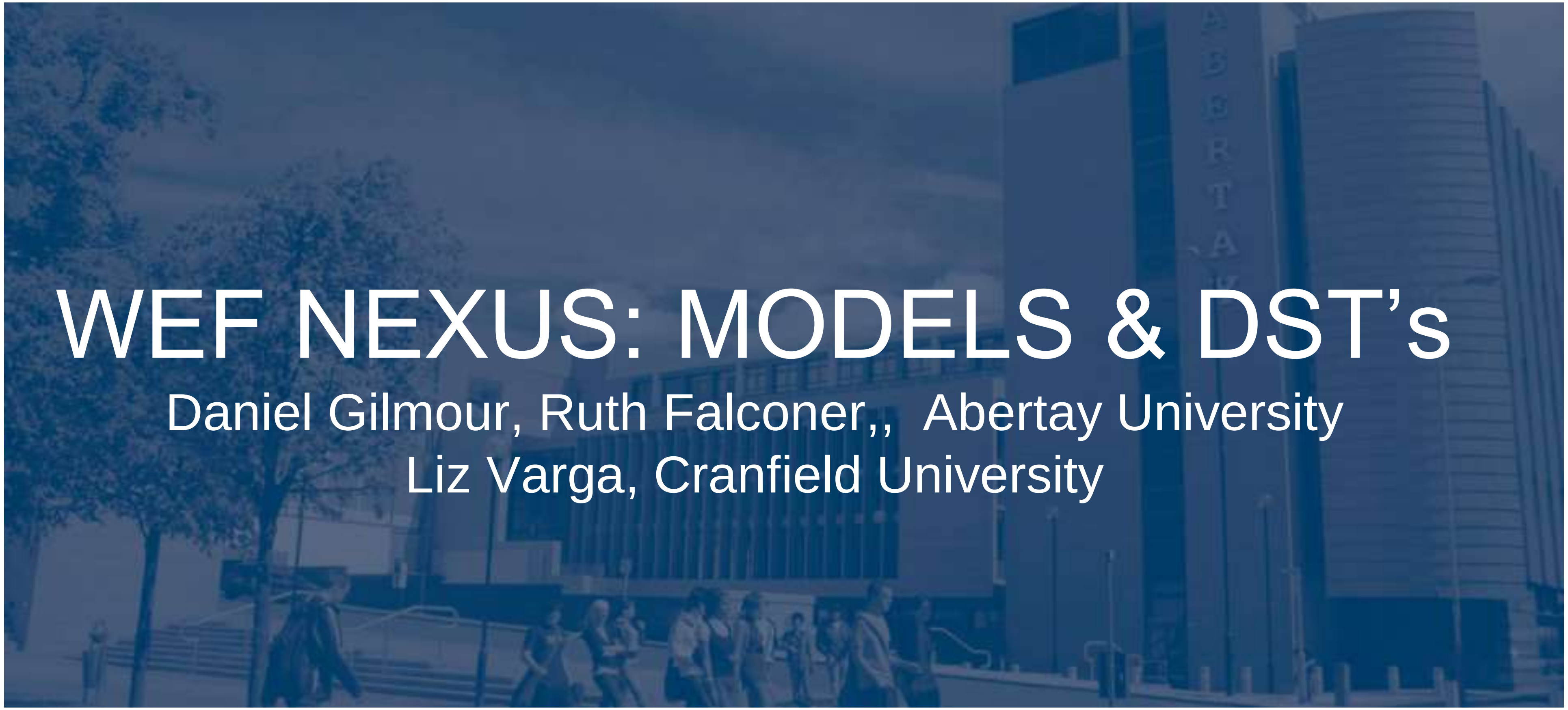
STEPPING UP



WEF NEXUS: MODELS & DST’s

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Liz Varga, Cranfield University

Abertay University

Talk outline

- Landscape of nexus models and tools
- Discipline perspectives
- Challenges in NEXUS modelling & some examples
- Challenges in NEXUS DST’s & some examples
- Summary

Stakeholder engagement, analysis at multiple scales & trans-disciplinary

UNIVERSITY OF SURREY — Learning from live case studies

UNIVERSITY OF EXETER — Governance & Power

Cranfield UNIVERSITY School of Management — Complex infrastructure systems

HR Wallingford Working with water — Hydrological and land-use modelling

MANCHESTER 1824 The University of Manchester — Cutting GHG

Loughborough University — Future climate impacts

Abertay University — Supporting decision making

University of Glasgow — WEF data & statistics

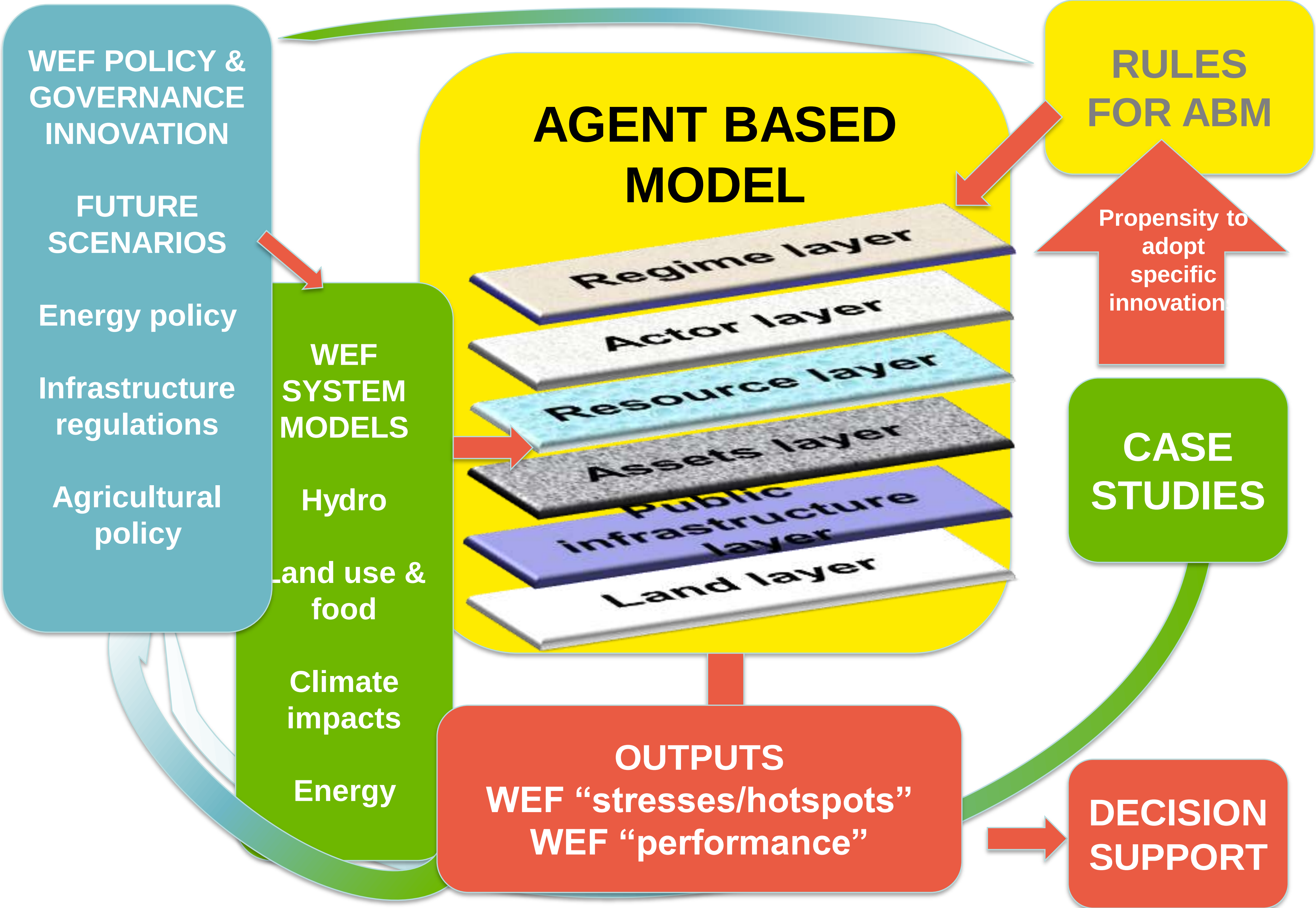
Science & Technology Facilities Council

Objectives are to…

- Explore food, water and energy provision systems at a range of scales, to identify low impact, secure and equitable systems
- Highlight techno-sociological interconnections & tensions between systems
- Develop a framework for accelerating change, applicable at a range of scales (household, community, city, regional, national) [STEPPING UP]
- Ensure the framework is embedded within a dynamic global context




Architecture of the research

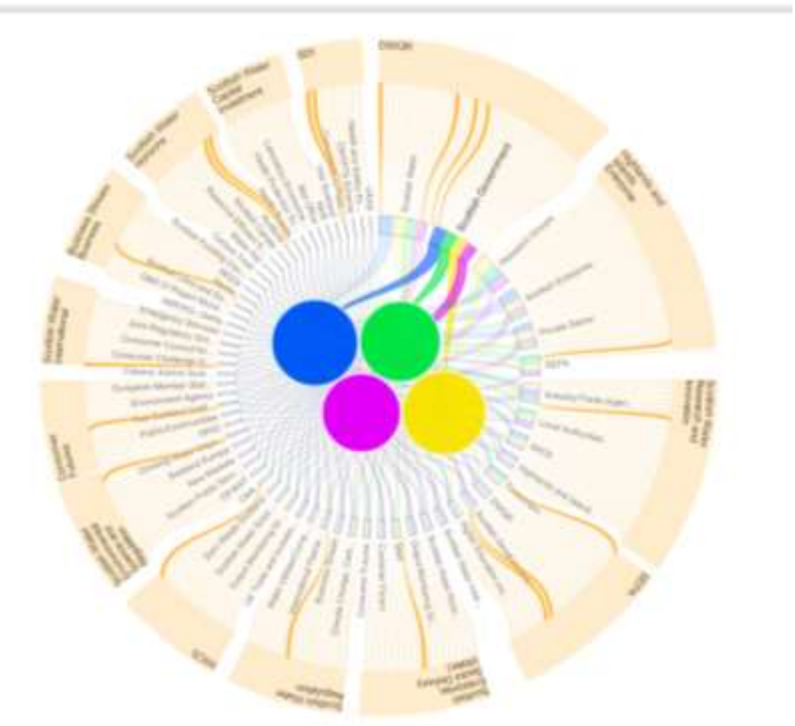

WEF POLICY & GOVERNANCE INNOVATION
FUTURE SCENARIOS
Energy policy
Infrastructure regulations
Agricultural policy
WEF SYSTEM MODELS
Hydro
Land use & food
Climate impacts
Energy
AGENT BASED MODEL
Regime layer
Actor layer
Resource layer
Assets layer
Public infrastructure layer
Land layer
RULES FOR ABM
Propensity to adopt specific innovation
CASE STUDIES
OUTPUTS
WEF "stresses/hotspots"
WEF "performance"
DECISION SUPPORT

Nexus Models

- At a practical level, a suite of techniques and guidance documents exist to understand and manage WEF
  - Categorised as: Sustainability Assessment (SA), Modelling & Optimisation, and Visualisation of Nexus

- Nexus models predominantly focus on:
  - Biophysical modelling of resource flows
  - Sustainability assessment models
  - Social simulation --- including policy driven and human disaggregated decision making

Nexus DST



- Nexus DST have many aims:
  - Collect and integrate knowledge
  - Identify and understand trade-offs
  - Characterise, monitor and enhance nexus performance

- The boundary between NEXUS models and DST's is becoming blurred

Models Types & Properties

- Systems Approach – Individual, Agent based models, treat the WEF as a complex system -- Complexity Science
  - Serious/applied game approaches – Game Design
- Partial Equibrium Models, Flow & Fund Models -- Economic
- Biophysical models - PDE's, DE's – Physical Sciences
- Sustainability Indicator models -- Engineering

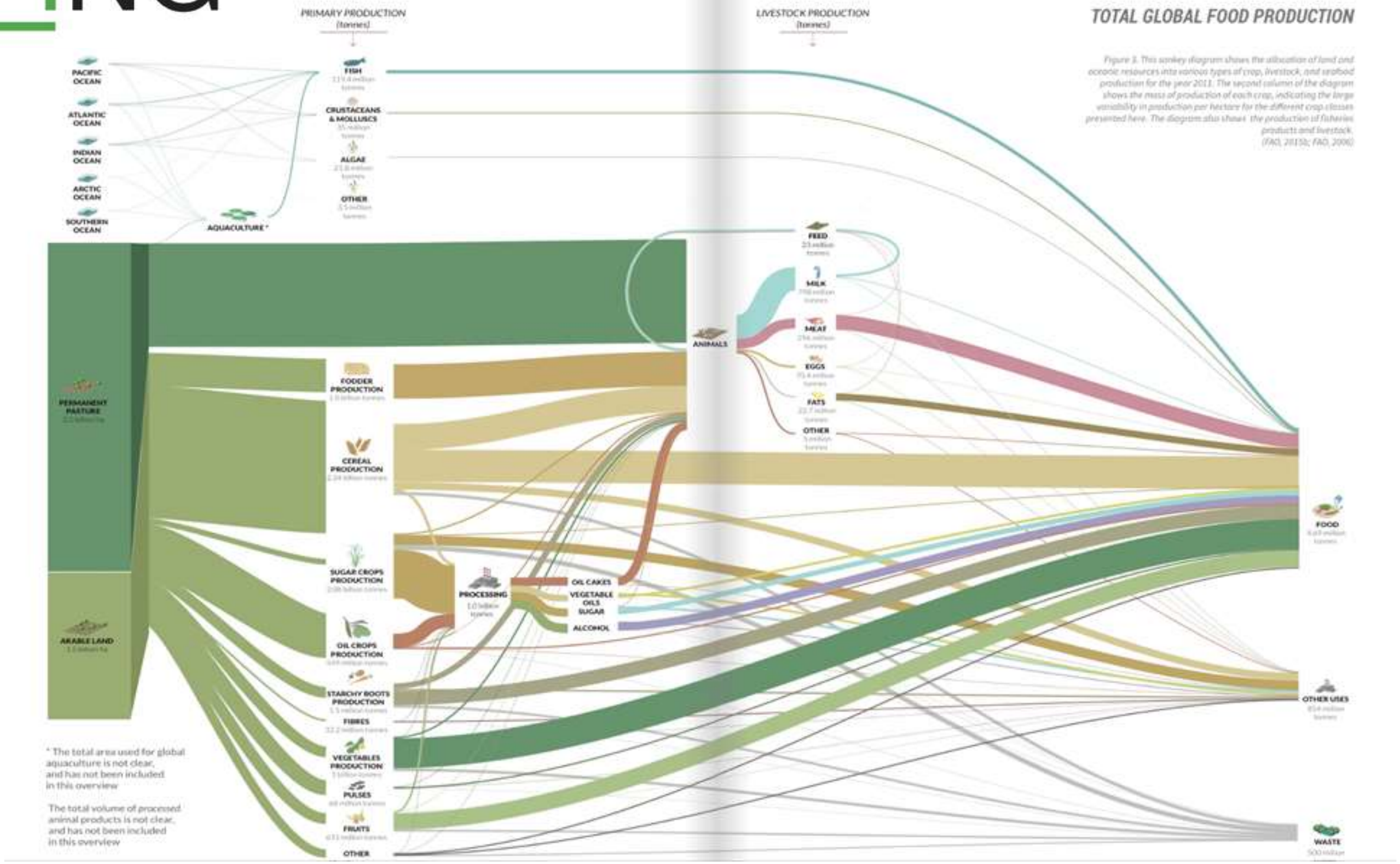
DST Types

- Multiple Criteria decision analysis
- MCDA
  - ANP
  - TOPSIS
  - SMART
  - MOO
- To aggregate or not?
- How to convey to Decision Makers?

Nexus Modelling Challenges

- Complexity
  - Emergence, Self organisation, Adaptation, Feedbacks, nonlinearity
- Data availability and accessibility is a key challenge for a nexus models & assessment
- Communicate model findings
- Which model?

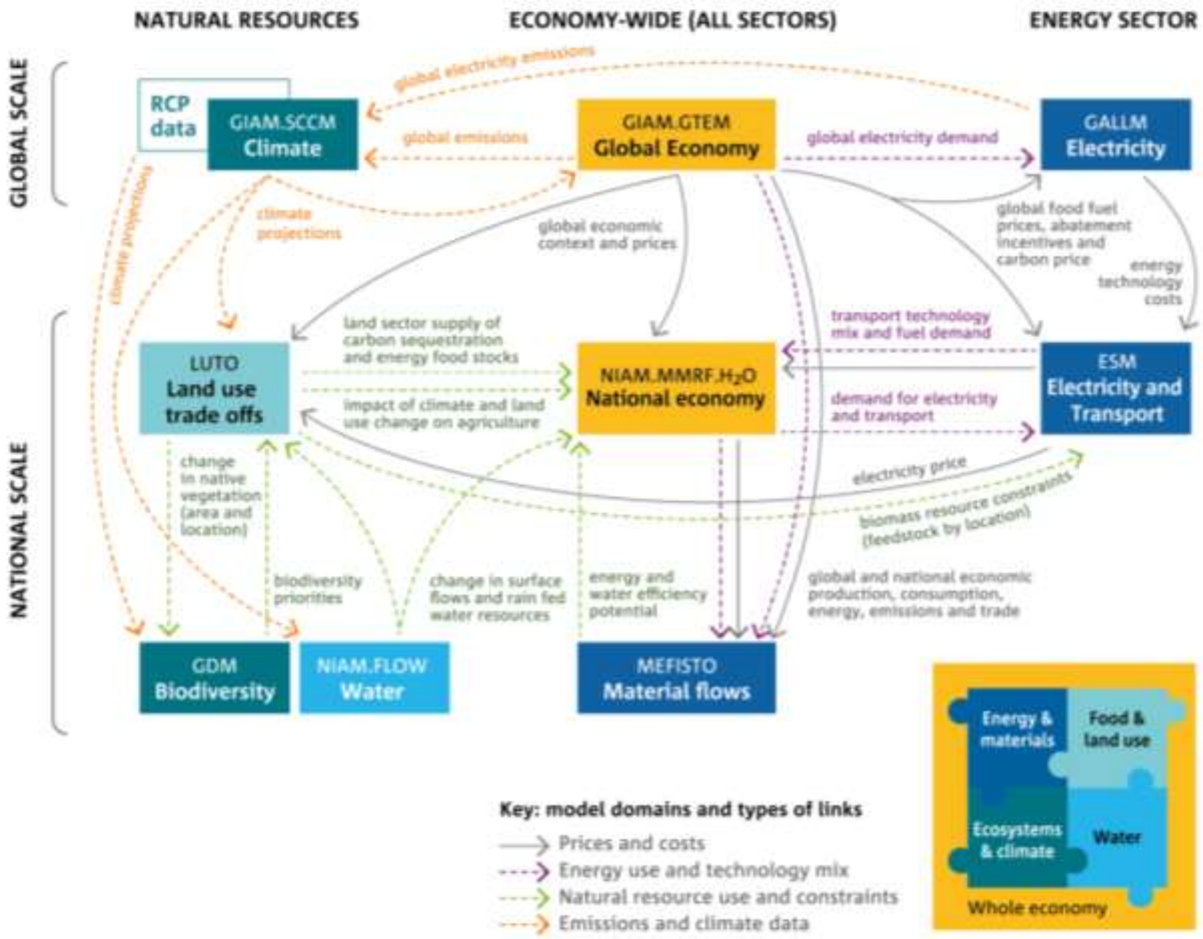
Global Food System



Gladek, E,… 2016

Australian Outlook

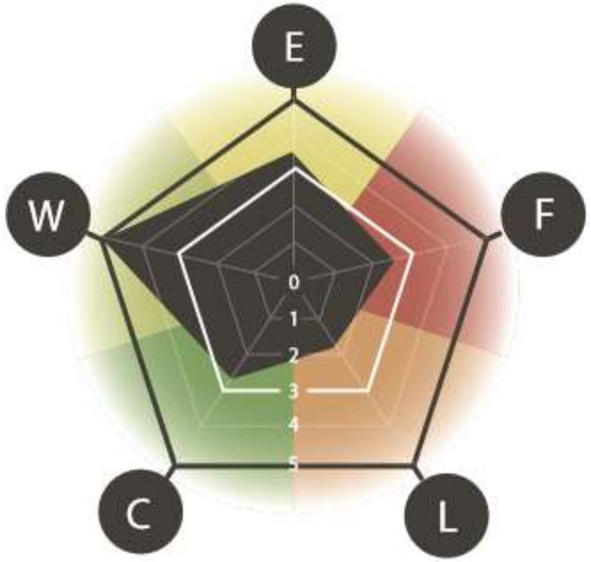
Figure 53. Overview of dynamic model linkages



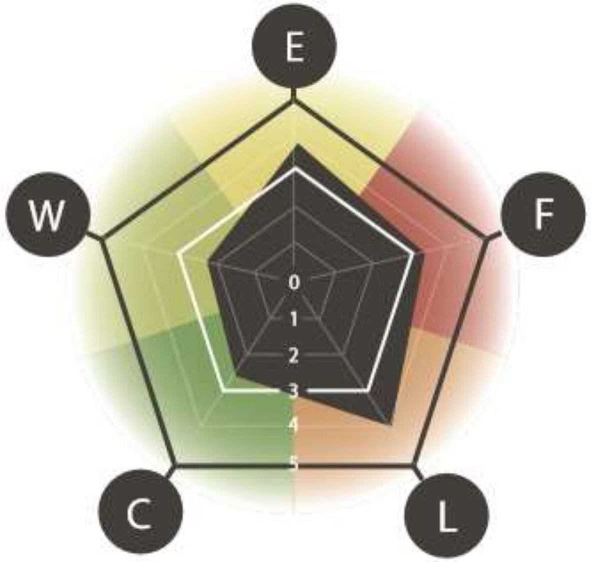
Notes: Figure 53 summarises the major data linkages between the models implemented for the *National Outlook* project.

Bryan, B., 2015.

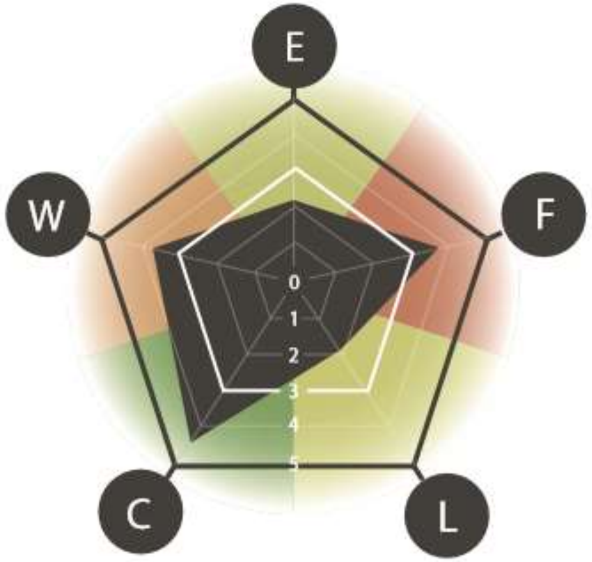
FAO’s RAPID ASSESSMENT



A. SOLAR IRRIGATION IN REGION a



B. HYBRID DIESEL-SOLAR IRRIGATION IN REGION a

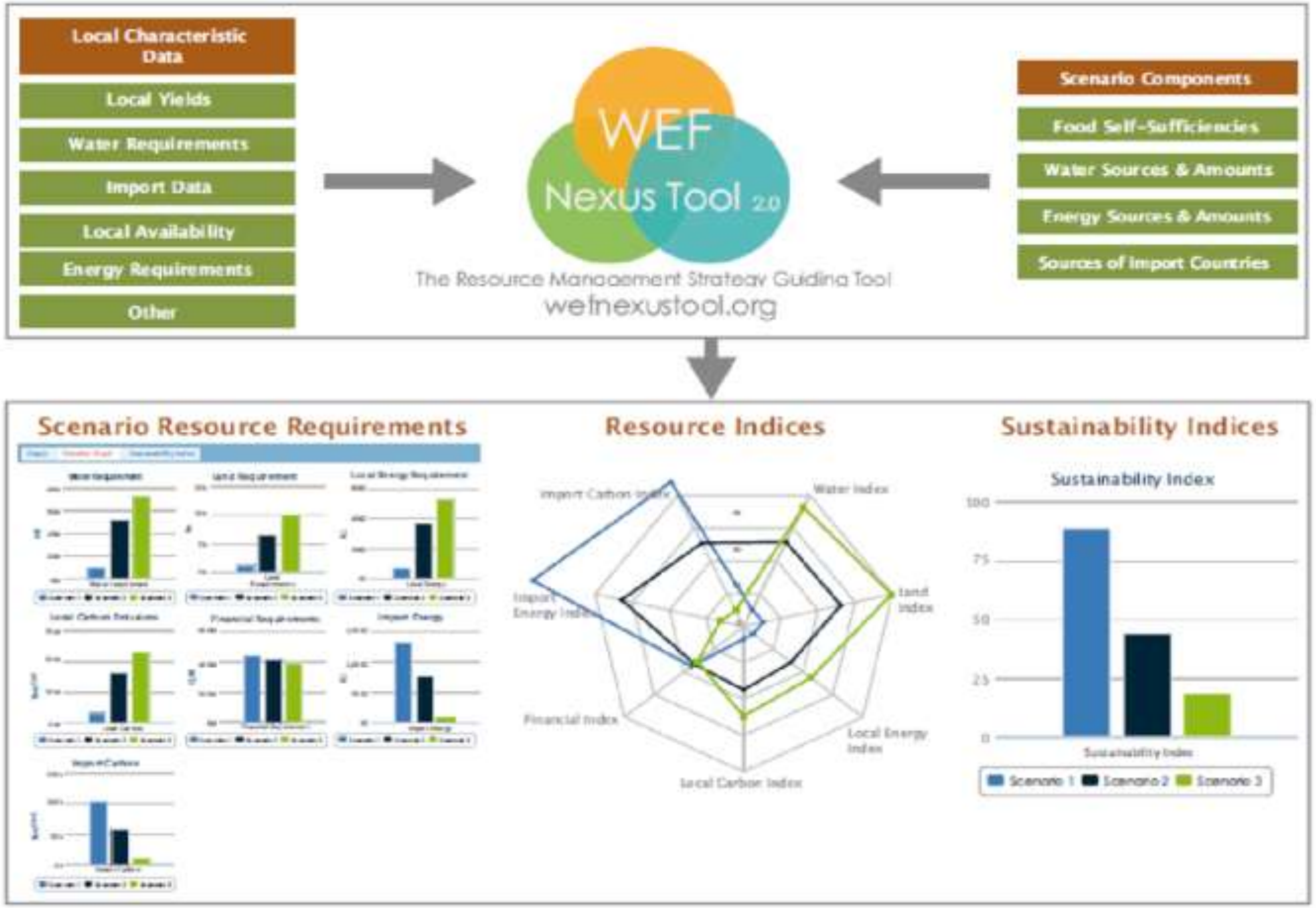


C. MINI-HYDRO IN REGION a

Flammini, A., 2014.

Water, Energy, Food Nexus Tool

- Sustainable resource management strategies based on quantification of resources
  - (water, energy, land, economic, societal) requirements:



Mohtar & Lawford 2016;

DM- Providing ‘just’ the right amount of info.

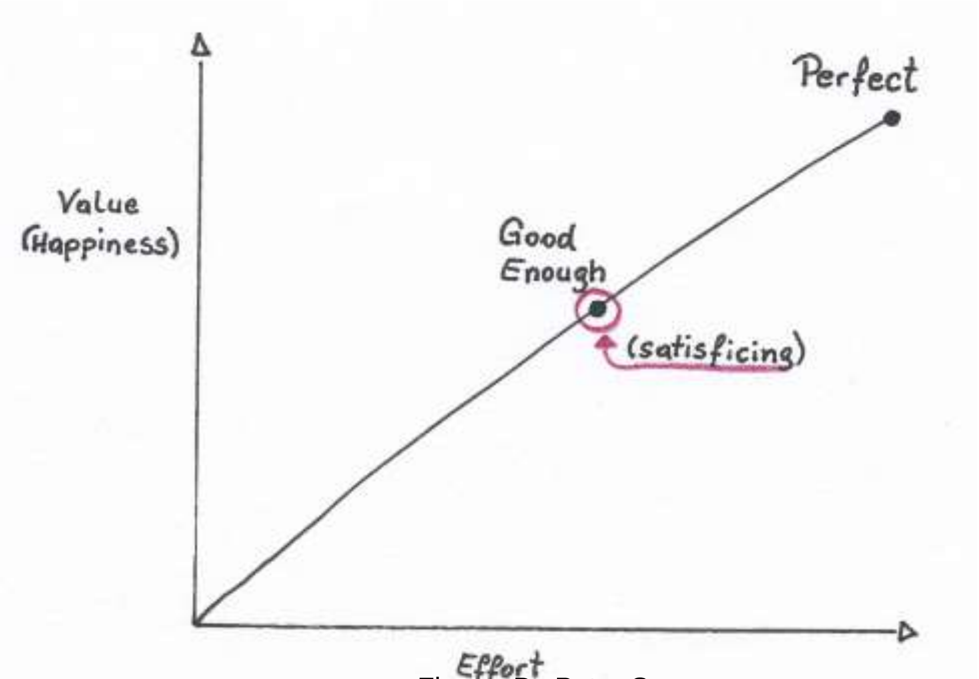


Figure: By Petra Somner

Concept of Satisficing
Herbert Simon, 1956

NEXUS Sustainability Indicators

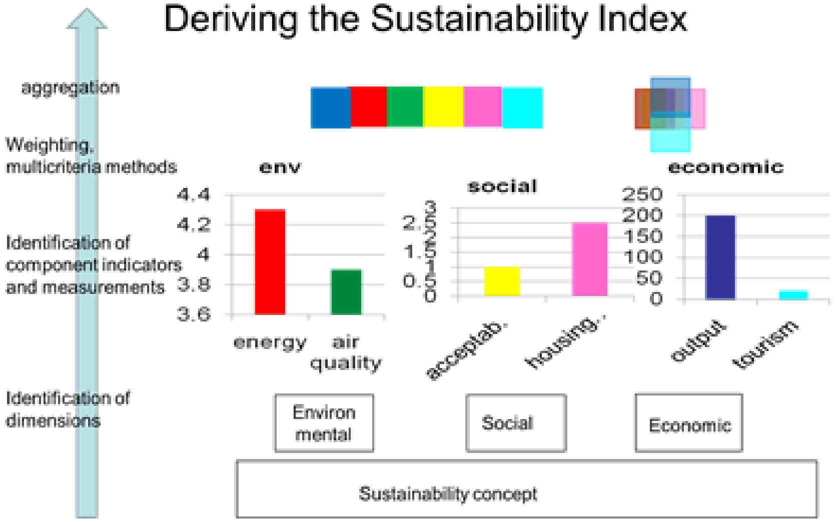
Table A.3 (part 3 of 3)

Summary table of data and indicators for specific nexus issues linking sustainable energy and food security objectives (indicators in italic are possible indicators currently not collected)

	ACCESS TO MODERN ENERGY SERVICES	EFFICIENT USE OF ENERGY	THE ENERGY PRODUCED AND CONSUMED IS CLEAN/ RENEWABLE	Indicators or indicator components relevant to all sustainable energy components
FOOD STABILITY	**Energy subsidies and high/ stable yields** *Variation of production of the 4 main crops/modern energy used in agriculture* **Underground water pumping** Percentage of agricultural land classified as having moderate to severe water erosion or wind risk [j] *Amount of water pumped for agriculture / cost of electricity, diesel, gasoline used in water pumping*	**New technologies and practices in agriculture** Agriculture, value added (% of GDP) [c] *Economic value of food products / Reduction of use of non-renewable energy* **Food transport** *Energy associated with transport of a national food basket*	**Delinking the food and energy markets** *Percentage of renewable energy used in agrifood systems* Change in consumption of fossil fuels and traditional use of biomass [e] , includes: i. Substitution of fossil fuels with domestic bioenergy measured by energy content and in annual savings of convertible currency from reduced purchases of fossil fuels [e] ii. Substitution of traditional use of biomass with modern domestic bioenergy measured by energy content [e]	Domestic food price volatility [m] Per capita food production variability [m] Per capita food supply variability [m]
...licator components ...curity components	Share of households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy [d] Energy use (kg oil equivalent)		Fossil fuel energy consumption (% of total) [c] Primary production of renewable energy (total and disaggregated by hydro, wind, solar, biomass and renewable waste, geothermal) [o]	

- Flammini (2014)

Indicator Complexity/Heterogeneity



Simplify yet preserve meaning?

Aggregation methods:

Simple (transparent).

SMART, TOPSIS

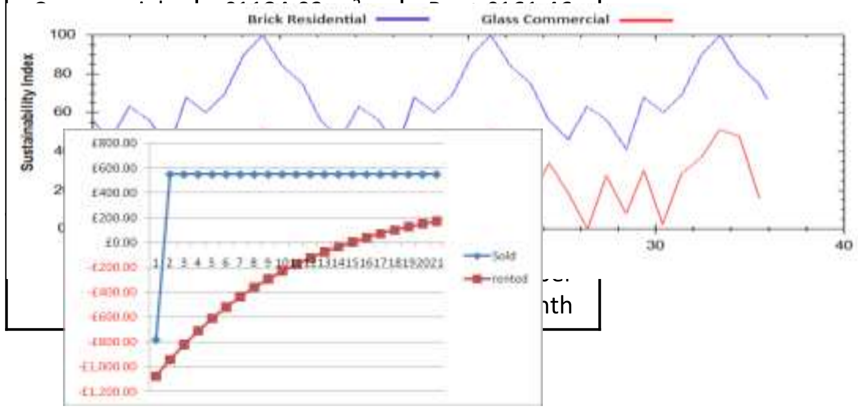
Blackbox methods.

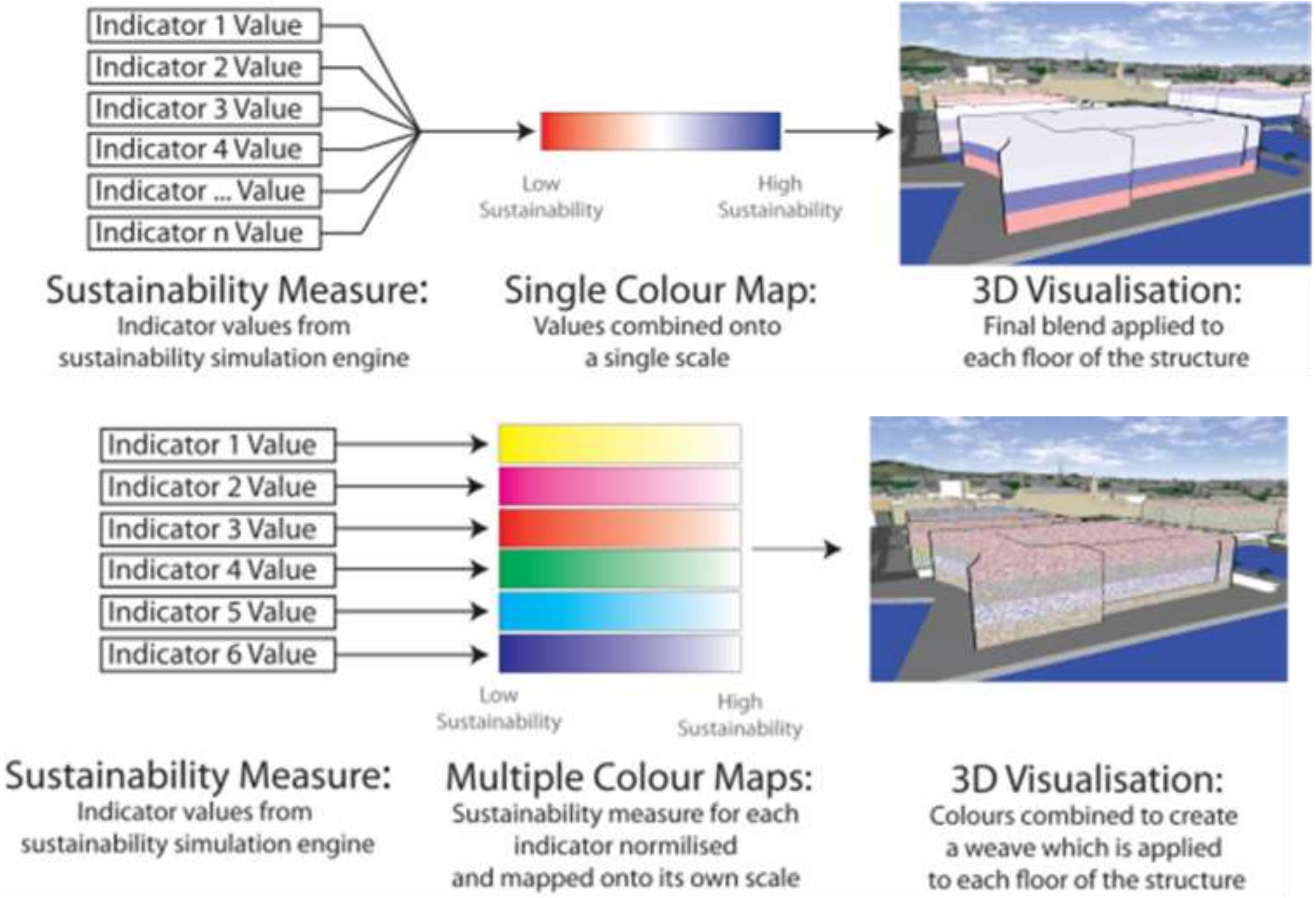
ELECTRE. PROMETHEE, ANP

Visualising Urban Sustainability Indicators

Energy efficiency, Noise pollution, Economic, Acceptability, Housing Provision

Building type	Capital Cost	Sale / Rental Value
Residential	£861.11 m^2	Sale £1614.59 m^2
[illegible]	[illegible]	[illegible]





$$\text{Total noise level} = 10 \log_{10}\left[\sum_{1}^{n} [Antilog_{10}\left(\frac{L_n}{10}\right)\right] dB(A)]$$

Falconer R,… 2013

Decision Support Framework & Criteria

Stage1: Identification of appropriate candidate technologies
- Facilitator

Stage 2: Criteria Ranking, Weighting and Scoring; initial MCDA
- Multi Stakeholder

Stage 3: MCDA and Risk Analysis
- Facilitator

Stage 4: Final Decision
- Multi Stakeholder

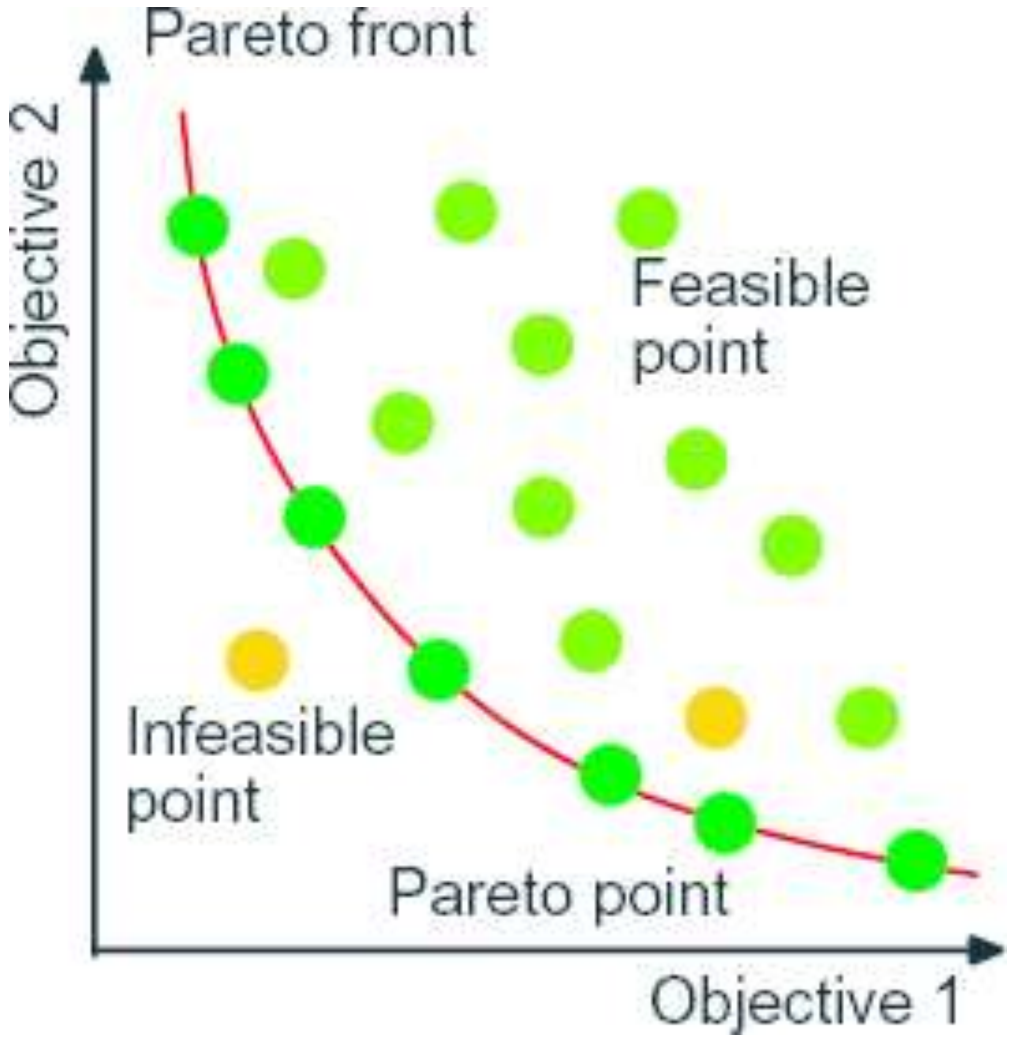
Category	Primary Criteria	Criteria	Description	Units
Economic	Life Cycle Cost	**Capital Cost**	Capital Cost	£
		Maintenance Cost	Maintenance Cost	£/year
		Operational Cost	Operational Cost	£/year
Social	Affordability	**Affordability to householders**	Ability of householders to pay for services delivered	% of household budget
	Willingness to pay	**Williness to pay**	Willingness to pay for attributes covering environmental , safety and health factors	£/unit of reduced risk
	Complexity of operation	**User input required**	User input required to operate the system based on frequency of input needed and competency required	Qualitative
Performance	Flexibility and adaptability	**Adaptability**	Level of accommodation in design: potential and ability to accommodate future changes (qualitative)	Qualitative
	Reliability	**Reliability of the system**	Risk of failure to meet consent conditions due to treatment process malfunction (qualitative).	Qualitative
	Durability	**Durability of the system**	Design life- Number of years system expected to operate successfully	years

MCDA -- SMART & TOPSIS

Label 1: n criteria	criteria label/tech stage 1	C1	C2	C3	C4	C5	C6
Enter weights							
	weights	0.10	0.60	0.09	0.09	0.10	0.06
Enter preference data [1=low, 9=high]	Alternative 1	5	9	9	9	9	8
	Alternative 2	9	9	5	5	6	9
	Alternative 3	1	1	1	1	1	1
Smart calculation performed per alternative		0.5	5.4	0.81	0.81	0.9	0.48
		0.9	5.4	0.45	0.45	0.6	0.54
		0.1	0.6	0.09	0.09	0.1	0.06
		SMART SCORE	RANK				
		11.31	1				
		9.83	2				
		4.75	3				

Closest alternative to ideal solution (highest value is best)		TOPSIS SCORE	Rank
	Alt 1	0.015	2.00
	Alt 2	0.955	1.00
	Alt 3	0.000	3.00

MCDA – Pareto Fronts MOO



- An exploratory approach of the entire problem space can be tremendously valuable to DM by laying bare unforeseen issues and rebound effects.
- When solving real-world nexus problems, it is difficult to constrain the number of decision variables/objectives leading to both larger problem space and increased cost per evaluation .

Summary

- No silver bullet – method depends on the aim: understand, govern or enhance the nexus
- Mixture of methods will be required reflecting the interdisciplinary nature of WEF problem.
- Stakeholder engagement will be key in model/tool development as no one discipline can build a NEXUS model
- Visualisation will be a key tool in conveying and understanding the complexity