Environmental Health Indicators: a tool to assess and monitor human health vulnerability and the effectiveness of interventions for climate change

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Abstract

New threats to human health, particularly the emergence and spread of diseases, are becoming a major issue associated with components of global environmental change. Contributing to these human health threats is the role that climate variability and change, and extreme weather events, play in altering disease risk. The role of climate variability and change is important as the process will compound the already significant burden of infectious diseases (eg, vector-, food- and water-borne disease) on national economies and public health. Authorities need to be able to assess, anticipate and monitor human health vulnerability to climate variability and change, in order to plan for, or implement action to avoid, these eventualities. Environmental health indicators provide a tool to monitor human health, to aid in the design and targeting of interventions, and assess the effectiveness of climate change adaptation and mitigation activities.

The primary aim of the research presented was to identify and develop a set of environmental health indicators to explore the relationships between and impacts of climate change on human health, primarily food- and water- borne diseases in New Zealand. In particular, the research focused on salmonellosis and cryptosporidiosis.

Using the Driving force-Pressure-State-Exposure-Effect-Action (DPSEEA) framework, a set of 18 environmental health indicators were identified and developed. Their utility as a tool to assess and monitor human health vulnerability, and the effectiveness of

interventions for climate change, is being explored using a Bayesian network analysis approach. This novel approach involves using historical data for the 18 environmental health indicators to make what-if predictions of possible health outcomes (Effects eg, disease notifications) from a range of likely interconnected input scenarios (Driving forces, Pressures and Exposures eg, population growth, climate change, water quality) to inform adaptation and policy development (Actions eg, reduced private car use).

Environmental Health Indicators

a tool to assess and monitor human health vulnerability and the effectiveness of interventions for climate change

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NEW ZEALAND CLIMATE CHANGE CENTRE

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Health Analysis & Information For Action (HAIFA) project

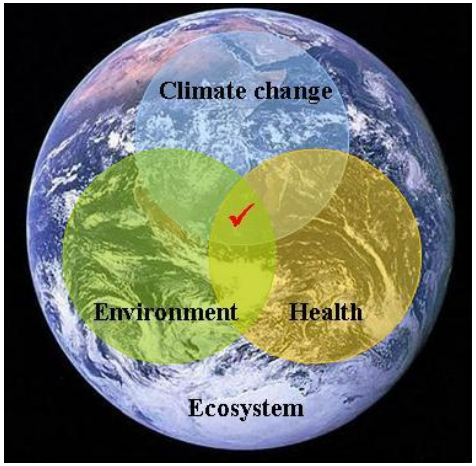
- Develop a resource system for reducing NZ's vulnerability to human health impacts of climate variation & change
- To support central, regional & local authorities respond to potential infectious disease risks associated with climate change
- Aim to provide end-users with scientifically robust methods & tools to develop appropriate responses & adaptive strategies for increasing human health resilience to the infectious disease consequences of climate variation & change

Health Analysis & Information For Action (HAIFA) project - components

1. Development of disease specific predictive models for climate change projections via the analysis of health, climate & environmental data at the 5x5 km spatial scale
2. Development of a GIS web-based interface, incorporating Component 1, with the ability to carry out 'what-if' scenarios for different climate change projections
3. Provision of further stakeholder support by the development of additional stand alone modules
   - DAISY (Disease Attribute Intelligence System)
   - Stakeholder interviews
   - Water Vulnerability Assessment Framework
   - Environmental Health Indicators (extended by MPhil work)

Environmental health indicators objective

- **Identify & develop a set of EHIs to explore the relationships between & impacts of climate change on human health**
  - **focused on food- & water-borne diseases**
  - **salmonellosis & cryptosporidiosis**



Environmental health indicators

- **Provide information about a scientifically based linkages between the environment & health**
- **Enable the conversion of data to information by:**
  - **summarising the complex relationships between the environment & health**
  - **presenting them in a form that is more easily interpreted by the end-users (e.g. policy makers)**

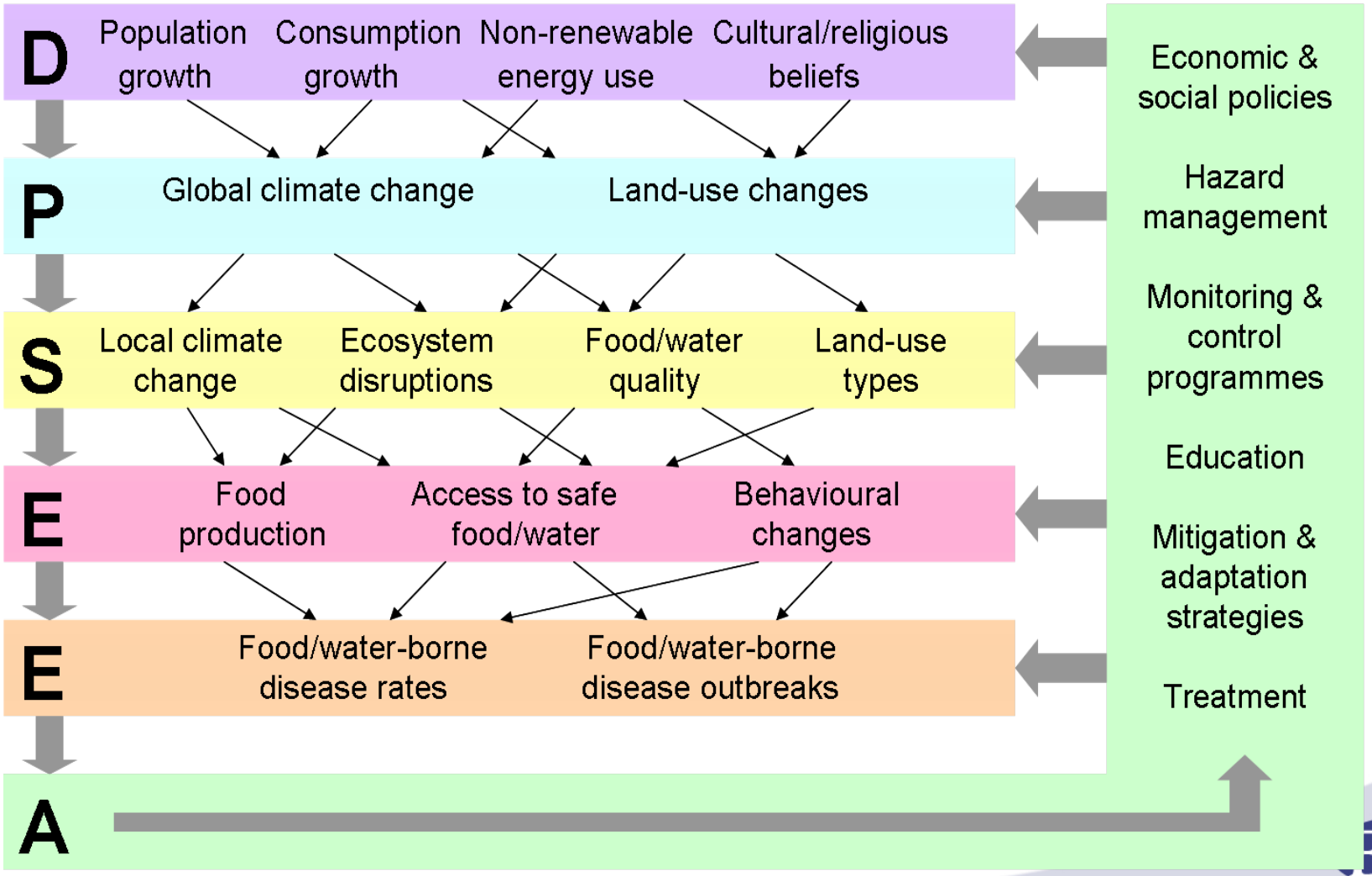
Environmental health indicators

- **EHIs are a tool to:**
  - **assess & monitor health vulnerability**
  - **identify interventions & measure their effectiveness**
- **Provide baseline information for monitoring risks & to detect hotspots & trends**
- **Used with modelling to enable scenario projections (e.g. epidemics, cost/benefits of interventions)**
- **Improve ecological well-being by identifying intervention points higher up the causal chain/network**
- **Early warning tool for identifying ecosystem disruption**

Framework

Driving force – Pressure – State – Exposure – Effect – Action

- **Evaluated 11 frameworks (published paper)**



 Adapted from: WHO (2001) & Hambling & Slaney (2007)

Selected environmental health indicators

- **18 EHIs: 13 for cryptosporidiosis & 14 for salmonellosis**

DPSEEA component	EHI name
Driving force	Population growth
Pressure	Energy consumption
	Greenhouse gas emissions – total; animals & fertiliser
	Land cover
	Livestock numbers
	Climate – temperature; rainfall
State	Drinking water quality – protozoan compliance
	Recreational water quality
Exposure	Drinking water quality – population exposure
Effect	Cryptosporidiosis – notifications; outbreaks
Action	Adaptations and policy development

Bayesian network

- Network that depicts conditional probability relationships between nodes
- Nodes represent system components e.g. specific indicators
- Links represent probabilistic dependencies between states of components
- Can model a situation where causality plays a role but our understanding of what is going on is incomplete
- Allows the modelling of uncertainty & outcomes by combining common sense knowledge & observational evidence
- So probability is based on knowledge & data

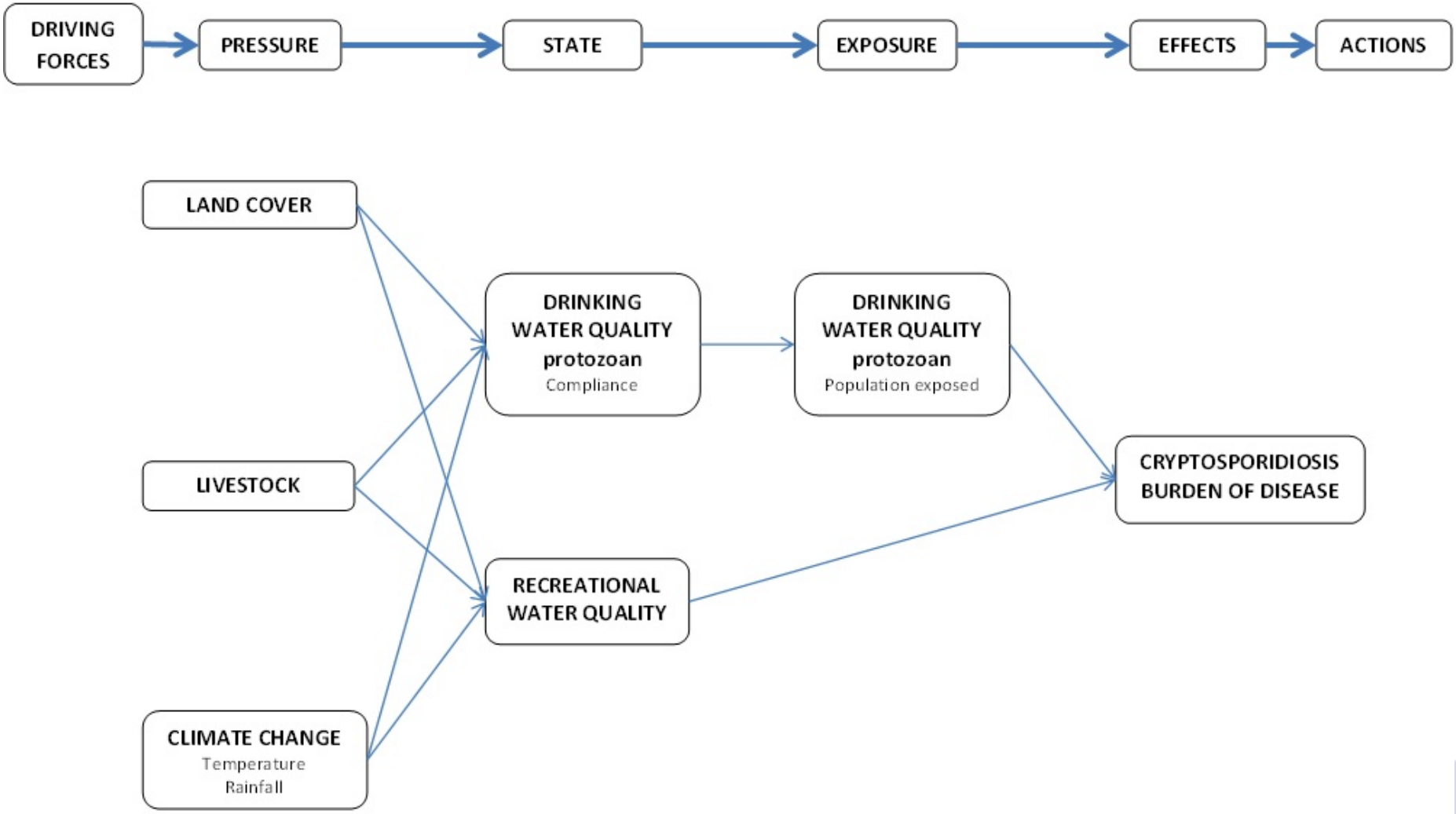
Bayesian network - advantages

- Easily updated with new submodels and new information
- Spatial and landscape components can be included as separate nodes
- Tool for communicating complex environmental problems among experts, managers and stakeholders
- Integrate models of different types
- Can be used as a decision making tool
- Transparent

Bayesian network - disadvantages

- Can not use feedback loops
- Variables must be discrete
  - continuous variables can be categorised to discrete ones
- Not optimal for statistical inference
- Difficulty reaching agreement on network structure?

Bayesian network
Cryptosporidiosis model



Bayesian network

- **Will use a combination of historical data & expert opinion to inform the probability matrix**
  - difficulty using just historical data because data at different spatial scales
- **Use model informed by the EHIs to**
  - make predictions of health outcomes (effects)
  - from a range of ‘what-if’ input scenarios (pressures or interventions)
  - to inform adaptations & policy development (actions)
- **Examples**
  - investigate the potential impact a 2–5 ^{o}C increase in temperature will have on the burden of disease
  - or the effect of altered vegetation cover (e.g. riparian vegetation)

Thank you

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Framework paper reference

Hambling T, Weinstein P, Slaney D. (2011) A review of frameworks for developing environmental health indicators for climate change and health. ***International Journal of Environmental Research & Public Health*** **8(7):2854–2875; doi:10.3390/ijerph8072854**