Sustainable systems

Cambridge Resilience and Sustainable Infrastructure.

Developing future leaders for a complex world

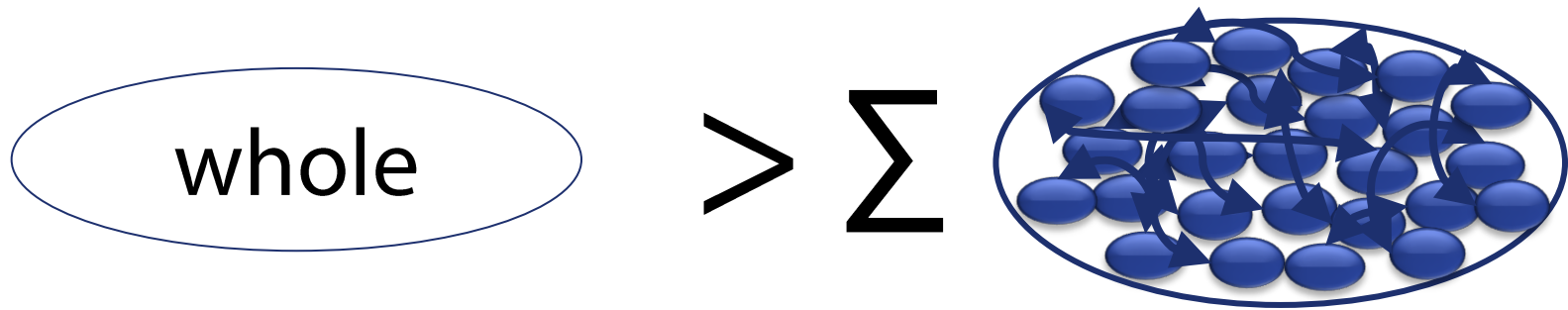**Engineering a Holistic Approach to Innovation, Design & Learning**
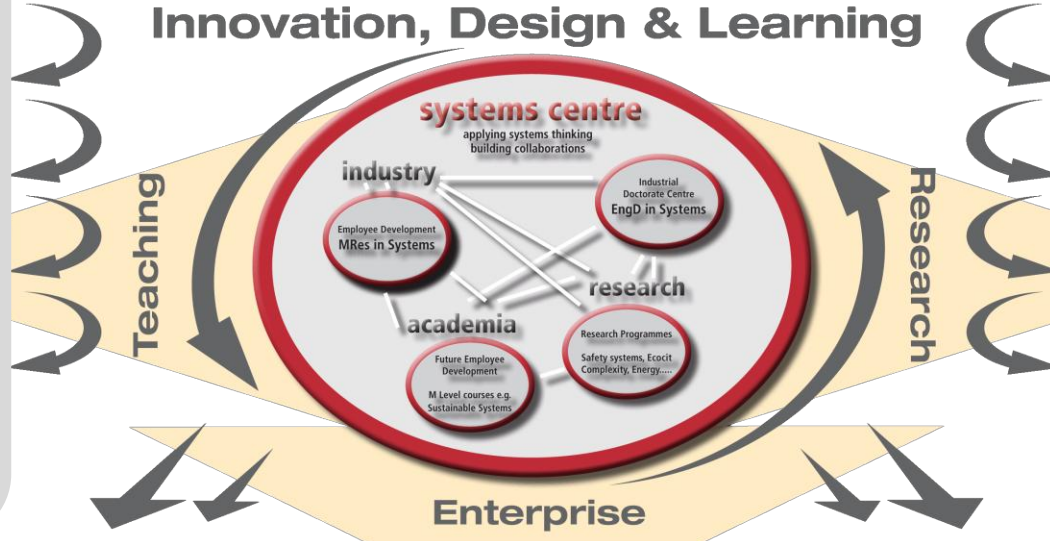
Delivering world class research in socio-technical systems

Enhancing business and Government performance through systems practice

Engineering Synergy

$$\text{whole} > \sum$$

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Establishing a common language for integration of all processes

Soft, Human, Natural

Physical, Anthropogenic
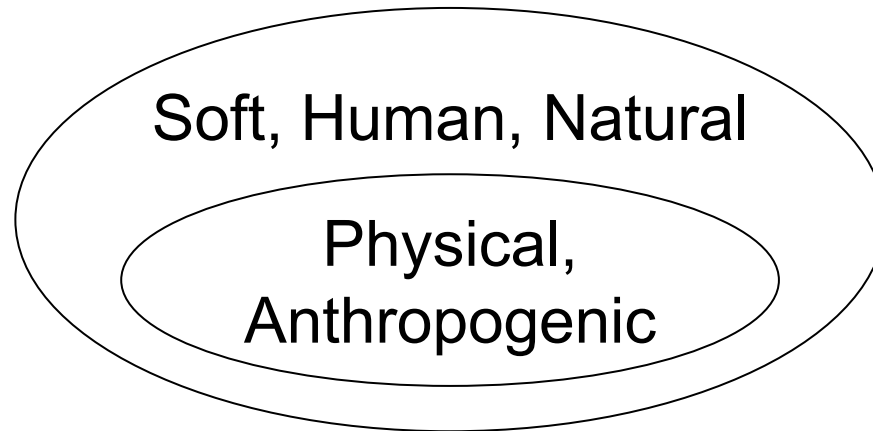
Why = How (What, Where, When, Who)

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Bristol Generic Model

Our Environment

Stakeholder needs

needs   how

Design or solution

needs   how

Enabling technology

needs   how

Fundamental knowledge

Natural

Community

Business

Purpose - Why

Means How

Bristol Generic Systems Model after Prof C. Taylor

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Sustainable Systems –
Royal Academy of Engineering, Visiting Professors Project

Taught by

- 4 Visiting Professors
- 3 Visiting Fellows

Pro bono

- Various academics and systems research engineers.

• 200 students (3 years)

- In one week of intensive interactive teaching
- Assignments demonstrate they can do it

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The assignments

- Select, develop and apply an appropriate systems architectural framework to assess and improve the sustainability of the target.

- Select and establish a sustainability measurement regime for their selected target project.

- Establish an implementation process that will recognise unintended consequences and opportunities for synergy improvement

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Assignment Topics

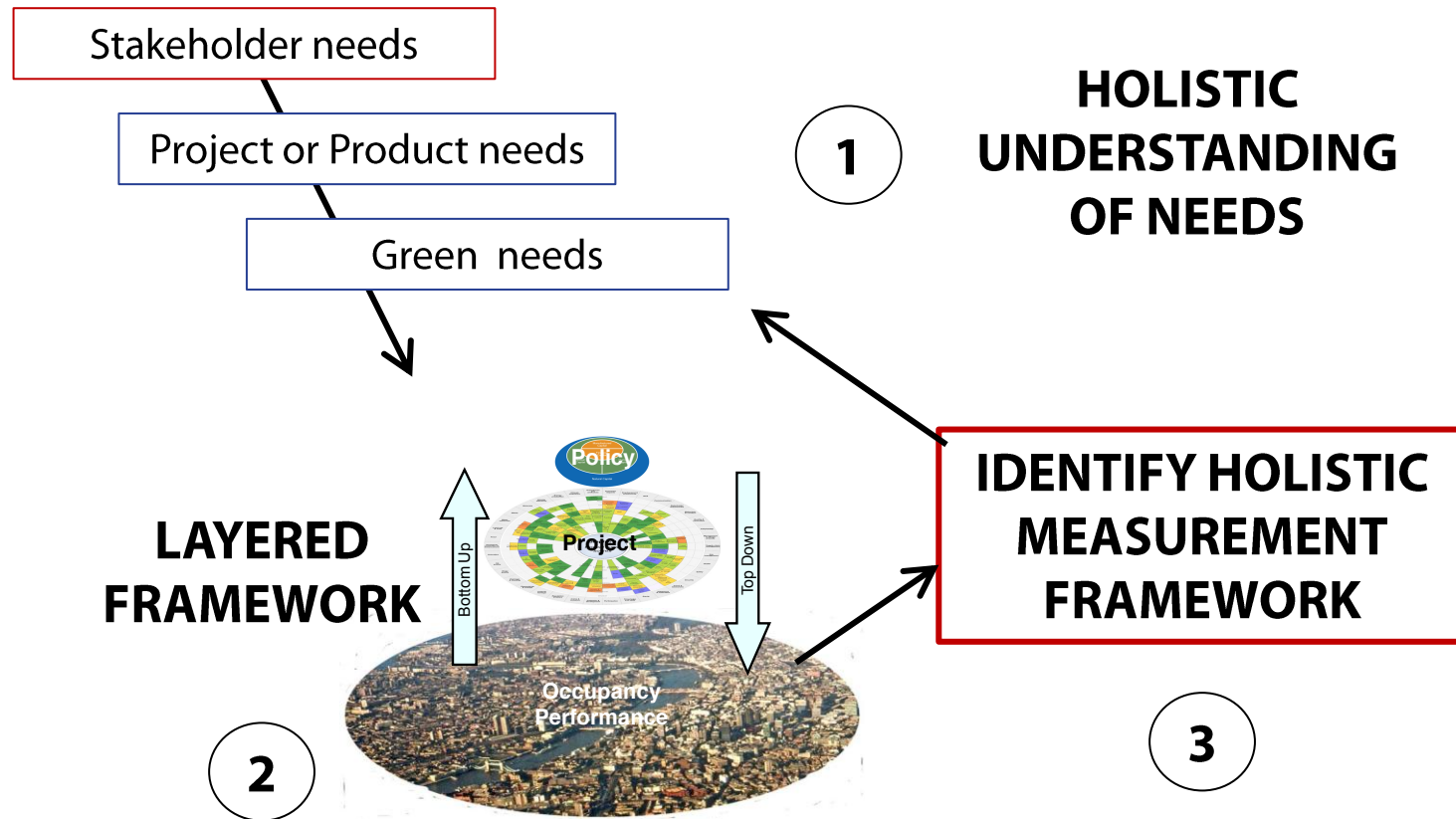| Table 1 List of assignment topics : Improving the sustainability of			
Countries	Haiti	Institutions/companies	NHS
	Afghanistan		Supermarket Chain
Mega projects	3 Gorges dam		BP
	Crossrail		University
	Olympics	Leisure	F1 Motor sport
	Aircraft carrier		Rugby World Cup
	Airbus A380		Eden Project
Managing resources	Polar Mineral Extraction		Ski resort in Dubai
	Rainforest	Infrastructure	Nuclear Power
	Carbon capture, coal fired Power stations		Air Transport
	Hydrogen Infrastructure		Sustainable Tourism
	Eating Meat		An eco-district
	Rare earth metals		Internet infrastructure
	Euro currency		

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Core approach for dealing with complex Systems
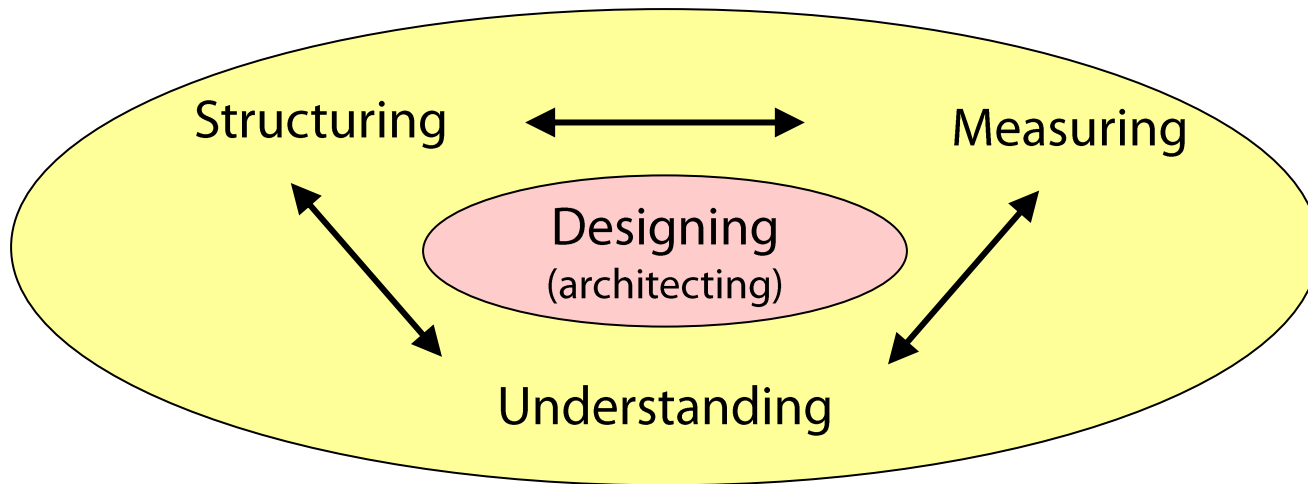
A Learning Loop

© Thales UK Hillary Sillitto

Core approach for dealing with Sustainable Systems

Stakeholder needs

Project or Product needs

Green needs

1 HOLISTIC UNDERSTANDING OF NEEDS

LAYERED FRAMEWORK

Policy

Project

Bottom Up

Top Down

Occupancy Performance

IDENTIFY HOLISTIC MEASUREMENT FRAMEWORK

2

3

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Holistic frameworks for sustainability
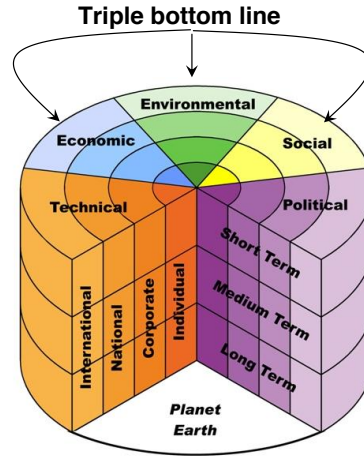
Triple bottom line

Forum for the Future
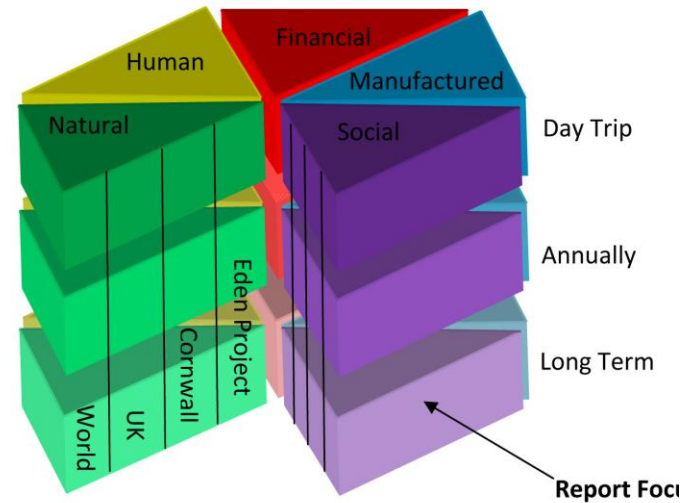
PESTE and triple bottom line
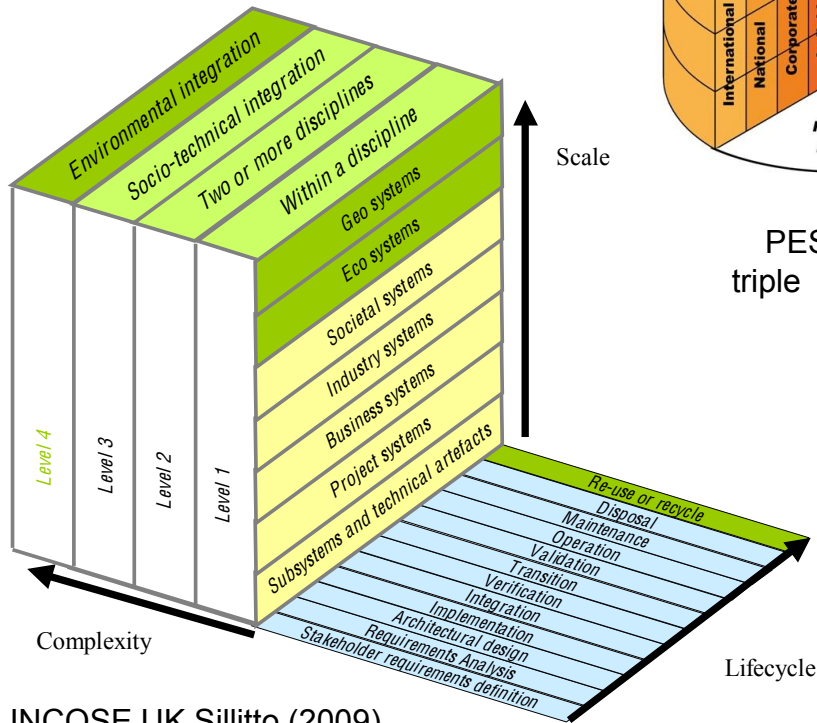
INCOSE UK Sillitto (2009)

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Comparing different Sustainability frameworks

Triple Bottom Line
Herman Daly's "3Es"
ESG Framework
Elkington's 3Ps
5 Capitals model

Environmental
Environment
Environmental
Planet
Natural

Economic
Economy
Governance

Profit

Financial
Value & Risk
Reputation
Climate change
Resource Use
Biodiversity
Environmental Quality

Design & Development
Supply Chain
Manufactured

Sustaining and improving the quality of people's lives

Governance
Community
Social

People
Health & Safety
Human

Economy
People
Social
Equity
Social

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Learning together

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Afghanistan Stakeholder Analysis related to Metrics

| #	Metric
1	Complaints about official corruption
2	Qualitative assessment of commentary
3	Qualitative assessment of Israel-Palestine
4	Afghan opiate production, by weight
5	Global opiate production, by weight
6	ISAF leaving Afghanistan
7	GDP of Afghanistan
8	Investment into Afghanistan
9	Cost of deployment (US$)
10	Number of ISAF casualties
11	Effectiveness of attacks on ISAF/locals
12	Civilian casualties
13	Effectiveness of Afghan Army & Police
14	Domestic terrorism, weighted by impact
15	Employment Conditions Abroad assessment
16	Number of linked foreign terrorist incidents
17	Number of attacks on foreign owned assets
18	Qualitative assessment of US threat position

Edward Reid (2009)

Stakeholder Analysis

| Level	Stakeholder	Interest Area	Type	Position/Vision	Metri
1. Multinational	Shanghai Co-operation Organisation	Security	Maker	Security of SCO members (particularly China & Russia)	15
		Afghan Stability	Maker	Favours regional stability	15
		Trade	Maker	In favour of Russian and Chinese economic imperialism	7, 8
		Raw Materials	Taker, Maker, Breaker	Supports China's efforts to mine in Afghanistan	7, 17
		Drugs	Maker	A threat to key SCO stakeholders, therefore against trade	5, 6
	North Atlantic Treaty Organisation (NATO) & International Security Assistance Force (ISAF)	Casualties	Maker, Breaker	Minimise casualties	10
		Cost of War	Taker, Maker	Limit the total cost of the conflict	9
		Alliances	Maker	Maintain/strengthen alliances	2
		Afghan Stability	Breaker, Maker	In favour, as heralds ISAF's withdrawal	2, 15
	United Nation (UN)	Drugs	Maker	UN Office on Drugs & Crime opposes opiate production	5, 6
		Terrorism	Maker	Aims to reduce national and international terrorism	14, 16
		Diplomacy	Maker, Breaker	Strengthen international relations	2, 3, 6
2. Foreign Nations	China	Border	Maker	Proximity of ISAF troops is a concern, favours withdrawal	6
		Exports	Maker	Safety of exports via Afghanistan	13, 15, 17
		Access	Taker	Access to Chinese investments , e.g. Aynak Mine	13, 17
		Investment	Taker, Maker	Maximise return on investments made by China in the region	13, 17
		Islamist Extremism	Maker	The rise of Islamist extremism in Afghanistan will not affect domestic Islamist issues in Xinjiang province	14, 16
		ISAF Withdrawal	Maker	Mistrust of the US/NATO, resulting in a preference for ISAF withdrawal	6
	Russia	ISAF Withdrawal	Maker	Mistrust of the US/NATO, resulting in a preference for ISAF withdrawal	6
		Islamist Extremism	Maker	Issues with Islamist Chechnya are a concern, particularly if linked with Afghanistan	14, 16
		Drugs	Maker	Kill 30,000 Russians annually, 200 000 addicts. Afghan drugs are a major concern to Russia.	4, 5
	USA	Casualties	Maker	With 960 fatalities in Afghanistan and 4,396 in Iraq, further casualties could lessen public resolve.	10
		ISAF Withdrawal	Maker, Breaker	Face saving withdrawal would be ideal to limit further cost from the conflict	6
		Drugs	Maker	Reduction in global illegal drugs sold to the USA	4, 5
		Islamist Extremism	Maker	Lower threat from Islamist extremism to the USA	14, 16
	Minor NATO/ISAF, Mainly Europeans	US Alliance	Maker	Continued/strengthened US/NATO alliance	3
		Security	Maker	Domestic security continued	18
		Terrorism	Maker	Reduced domestic terrorist threat	14, 16
		Cost of War	Maker, Breaker	Limiting the cost of the war on domestic budgets	9, 10
		Casualties	Maker, Breaker	Limiting casualties to prevent a public backlash	10
		Drugs	Maker	Keeping Afghan drugs out of their domestic markets	4, 5
3. Afghanistan	Afghans	Safety	Maker, Breaker, Taker	Improvements in personal safety of population	11, 12
		Stability	Maker, Breaker	A stable Afghanistan, although terms of stability vary	11, 12, 15
		Corruption	Maker, Breaker, Taker	Low corruption of public officials	1
		Economic	Maker, Taker	Ensure continued personal income for living (food, water & housing)	7, 8
		Civilian Casualties	Maker	Minimal civilian casualties	12
		Drugs	Maker, Breaker, Taker	Drugs provide income for farmers, this stream must be replaced or drug cultivation will continue	4, 5, 7,

Afghanistan architecting framework

Edward Reid (2009)
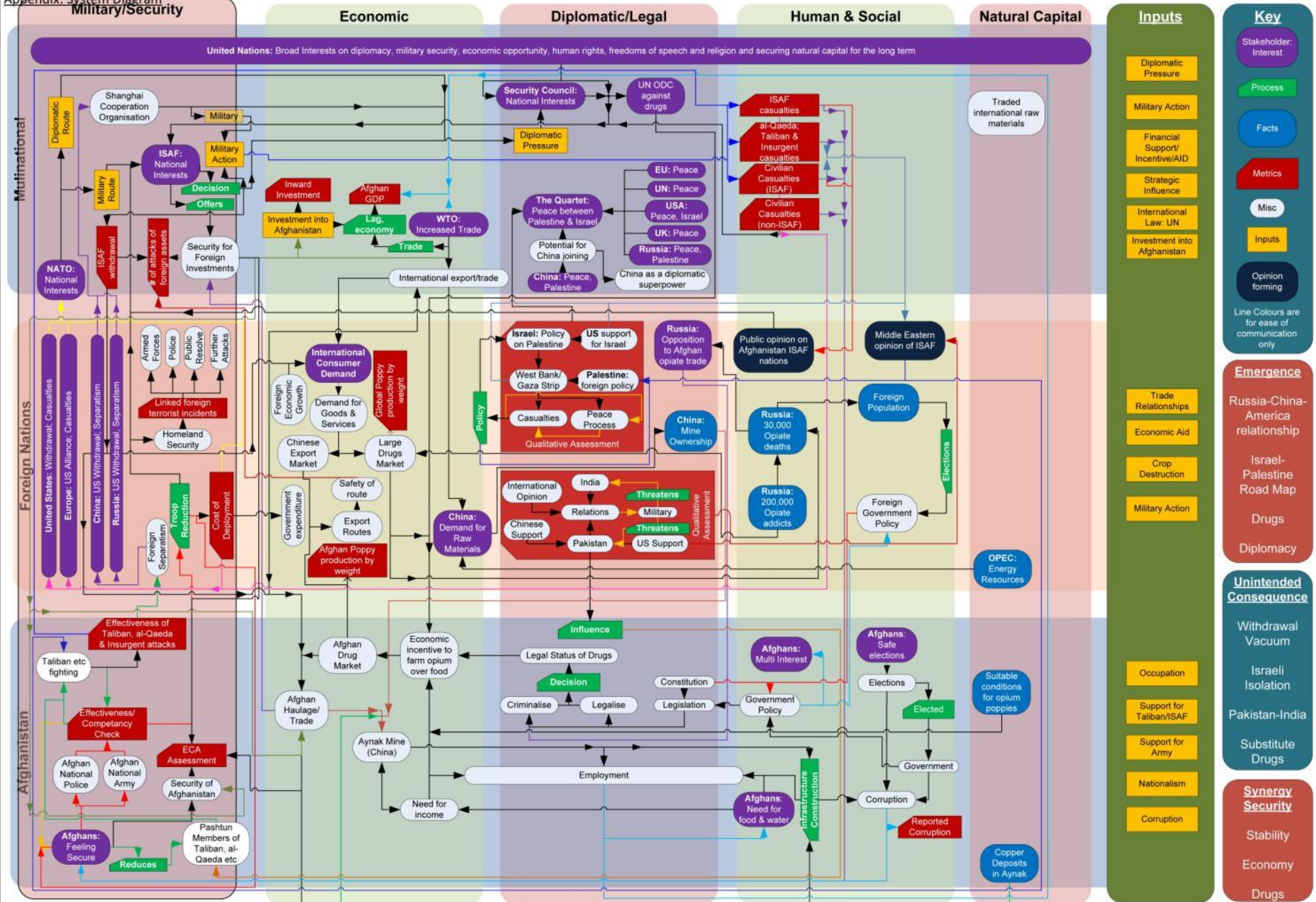
Example of stakeholder analysis Eden Project
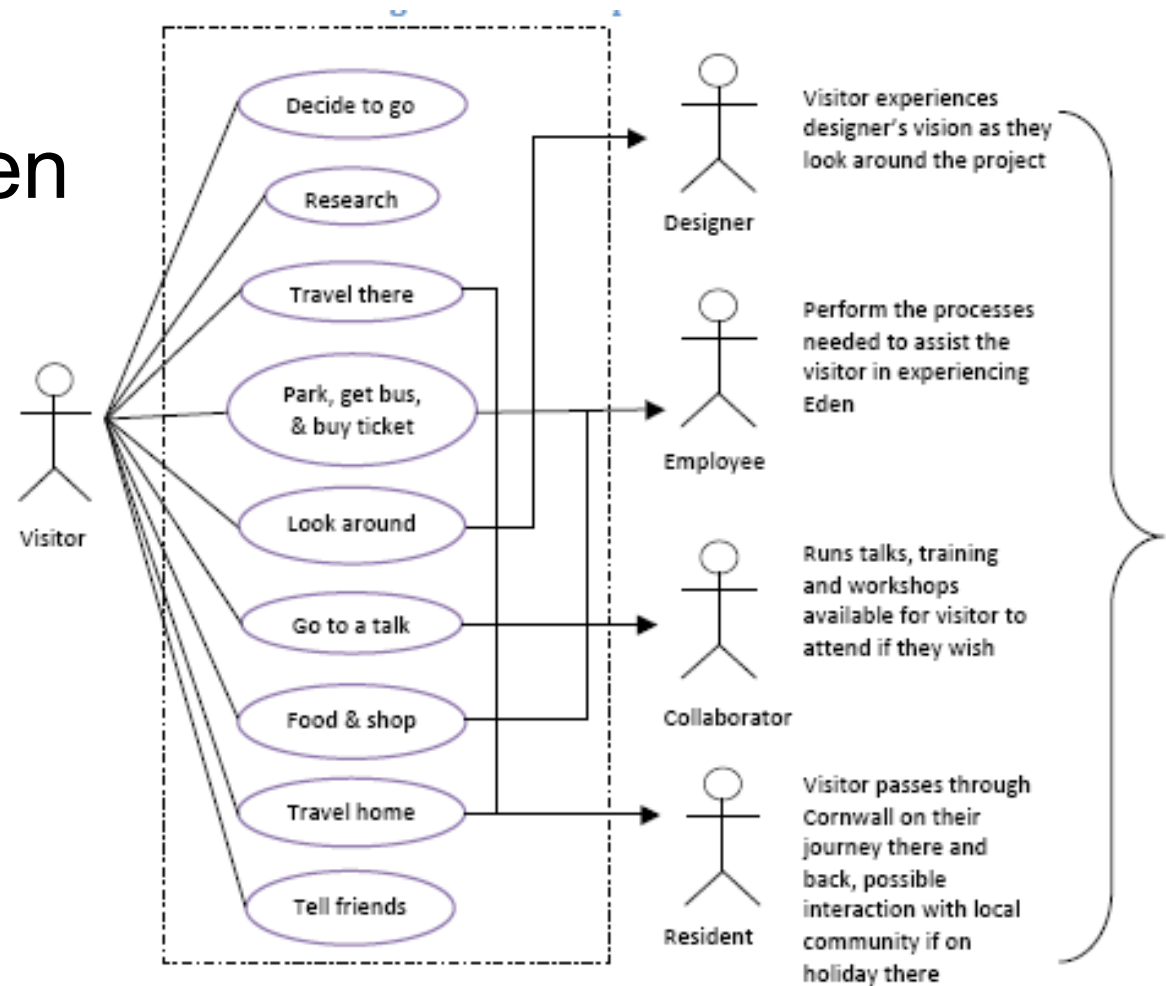
Ruth Eabry (2009)

The Design View
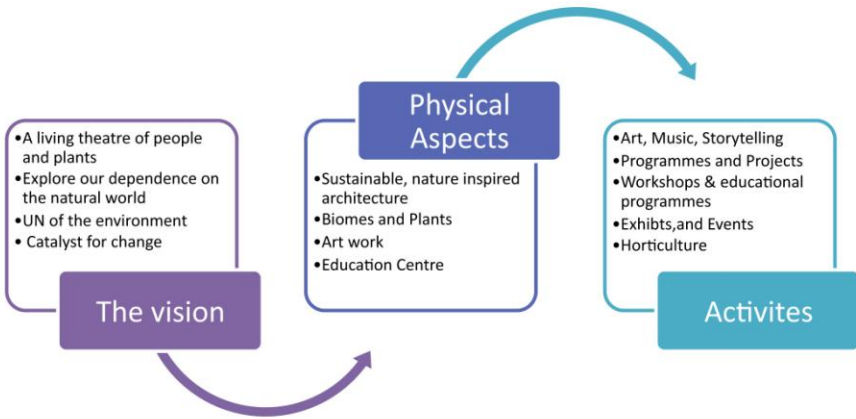
The vision
- A living theatre of people and plants
- Explore our dependence on the natural world
- UN of the environment
- Catalyst for change

Physical Aspects
- Sustainable, nature inspired architecture
- Biomes and Plants
- Art work
- Education Centre

Activites
- Art, Music, Storytelling
- Programmes and Projects
- Workshops & educational programmes
- Exhibts, and Events
- Horticulture

The Designers are continually integrating with employees, collaborators and the external community through the wide range of projects and continually changing programme.

The Operational View

Inputs
- People, water, plants, materials, and money
- Energy and time

Activity
- Movement to correct location
- Running activities, workshops, training and research
- Maintenance, cleaning
- Selling tickets, food, books

Outputs
- Waste, recycling
- Re-use of materials
- Satisfied visitors

There exists excellent team mentality, with constant references to individuals' contributions in Eden literature. Also between the visitors and employees as this visitor quotes demonstrates "The staff were warm, friendly and generally jovial characters". The volunteering scheme also helps promote visitor interaction by enabling visitors to get involved in the operations of the project.

Use Case
The visitor experience
(See page 8)

The External View

Effects locally in Cornwall wider in the UK:

Environment
- Cornwall: Increase in traffic leading to increase in pollution
- UK: Increasing environmental awareness and consideration

Economy
- Cornwall: Source of jobs, Increase tourism, Increase trade to businesses
- UK: Attracts overseas tourists

People
- Cornwall: Encourages pride in area, Caused regeneration, Puts Cornwall on the map
- UK: Educational centre

Many of the project's collaborators are local groups and the Eden project runs community projects such as 'Great Day Out' which offers socially excluded groups (homeless, offenders etc) the chance to be involved in tailor made days which break down barriers, build confidence and other long term benefits [4]. UK wide projects include 'The Big Lunch' - encouraging people across the country to come together and share lunch outside.

The Collaborative View

The Collaborators
- Investment
- Good connotations
- Environmental credentials

The Eden Project
- Training and assistance
- Funding and resources

Good links between Eden Project and a wide range of collaborators with mutual benefits for both parties

"Eden suddenly gave us exposure to a vast number of people and we now have a six-fold increase in bulb sales through Bulb Mania" James Hosking, Partner at Fentongollan

Examples of Collaborators: Sensory Trust, Business in the Community, The Carbon Trust, SWRDA, Universities, Schools, UN Global Contact, The Big Lottery Fund, BT, Arts Council, ...and many more

Ruth Eabry (2009)

Learning together

SC SYSTEMS CENTRE

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Who? →	Why? →	What? →	How? →	When?
Stakeholder	**Driving Factors**	**Ideal Outcome**	**Proposed Method**	**Time Scale**
Creator & Chief Executive Tim Smit **X**	Maintaining original vision	Development of vision	Involvement in design	Indefinate
Investors **X**	Making money	Money back on investment	Project development	Financial year
Land Owner **X**	Rent / Land value	Increase in land value / rent	Sucess of project	Indefinate
Eden Project Executives **X**	Achieving project's aims	Success - promotion?	Imaginative management	Financial year
X Eden Employees	Pay / Job satisfaction	Pay rise / Job security	Hard work, involvement	Indefinate
X Local Residents	Minimising disruption	Postive change to lifestyle	Service improvements	Indefinate
X Visitors	Price / Quality experience	Value for money	Good project management	Current season
X Suppliers	Keeping their client	Stronger client relationship	Reliable, best price, loyalty	Current season
Local Authorities **X**	Interests of local area	Money bought into area	Sucess of project	Indefinate
Planners **X**	Suitablity to site	Strong, suitable design	Imaginative design	Indefinate
Government **X**	Investment / Tourism	Tourism rise / money to area	Project sucecss , infrastructure	Indefinate
X Horticultural expects/Researchers	Potential knowledge	New plants / more research	Projects / research investment	Indefinate
X Construction Companies	Future work / Pay	Development of the site	Physical development of site	3 years
X Supported Charities/Organisations	Eden's ability to fundraise	More money raised	Future fundraising activities	Indefinate
X Transport Companies	Changes in transport use	Increase in public transport	Better services, car use reduction	3 years
X Artists/Performers	Loss of platform	Opportunities to perform	Future performances	Current season

Interest (↑) / Influence (→)

Figure 5 - Stakholder Analysis - Interest, influence and requirements

Ruth Eabry (2009)

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EDEN PROJECT REGIONAL LAYER

WORLD

UNITED KINGDOM

SOUTH WEST ENGLAND

CORNWALL

LOCAL AREA

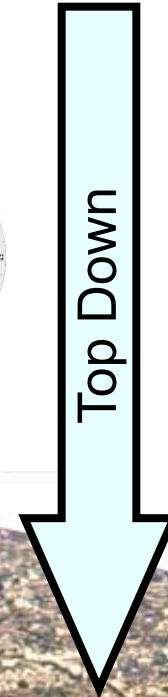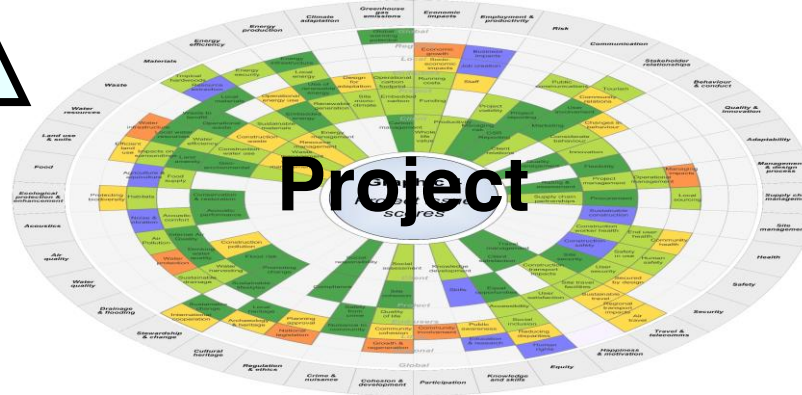THE EDEN PROJECT
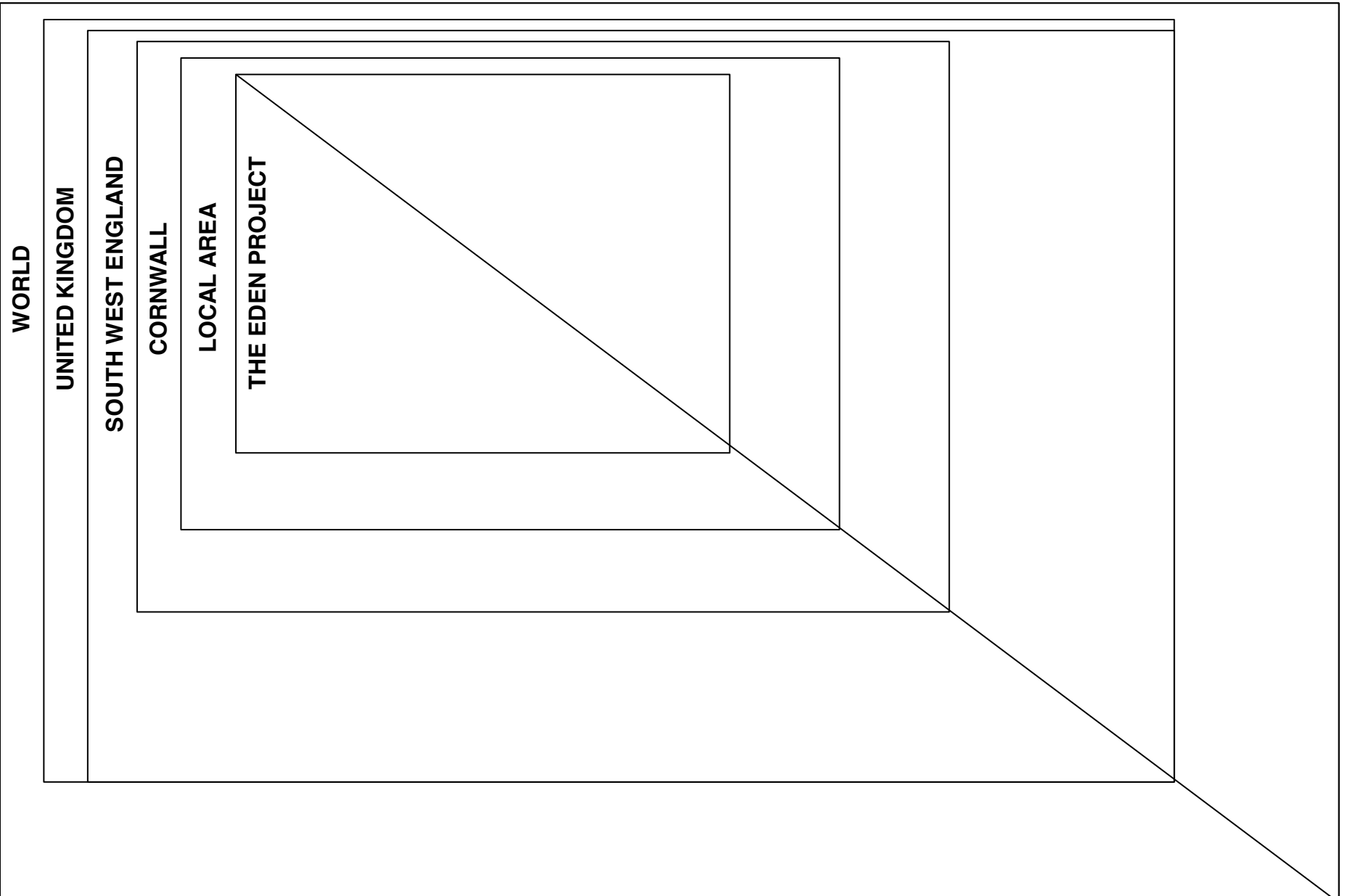
ACTIVITIES

INTENDED AND UNINTENDED CONSEQUENCES

Thinking in layers
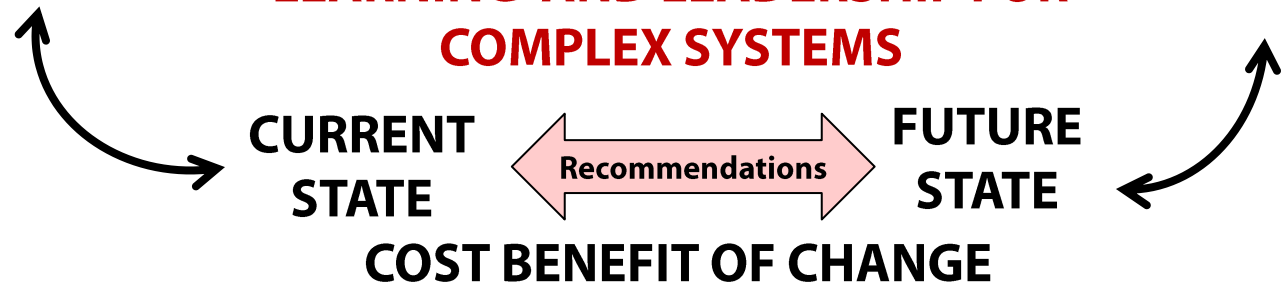
Policy

Project

Occupancy Performance

Bottom Up

Top Down
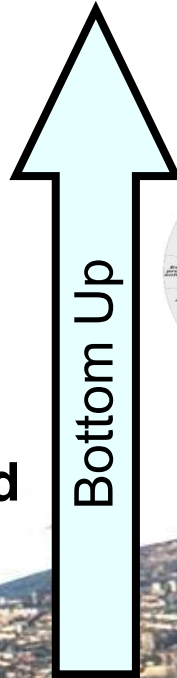
Agent Based Modelling?

Systems dynamics?

Stakeholder needs

Project or Product needs

Green needs

LAYERED FRAMEWORK

Policy

Project

Bottom Up

Top Down

Occupancy Performance

Agent based modelling to understand what people do

Systems Dynamics Stock flow simulation

To understand influence of governance

Using consistent holistic measurement framework
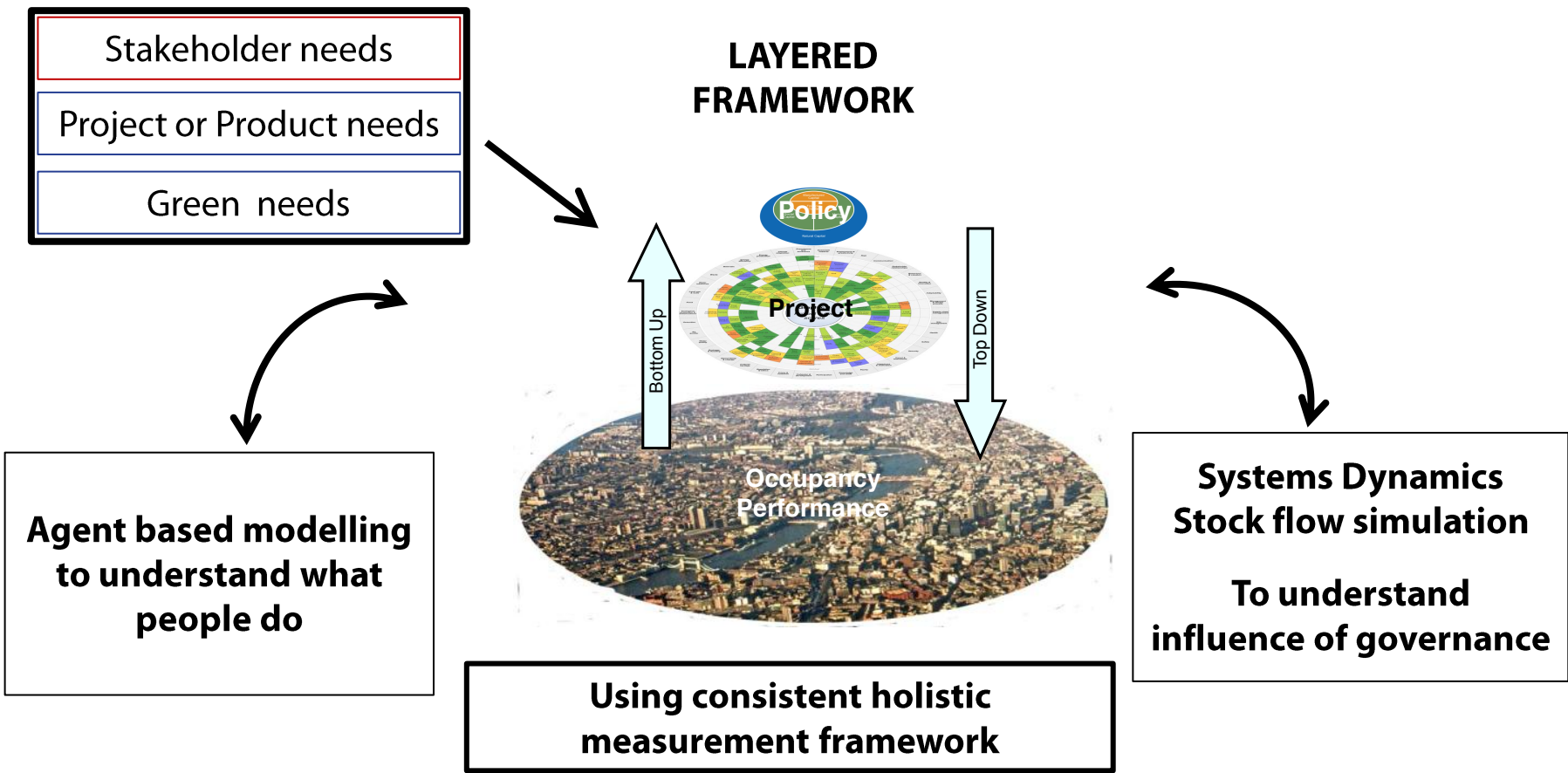
LEARNING AND LEADERSHIP FOR COMPLEX SYSTEMS

CURRENT STATE

Recommendations

FUTURE STATE

COST BENEFIT OF CHANGE

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Conclusion

The challenge is to resolve the inconsistency between governance for civil and environment systems and there performance in practice

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