and environmental goals within resilient inclusive development.

The platform is one part of our overall approach of supporting transformational change through integrated thinking and collaborative approaches. Our approach is described by the five components on the right.

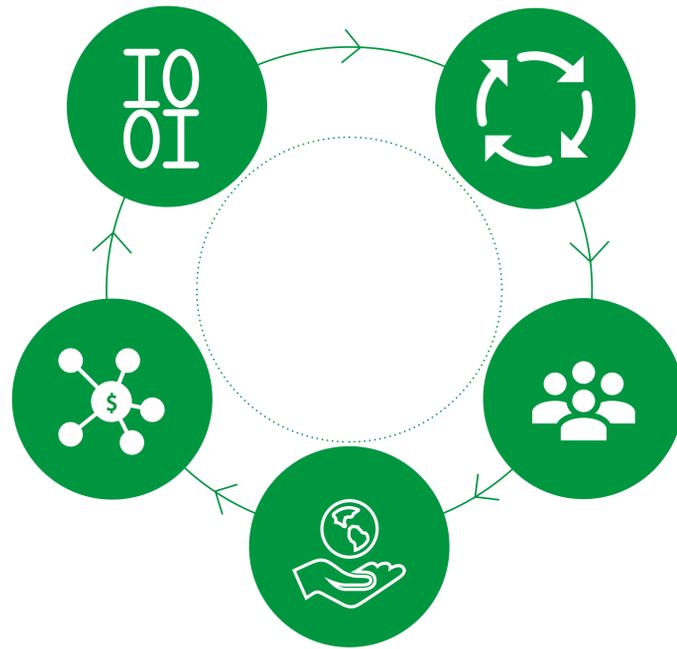


Figure 1: An integrated, collaborative approach to urban resilience

### Data brokerage



The value of the platform will rest on the quality and range of data available to it. The Trust, in conjunction with its partners have developed a data collection strategy identifying the minimum data and data quality requirements for operating the platform successfully and this forms a part of installing the platform in a new city-region location. The Trust is ensuring that rapidly emerging globally recognized open data protocols and measurement systems are followed so that **resilience.io** will support data collection requirements such as for the Sendai framework. In order to achieve this level of data access, a defined cataloguing and data processing service will be developed so that models can access these data sets.

### Integrated systems



To address the challenges of climate-change and risks from shocks and stresses, a systems approach is needed that provides an integrated systems viewpoint of a city region as it stands and which allows evaluation of proposed planning, policy and infrastructure interventions. A systems approach provides insights into the interconnectivity and relationships between places, people and the environment including systems such as transport, housing, energy, water, waste, food and human health, and the associated chemical and physical changes that are functioning within a city-region over time. The research behind the development of this component is further described below.

### Collaboration laboratory



We see a clear need for a new type of Organisation with deep multi-disciplinary skills, to act as a neutral, trusted catalyst to foster new forms of collaboration between the public and private sectors. This collaborative decision-making process will lead to shared knowledge, mutually beneficial partnerships and enhanced capacity for achieving shared goals which are inclusive. At The Trust we call this **Collaborative Intelligence** contained within a **Laboratory**. Citizens are often un-empowered and placed outside the critical processes shaping and driving change. Our aim is to ensure that the information and insight we help regions to develop, will draw on input from across cultures and communities and is made available to as wide a section of society as possible.

### Accessibility



This entire initiative will be open-source and provide a quantitative analysis of the system interactions between the economic (values and market), ecological and societal aspects of the region's resource flows and their connection to national and global resources. The platform is built on an architecture of agent-based, socio-economic simulation, that includes an integrated view of land use, agent activity, resource flows, and infrastructure networks. With this in place, perhaps the most critical element of the platform will be the creation of accessible user interfaces. The aim is to provide human access to the model via a friendly, intuitive interface. A very detailed view of all of the integrated systems could perhaps be too complex for most purposes. To this end a set of sector specific cockpits will be developed providing a sector view into the overall city-region model.

### Urban Investment fund



Currently, both local and international sources of private capital for investment in cities are concerned about risk and return. Further incentives are needed to increase the level of investment in city-level sustainable and resilient infrastructure that is risk sensitive. Such incentives could include risk amelioration through the utilisation of longer-term public sector support, including the use of guarantees for specific risk elements. The Trust are developing and demonstrating **resilience.io** in a series of pilot regions globally. The practical nature of the pilots will facilitate local institutions collaboration on data generation and testing scenarios and proposals. These scenarios are presented as a pipeline of bankable projects which will attract investment through dedicated Urban Development and Investment Funds.

## Collaboration partners

### The Ecological Sequestration Trust



Is leading the development and deployment of the **resilience.io** human, ecological, economics urban systems model to support low-carbon, resource-efficient and resilient developments. Through this work, The Trust have developed a keen understanding of the building blocks required for a viable, integrated approach to urban resilience including, urban systems analysis through the **resilience.io** platform and the data requirements and brokerage thereof, to realise more efficient and transformational urban developments, collaboration to achieve meaningful outcomes, accessibility to the model and model outputs and investment methodologies to ensure tangible, transformational outcomes.

### The International Centre for Earth Simulation



The International Centre for Earth Simulation are developing an earth systems modelling platform and are experts at advanced computing, data and systems modelling. It is important to enable the set of models developed to communicate with many other existing or future models in a 'plug and play' fashion. We are engaging ICES to integrate their work, ensuring larger scale global impacts are taken into account as well as to integrate satellite and local sensor data.

### Future Earth limited



Future Earth develops and implements new, innovative projects and programmes for public and private sector with particular focus on climate change, integrated natural resource management, low carbon R&D and scale up, environmental protection, disaster risk management as well as arts, culture and social engagement. Experts in facilitation, they are leading leading the collaboration component of our integrated approach to urban resilience.

### Imperial College London



Imperial College London contains a world leading team of integrated systems modellers. This team led the Urban Energy Systems Project, have designed the **resilience.io** platform and are now working with The Trust to build and test the platform alongside the Institute for Integrated Economic Research. Within this project they will develop the algorithm connections between space data and city region resource economic data and advise on the requirements of integrated systems modelling on the brokerage portal.

### Institute for Integrated Economic Research



Are leading the research of resource flow and socio-economic relationships in city regions, to ensure we develop a robust model which confidently represents how a city region functions and how changes will affect its functioning over the long term. The Institute for Integrated Economic Research is a non-profit research organization focused on developing an unbiased view of global economic processes, they seek to re-focus economic research away from individual subsystems, towards a broader understanding of the larger forces driving overall progress or retreat.

### Geodan



Geodan is a leading geo-ICT company specialising in spatial information and applying new, innovative technologies. We have are collaborating with Geodan to build cutting edge data brokerage, visualisation and graphics capabilities. Geodan have supported the EC JRC Inspire and GEOSS programs and bring all that knowledge with them.

### Oasis

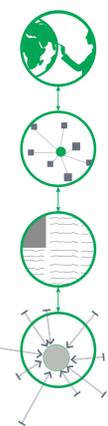


The Trust are partnering with OASIS to integrate this framework with the insurance sector investor requirements. The partnership outcome for this project should inform city region modelling relationships that are relevant to catastrophic risk and investment decision-making.

## Contribution to disaster risk reduction

The collaboration partners are establishing a scientific network which is supporting city-regions to become more risk resilient. The principle of bringing an understanding of both the global and local view, and of the interconnectedness of systems allows city-regions to better assess current risks, and changes to risks from proposed interventions. Further, providing access to this level of complexity helps investors to make funding decisions on resilient, risk-sensitive climate compatible projects. The platform includes global earth simulation and catastrophic loss models, supports efforts to attract investment into disaster risk reduction, and to better understand the potential impacts of global supply-chain risks and resource and skill constraints

### Data Brokerage system



- 4. User interfaces**  
Intuitive open source web based data to enable citizens to visualise the impacts of a proposal using portable devices through advanced visualisation.
- 3. Model services**  
The use of open modelling interface will allow plug and play connection of existing and future models to **resilience.io** based on like for like parameters.
- 2. Data cataloguing and processing**  
Data standards, cataloguing and maintenance will be developed for all data types and formats to ensure efficient storage, quality and cross communication.
- 1. Data access**  
The collection of multiple data sets of sufficient quality is fundamental. Data collection requirements and subsequent data collection strategies will ensure relevant high quality inputs into the data cataloguing and processing phase.

### Integrated Systems model



This open-source urban-rural model provides a quantitative analysis of the system interactions between the economic (values and market), ecological and societal aspects of the region's resource flows and their connection to national and global resources. While the model's spatial scale is a city and its hinterland, it is also an open system with mass and energy flows from and to the outside world.



**Service and infrastructure networks:** These networks include roads, railways and waterways, gas pipelines, power grids, water and communications networks. The **resilience.io** platform enables local networks to be modelled as part of an integrated regional system, so that owners can design changes in partnership with land-use development planning, and work together to improve resource efficiency. Additionally, this component is being developed to enable 'plug and play' connections to private sector building and infrastructure models.

**Resource flows:** the model uses the agent activities and land use to calculate the flows of renewable and non-renewable natural resource stocks and flows across the region (e.g. sun, wind, biomass, food, natural gas, biogas, carbon, nitrogen, phosphorus, water in different qualities), wastes (e.g. sewage, CO<sub>2</sub>) and energy flows (e.g. power, heating, cooling) from agent activities.

**Agent activities:** relate to human systems and businesses located spatially, to provide for simulated decisions, which drive physical systems that process resource inputs into outputs. Agent properties include well-being, health, skill, age and productivity.

**Land use and function:** A geospatial representation of the city-region, including surface and underground features, is used to characterise the spatially dependent properties of the system.

### Urban development investment fund

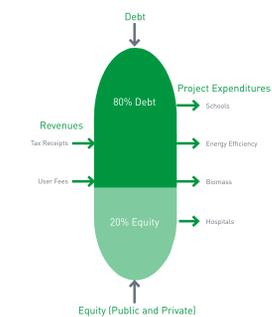


Figure 1 - Urban Development and Investment Fund model

We support the Brookings Institution's recommendation to establish new mechanisms for financing cities in developing countries by the end of 2016, and to bring 20 large cities to the international capital market by 2020. We also support the extended use of Public Private Partnerships (PPPs) in developing sustainable infrastructure, and we believe the above incentives will engage investors further in contributing to PPP projects.

One potential PPP mechanism for consideration by cities as a vehicle for development, is an enhancement of an urban agency concept into a financing vehicle, an Urban Development and Investment Fund (UDIF) that can bring institutional investors, development finance and the public sector together. This would build on an aggregator model used in PPPs, and serve as an aggregator of income from various sources within the cities (e.g. rates, taxes and user income from city services, including funds from sales of real estate to private investors or from development gains). It is envisaged that the ownership of the vehicle would be shared between the public and the private sector to ensure full transparency and accountability. Financing could be made available by those who would be attracted by the diversification benefits of investing in a series of projects, and leverage of around 70% could be raised.

## Contribution to implementing the science and technology aspects of the Sendai framework

The contribution to the science and technology aspects of the Sendai framework lie in our innovative approach to taking a systems approach at a city-region scale. Features of this approach include data collection, validation and standardisation through our brokerage system as well as through the analysis thereof with-in the **resilience.io** platform which is briefly elaborated in the adjacent explanation.

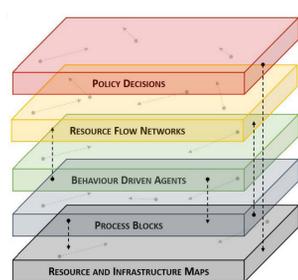


Figure 2: Building blocks of resilience.io

These are the building blocks of the **resilience.io** human - resource - economic model. Together these will simulate interactions between people, the ecology, and resource flows in a society of a city-region to build meaningful insights into more resilient pathways. Within the **resilience.io** model the five building blocks are defined as: **1. resource and infrastructure maps**; **2. process blocks** (resource conversion processes); **3. behaviour driven agents** (people and businesses); **4. resource flow networks**; and **5. policy and scenario decisions**. Within this framework, four data elements simulate an entire city-region as integrated systems. These building blocks will be created using space data, entity data (all physical non-human objects), agent data (this includes humans (and animals) that interact with the physical world) and process data (describing the relationships between entities and agents which change in time and space). The city region will then be analysed through organising data into fourteen sectors which describe the human ecosystem.

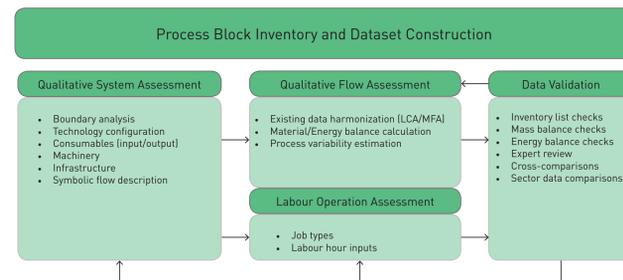


Figure 3: Process block inventory and dataset construction steps

The entire model is to be centred on depicting all relevant natural and human-operated processes as a computation of material and energy balances such that the resource basis of societies becomes transparent. By representing the economy in such we will be able to explore the benefits of alternative interventions and effects of disasters.

The calculation of resource flows is based on a detailed estimation of technology systems that exist at a spatial site or location, which form a 'process block'. To build a comprehensive understanding of a process block, its resource and labour input values are calculated using a rigorous methodology which combines process engineering based mass and energy balances, Material Flow Analysis (MFA), and Life Cycle Inventory (LCI) studies prior to its establishment within the model. In its initial version the model will include 200 process data sets which together are able to describe up to 90% of resource flows in a city region.