ES 27

Systems-2 Modeling

Human Challenges

are

Systems Challenges

Characteristics of Systems

- Purpose – a property of the system
- All parts must connect to fulfill the purpose
- All parts must be arranged in a certain order for the system to function
- Stability of the system is created by feedback loops
- Flow of information (Transmit and Receive)

Complex Systems

- Systems with many **interacting components**
- Distributed structure with feedback loops
- Interactions give rise to patterns of behavior
- Structure of a system gives rise to its **collective behaviors**
- Nonlinear response (output) to input , often sensitively dependent on input (i.e., can be chaotic)

Systemic Behavior

Types of Loops

- Reinforcing Loops
  - Create more growth (or collapse!)
  - Successive changes that add up (growth) or (decrease/collapse)
- Balancing Loops

Dynamics
System delays

Hidden troubles!

- Feedback control loops create dynamic processes
- Time delays in feedback loop are often
  - Response takes time: the system may over or under react, causing oscillations (swings) that can be very disruptive
  - Changing the duration of the delay, may make large effects on system behavior
- Physical delays – every transaction can take time to happen!
- Correction may take time to happen due to
  - Information delays
  - Perception delays
- Reactions are NOT instantaneous!!

Systems Archetypes

- Common patterns of behavior in organizations.
- Provide insight into the underlying structures
- Alert to future unintended consequences

8 Systems Archetypes

- **Fixes that fail**—A solution is rapidly implemented to address the symptoms of an urgent problem.
- **Shifting the burden**— attention shifts to short-term solutions or to the side effects.
- **Limits to success**—positive performance reaches its limit due to constraints that slow down the performance
- **Drifting goals**— when there is a gap between goal and actual performance, a conscious decision is to lower the goal, leading to lower system performance
- **Growth and underinvestment**—Growth approaches a limit potentially avoidable with investments in capacity.
- **Success to the successful**— A successful effort gets disproportionately larger allocation of the resources to the detriment of the others.
- **Escalation**—Parties take mutually threatening actions
- **Tragedy of the commons**—resource is overused and get exhausted resulting in the shutdown of the activities of all parties in the system.

Addressing Complex Systems

How can we start
Steps I do

Some steps

- Knowing what kind of system, you want to influence
- The rhythms of systemic change
- Scale: do you have to be big to be a systems innovator? small organizations can be catalysts

What can I do?

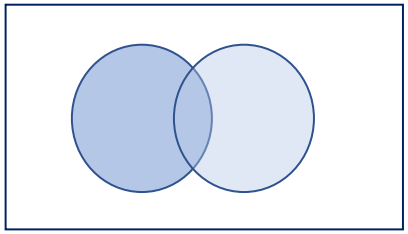
- Everyone has some power to influence systems
- Situate individual actions
- Articulate the direction of systemic change, and link big ideas to individual innovations.

What can you do

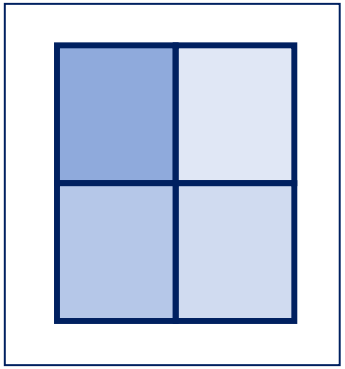
- There are many analytic tools for describing or modelling systems, sometimes with formal
- **Models** (e.g., of the behavior of an aircraft, or water flows in a city), or more conceptual

Mapping the System
Frameworks are Visual Representation

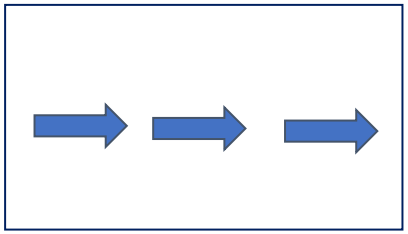
Venn Diagrams help you express a few key themes and the relationships between them. They help you to see the degree of connectedness, overlap and intersection between sets of data.



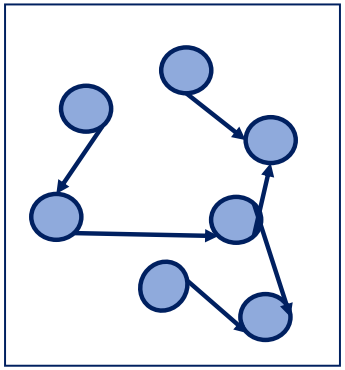
Two-by-Twos help emphasize tensions and categorize modes of behavior. It's a useful tool for categorizing things that can be reduced to two simple (but big) variables.



Journeys are great for looking at an experience over time, from the perspective of the user.



Maps help visually explain key relationships between individuals or systems



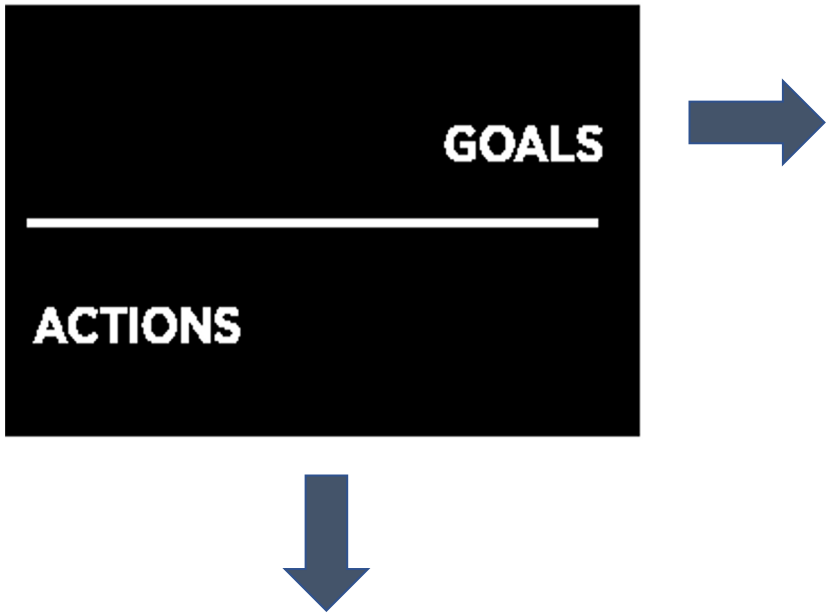
Always the aim is to

Show how different elements influence each other, and how changes in one might affect others.

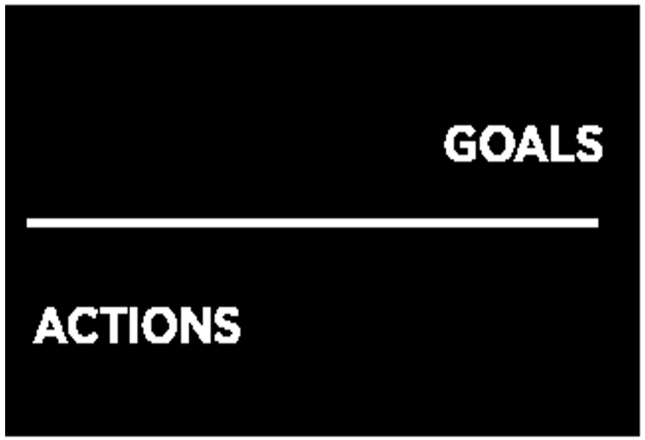
Examples:

- Mapping of the forces involved.
- Systems analysis of the supply chain
- Systems map of neighborhood regeneration (and the small number of variables on which government has significant influence).

Create a Table



Create a Table



An example: System Map for

Obesity

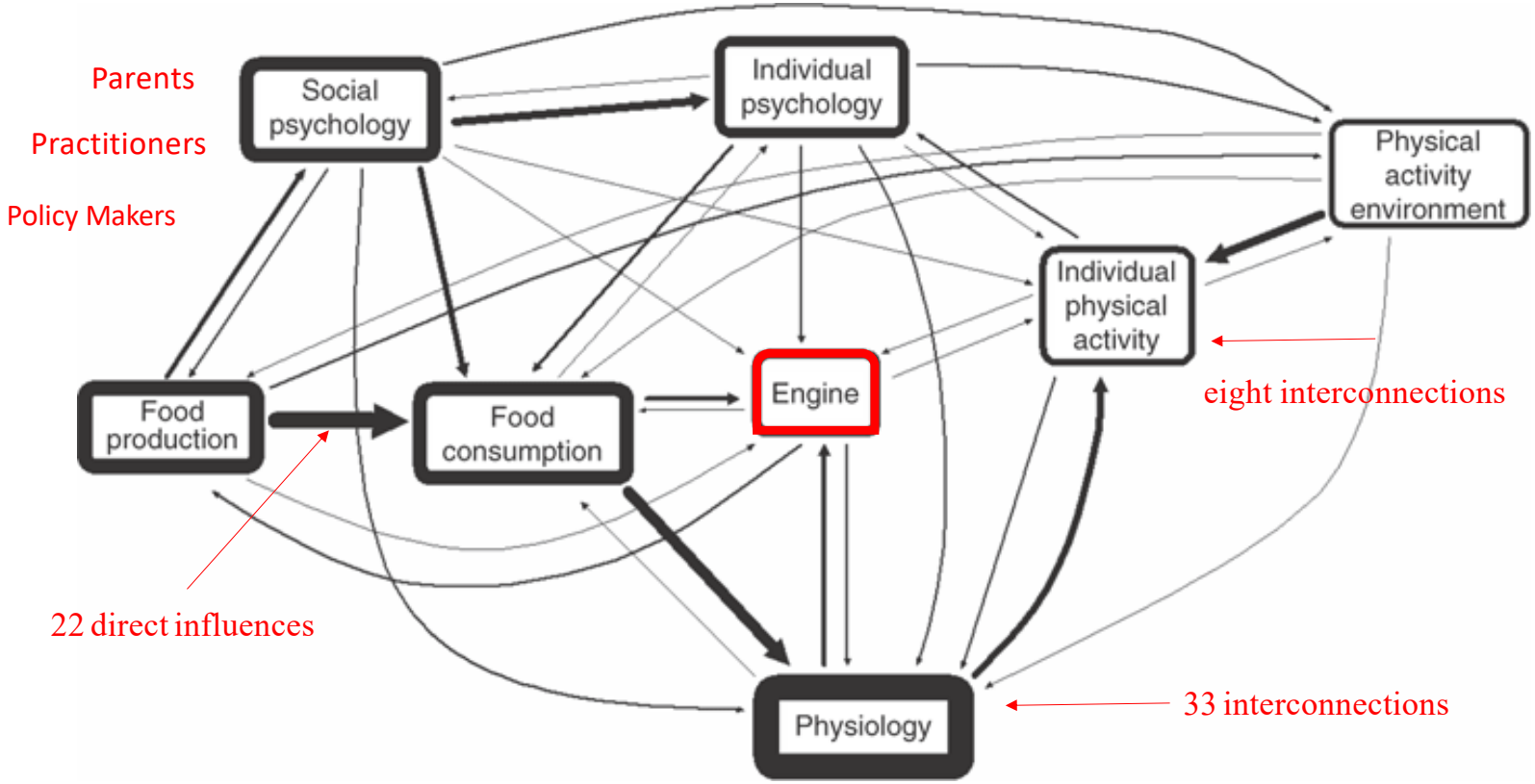
Obesity Causes

- Is the problem “people eat too much and move too little”
- Conceptual models
  - An epidemiological model: agents such as food, viruses, and toxins are acting on a host to produce disease
  - A homeostatic model: fat acts on the brain (controller) which in turn feeds back to act on the fat (controlled system)
  - Genetic model: background loads the gun, and the environment pulls the trigger

Obesity the environment

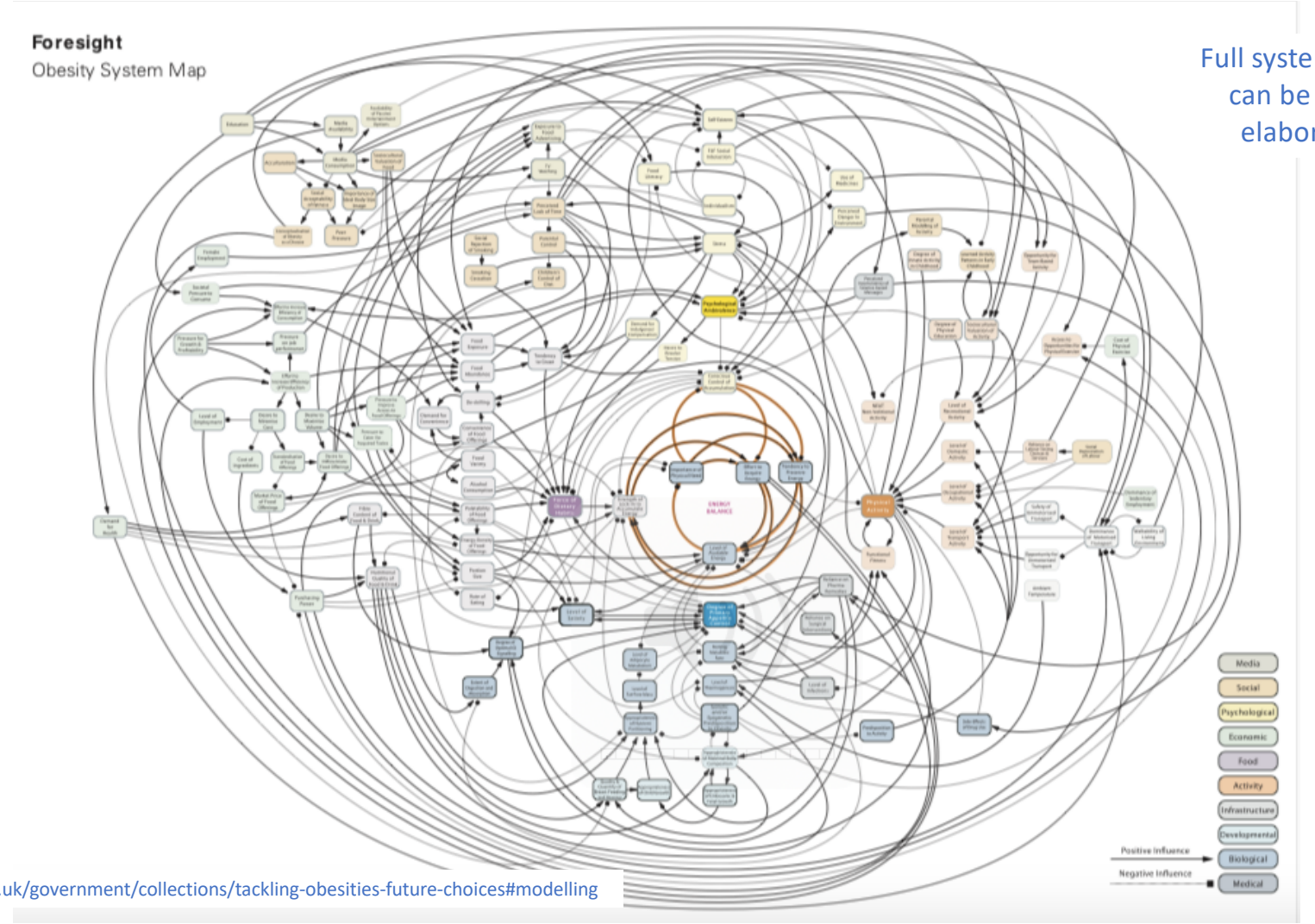
- Work/school/home
- Community/locality,
- National/ regional, and international levels.
- Distal contextual factors
  - globalization of markets,
  - media
  - culture

ENGINE: energy intake - energy expenditure



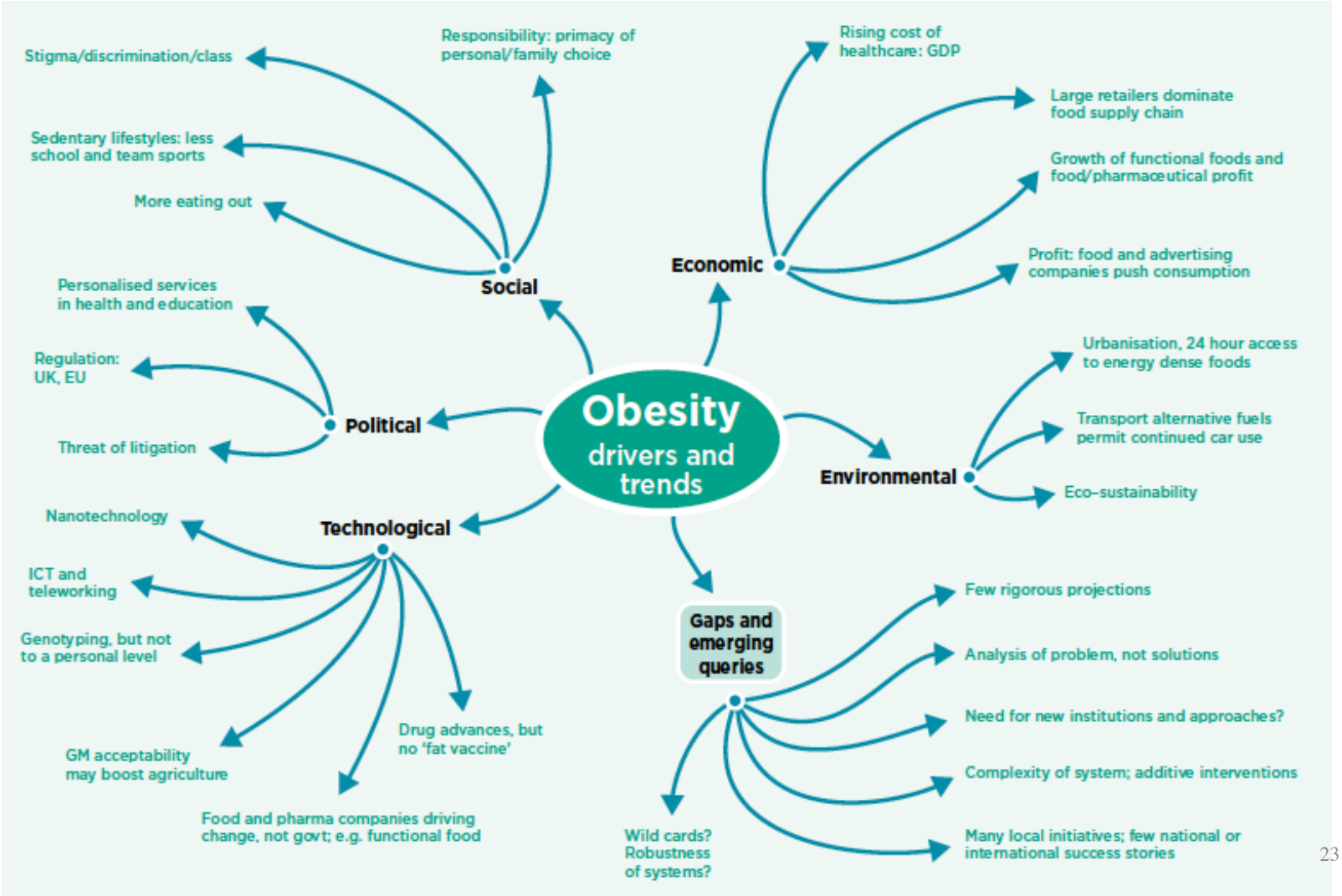
Implications of the Foresight Obesity System Map for Solutions to Childhood Obesity

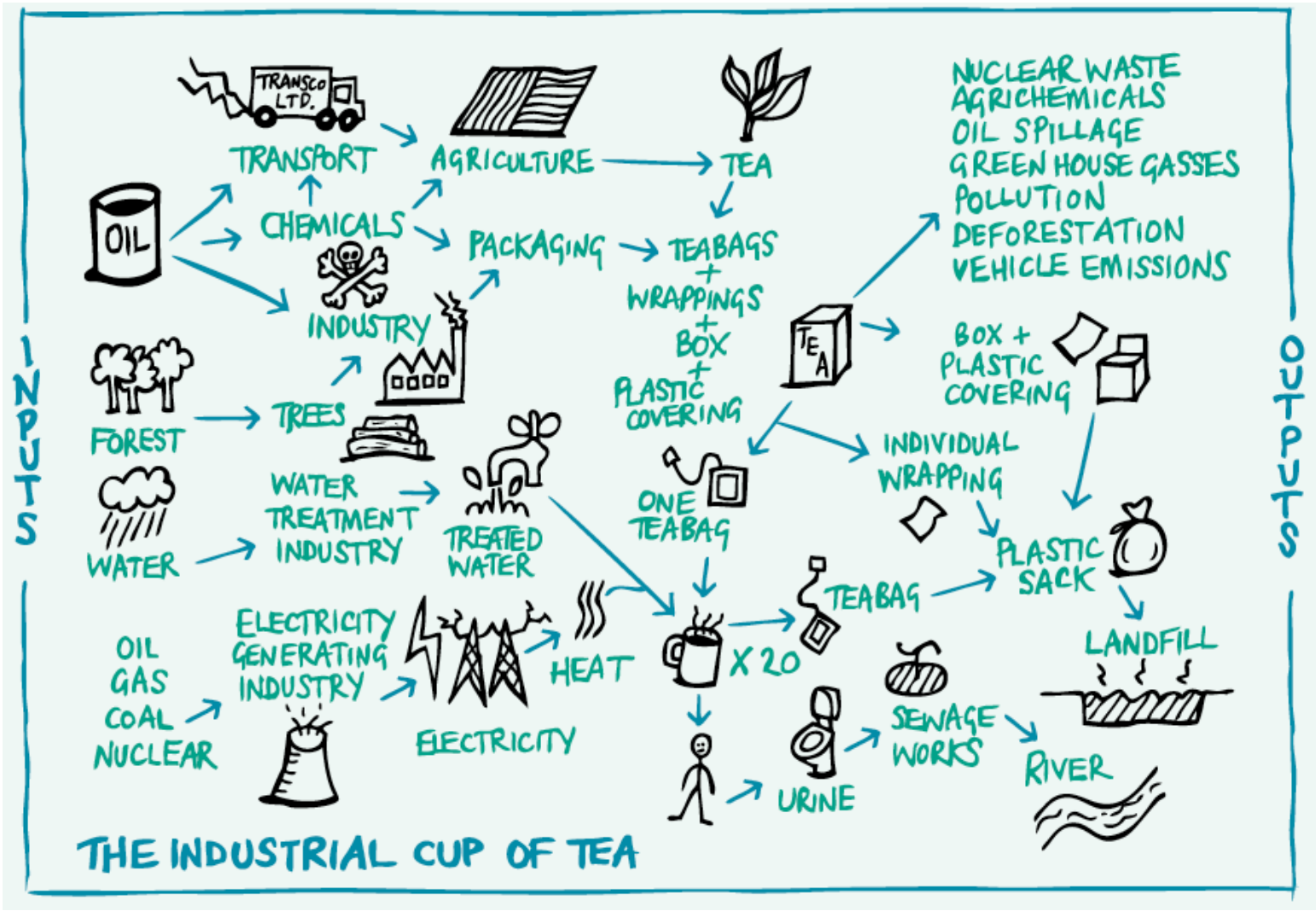
Diane T. Finegood, Thomas D.N. Merth and Harry Rutter -- *Obesity* (2010) **18**, S13–S16. doi:10.1038/oby.2009.426



Full system map can be very elaborate

https://www.gov.uk/government/collections/tackling-obesities-future-choices#modelling


Obesity
drivers and trends
Social
Stigma/discrimination/class
Responsibility: primacy of personal/family choice
Sedentary lifestyles: less school and team sports
More eating out
Economic
Rising cost of healthcare: GDP
Large retailers dominate food supply chain
Growth of functional foods and food/pharmaceutical profit
Profit: food and advertising companies push consumption
Political
Personalised services in health and education
Regulation: UK, EU
Threat of litigation
Environmental
Urbanisation, 24 hour access to energy dense foods
Transport alternative fuels permit continued car use
Eco-sustainability
Technological
Nanotechnology
ICT and teleworking
Genotyping, but not to a personal level
GM acceptability may boost agriculture
Drug advances, but no 'fat vaccine'
Food and pharma companies driving change, not govt; e.g. functional food
Gaps and emerging queries
Few rigorous projections
Analysis of problem, not solutions
Need for new institutions and approaches?
Complexity of system; additive interventions
Many local initiatives; few national or international success stories
Wild cards? Robustness of systems?


INPUTS
OUTPUTS
TRANSCO LTD.
TRANSPORT
AGRICULTURE
TEA
NUCLEAR WASTE
AGRICHEMICALS
OIL SPILLAGE
GREEN HOUSE GASSES
POLLUTION
DEFORESTATION
VEHICLE EMISSIONS
OIL
CHEMICALS
PACKAGING
TEABAGS + WRAPPINGS + BOX + PLASTIC COVERING
INDUSTRY
TEA
BOX + PLASTIC COVERING
FOREST
TREES
INDIVIDUAL WRAPPING
ONE TEABAG
WATER
WATER TREATMENT INDUSTRY
TREATED WATER
PLASTIC SACK
TEABAG
LANDFILL
OIL
GAS
COAL
NUCLEAR
ELECTRICITY GENERATING INDUSTRY
HEAT
X 20
ELECTRICITY
SEWAGE WORKS
RIVER
URINE
THE INDUSTRIAL CUP OF TEA

System Solutions integrates many factors