# Achieving human and ecosystem health benefits through integrated watershed management

**Ama Wakwella**

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Aaron Jenkins *(UniSyd/ECU, Public Health/Science)*

# Watersheds for people and ecosystems



Jane Thomas IAN Image Library (ian.umces.edu/imagelibrary)
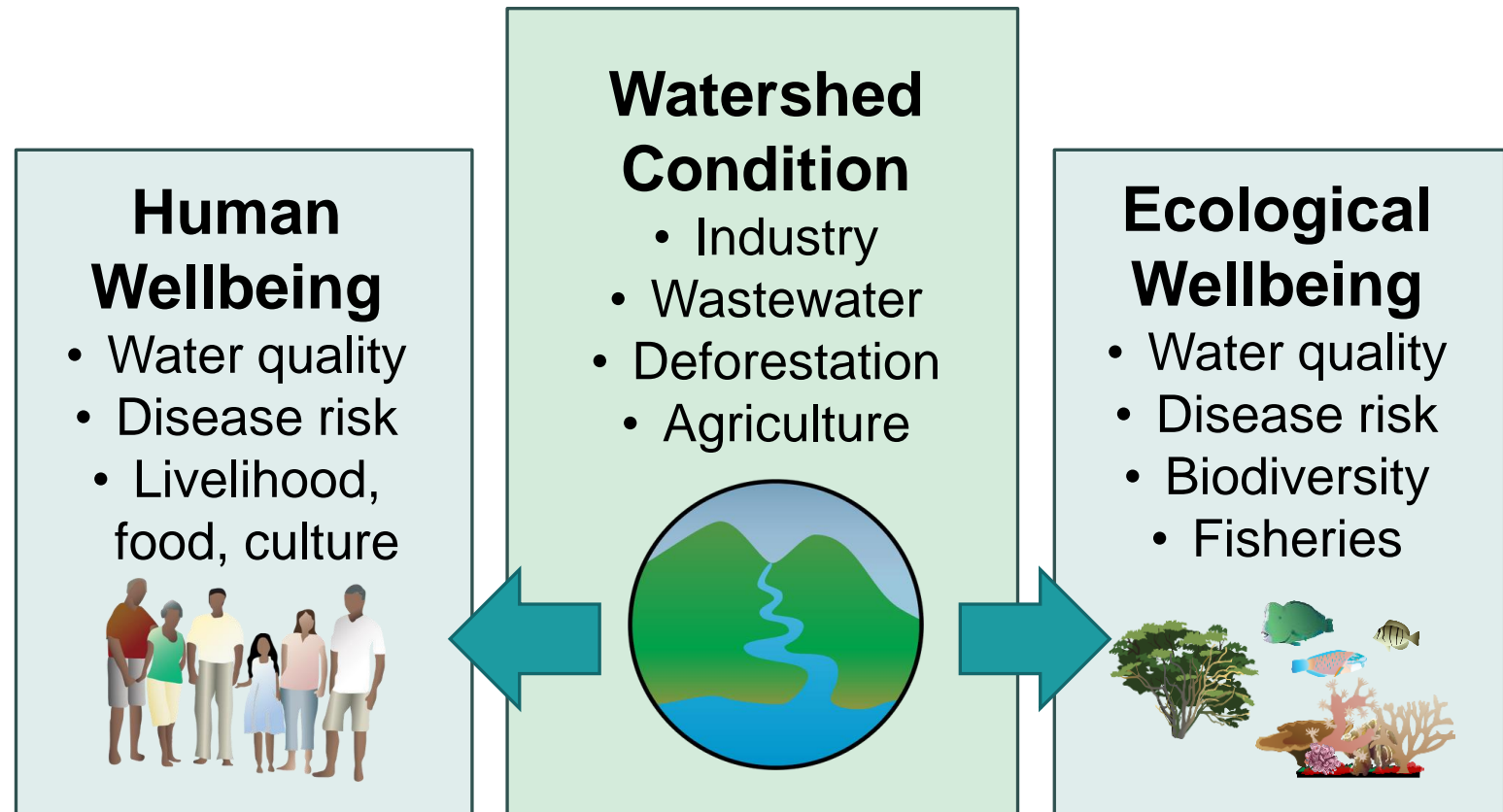
**Human Wellbeing**
- Water quality
- Disease risk
- Livelihood, food, culture

**Watershed Condition**
- Industry
- Wastewater
- Deforestation
- Agriculture

**Ecological Wellbeing**
- Water quality
- Disease risk
- Biodiversity
- Fisheries

# Fiji as a case study

Expanding human developments within watersheds can have big impacts on **coastal ecosystems**

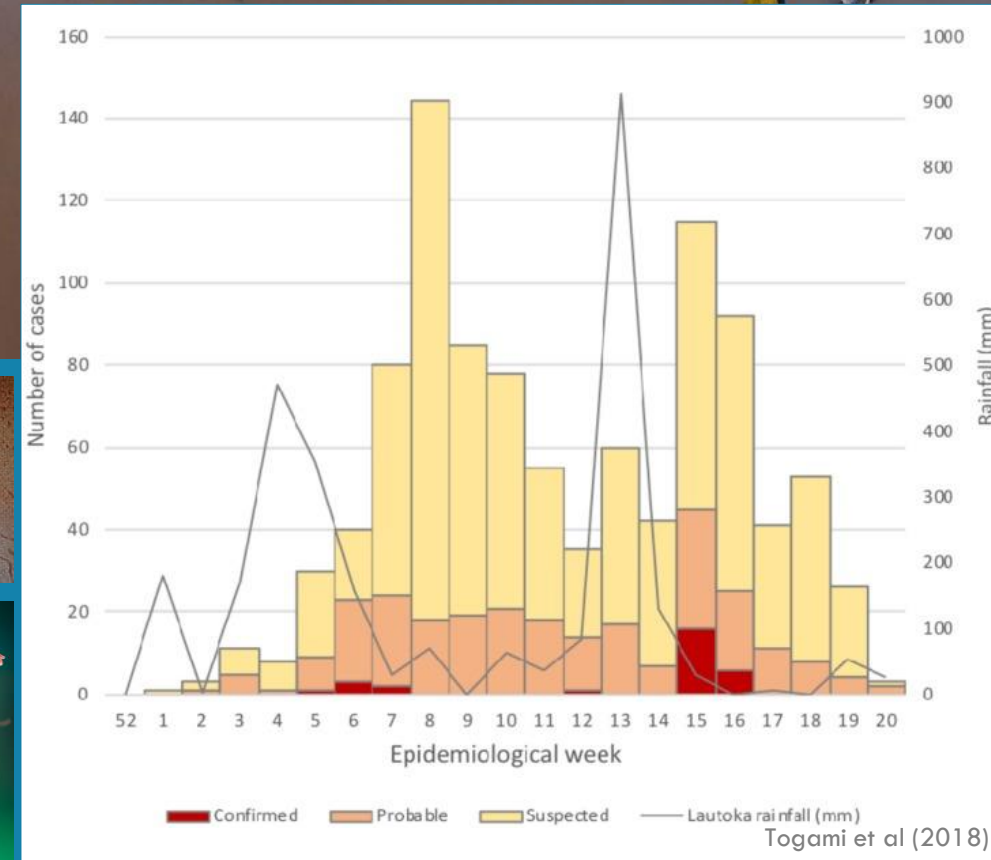Diverse and sensitive coastal ecosystems are threatened by land-based pollution
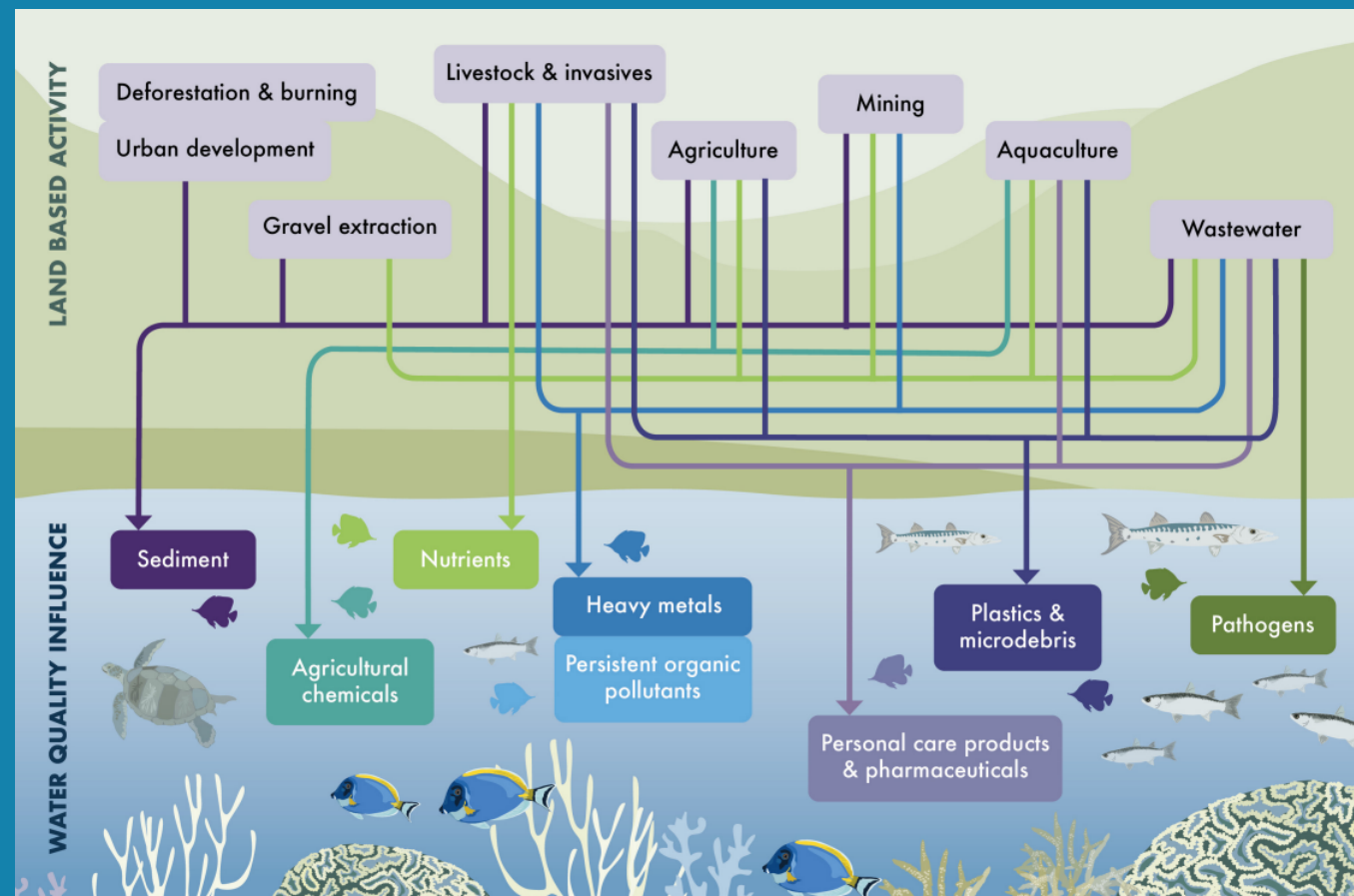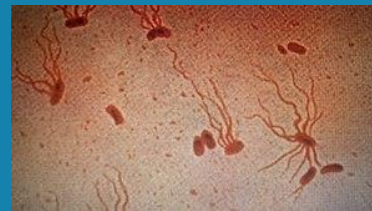
# Fiji as a case study

Expanding human developments within watersheds can have big impacts on **human health**

Endemic water-related diseases are associated with runoff, flooding, and watershed modification
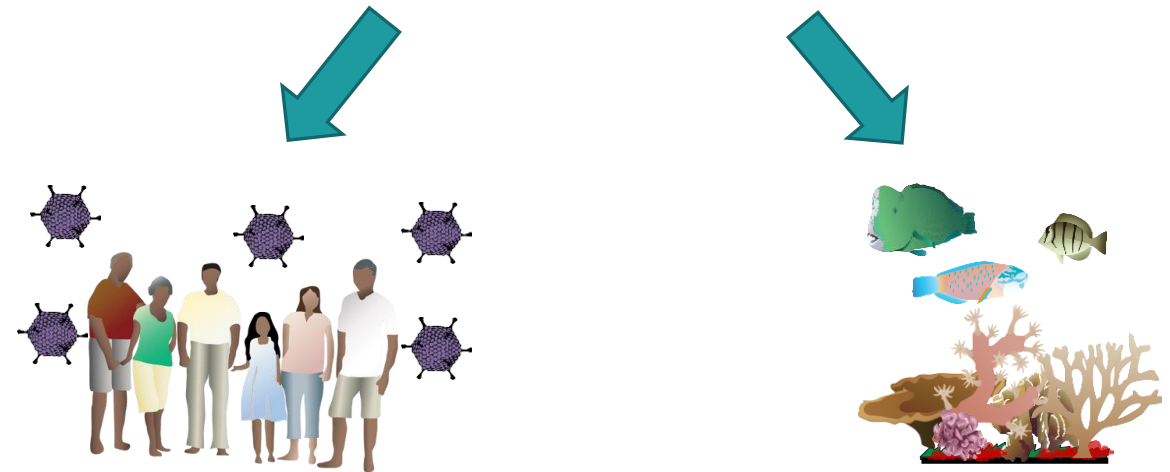


ABC: Ron Vave Photography

Togami et al (2018)

# Opportunity for co-management!

Can we find areas in Fiji where changing human activities might benefit both coral reefs and also disease mitigation?

# Identifying high-benefit sub-catchments in Fiji

**Aim** to identify and rank sub-catchments where watershed modification is contributing to:

(1) Above average levels of water-related infectious disease;
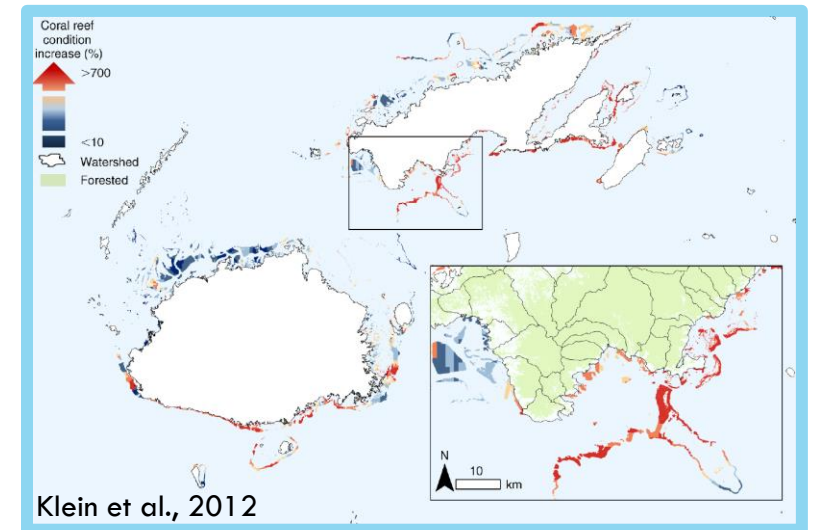
AND

(2) Reductions in coral reef condition



**Bayes network**

**Multipli-cative model**
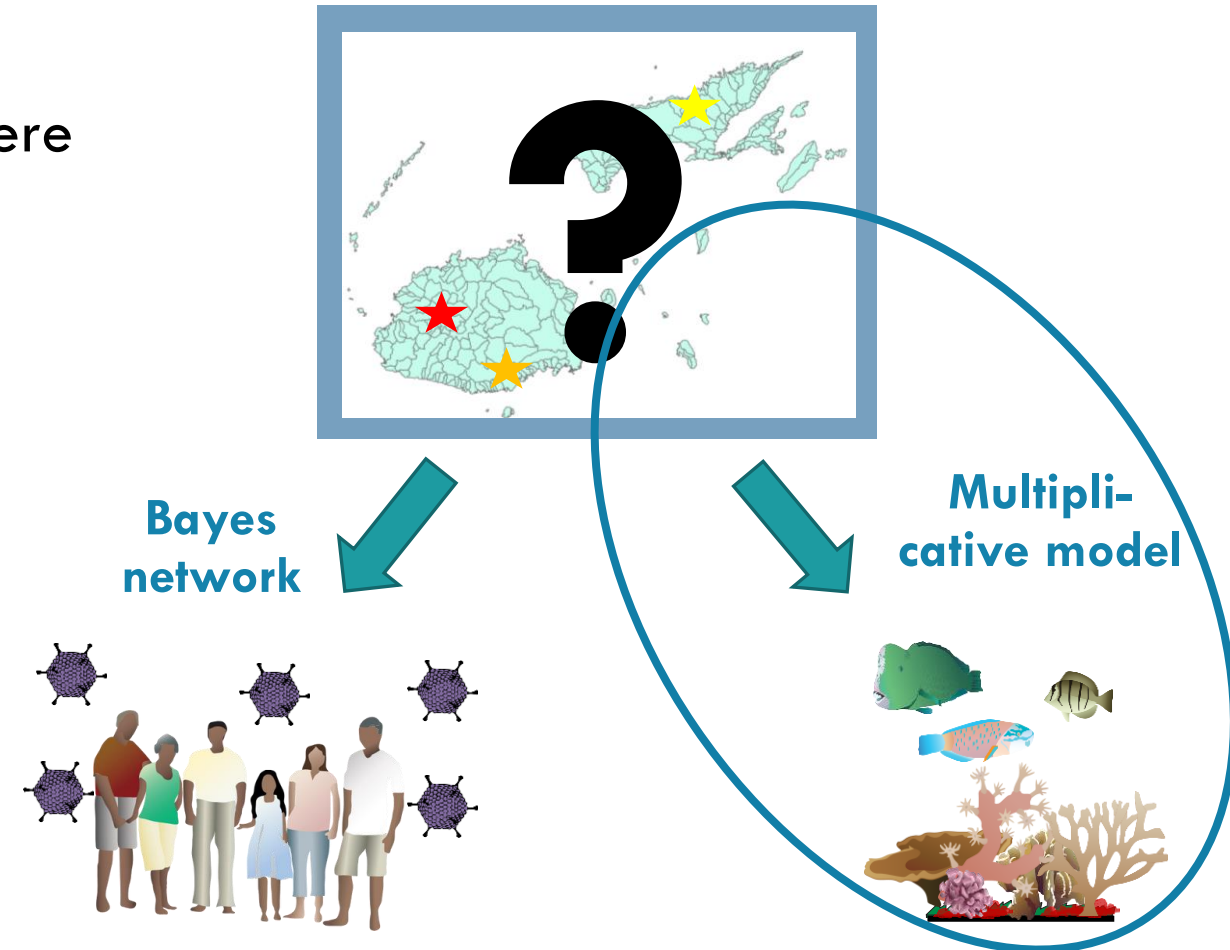
# Coral reef condition: multiplicative risk model

**(1)** Looking for sub-catchments contributing to reductions in coral reef condition
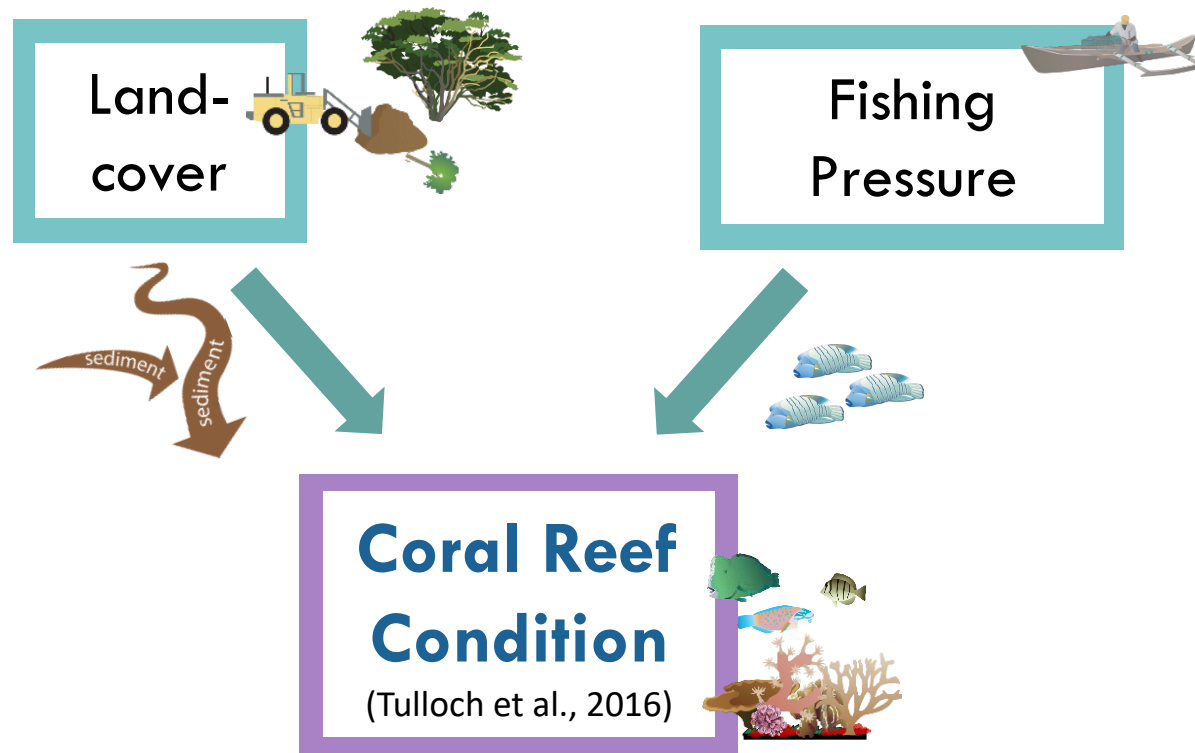


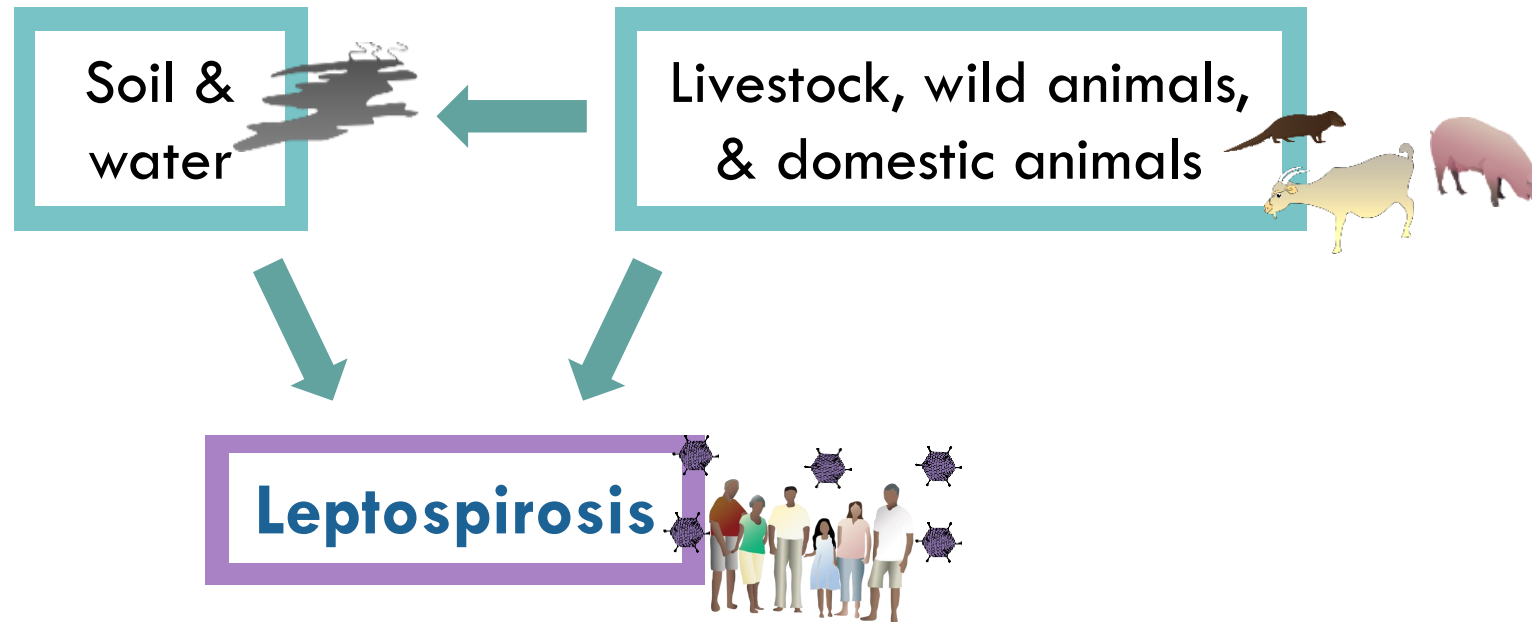- Existing models in use for Fiji and Pacific
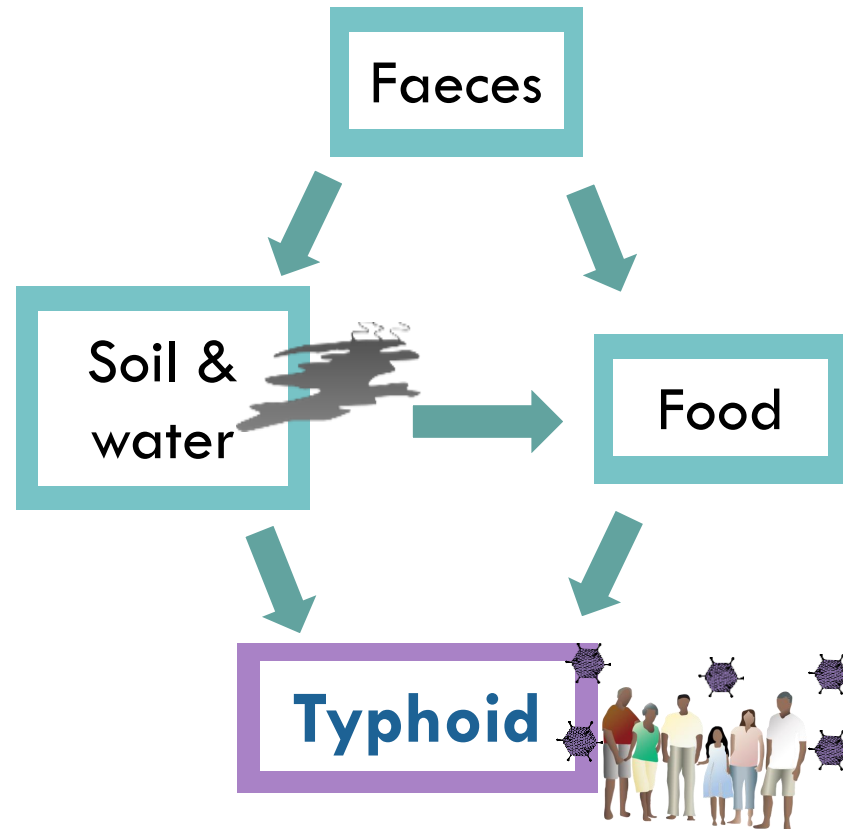
Klein et al., 2012

# Disease model: Bayesian belief network

**(2)** Looking for sub-catchments contributing to high levels of leptospirosis and typhoid

# Disease model: Bayesian belief network

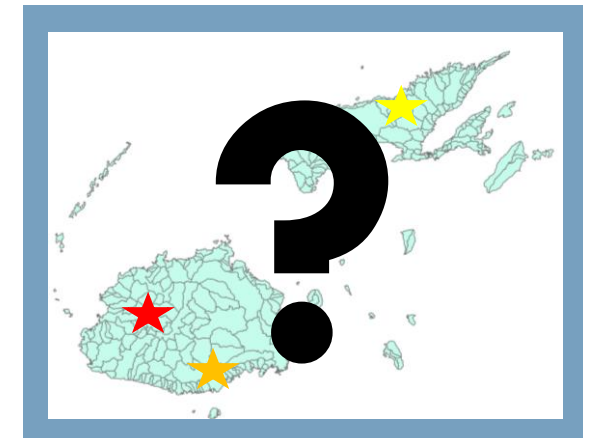**(2)** Looking for sub-catchments contributing to high levels of leptospirosis and typhoid
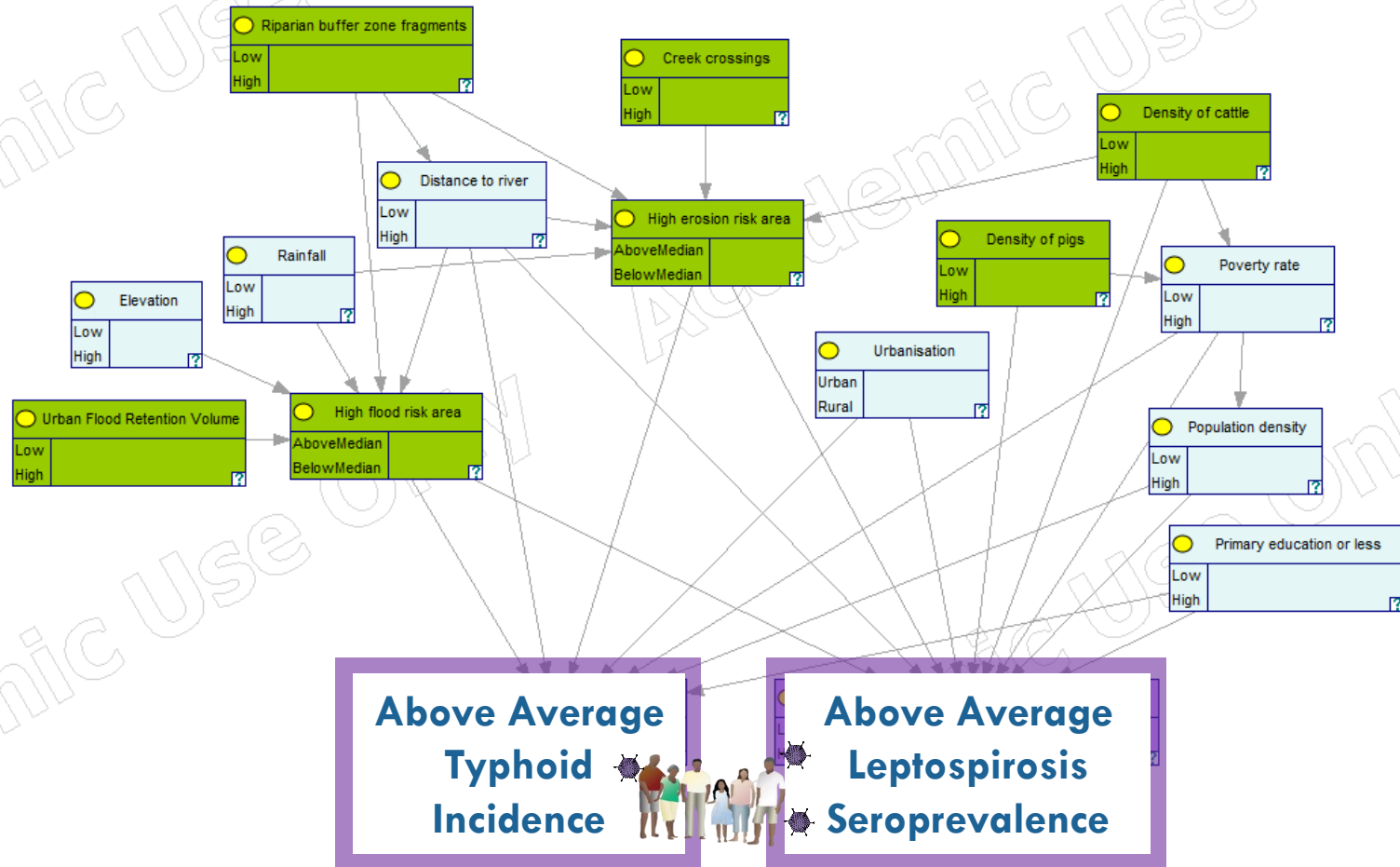
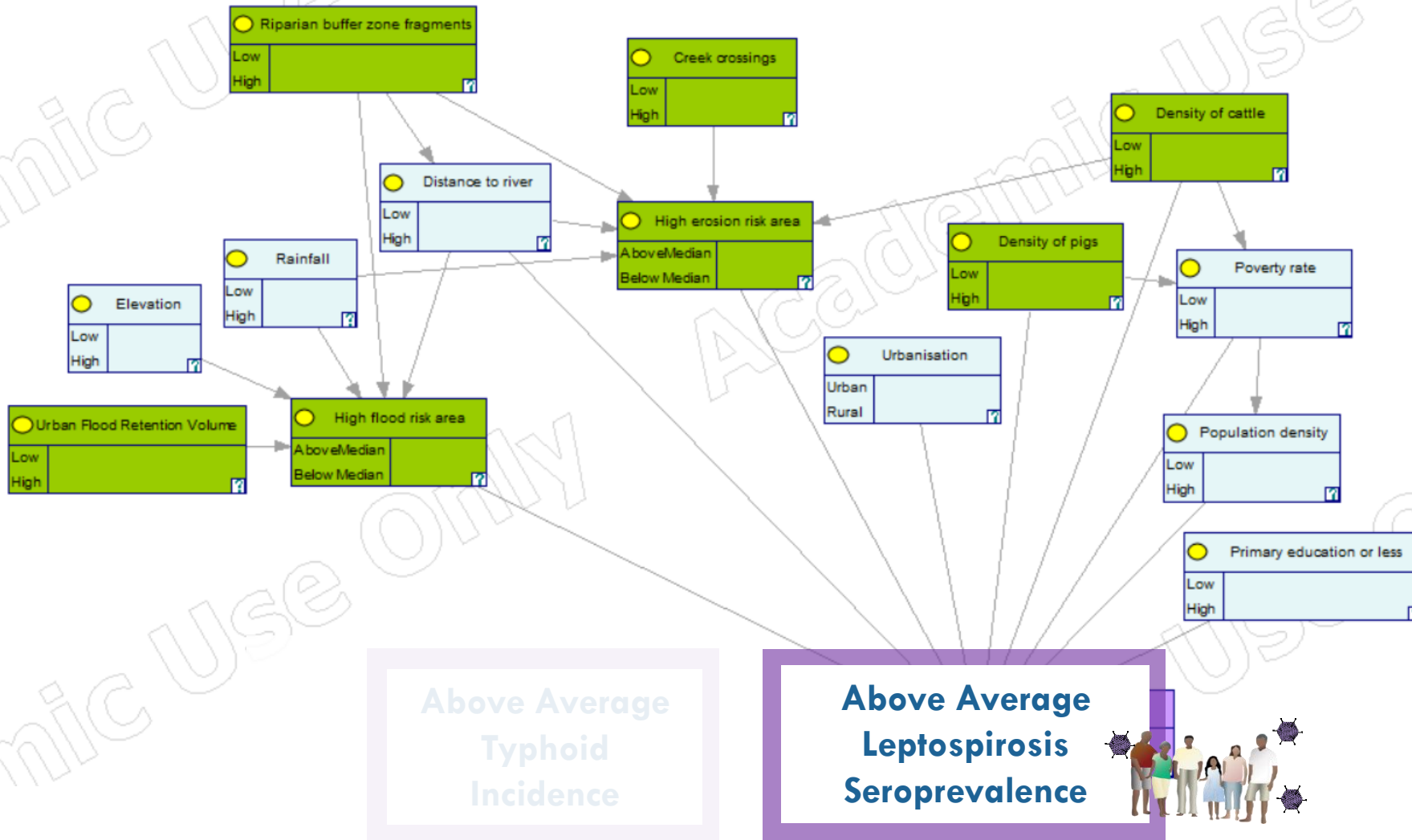# Disease model: Bayesian belief network

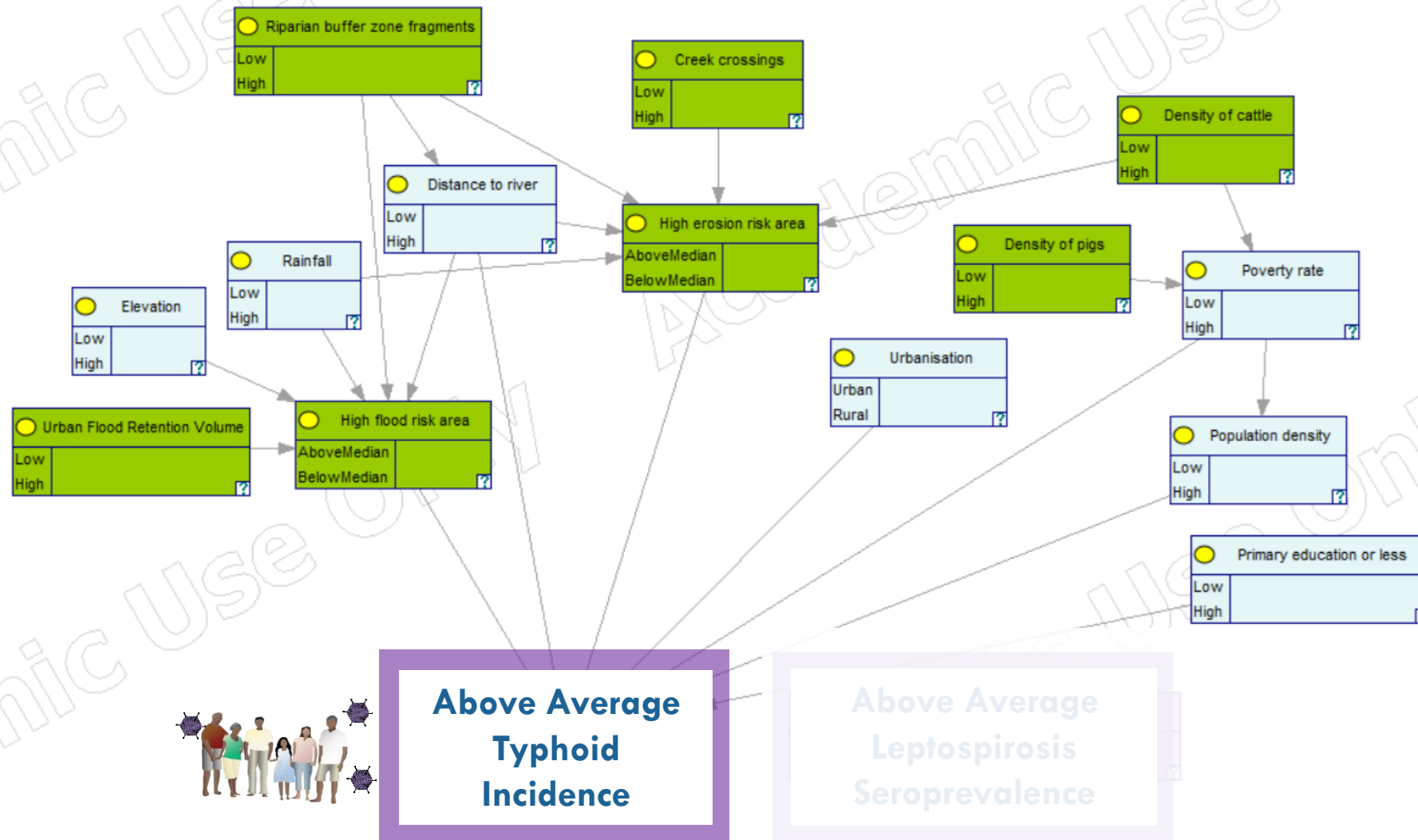**(2)** Looking for sub-catchments contributing to high levels of leptospirosis and typhoid

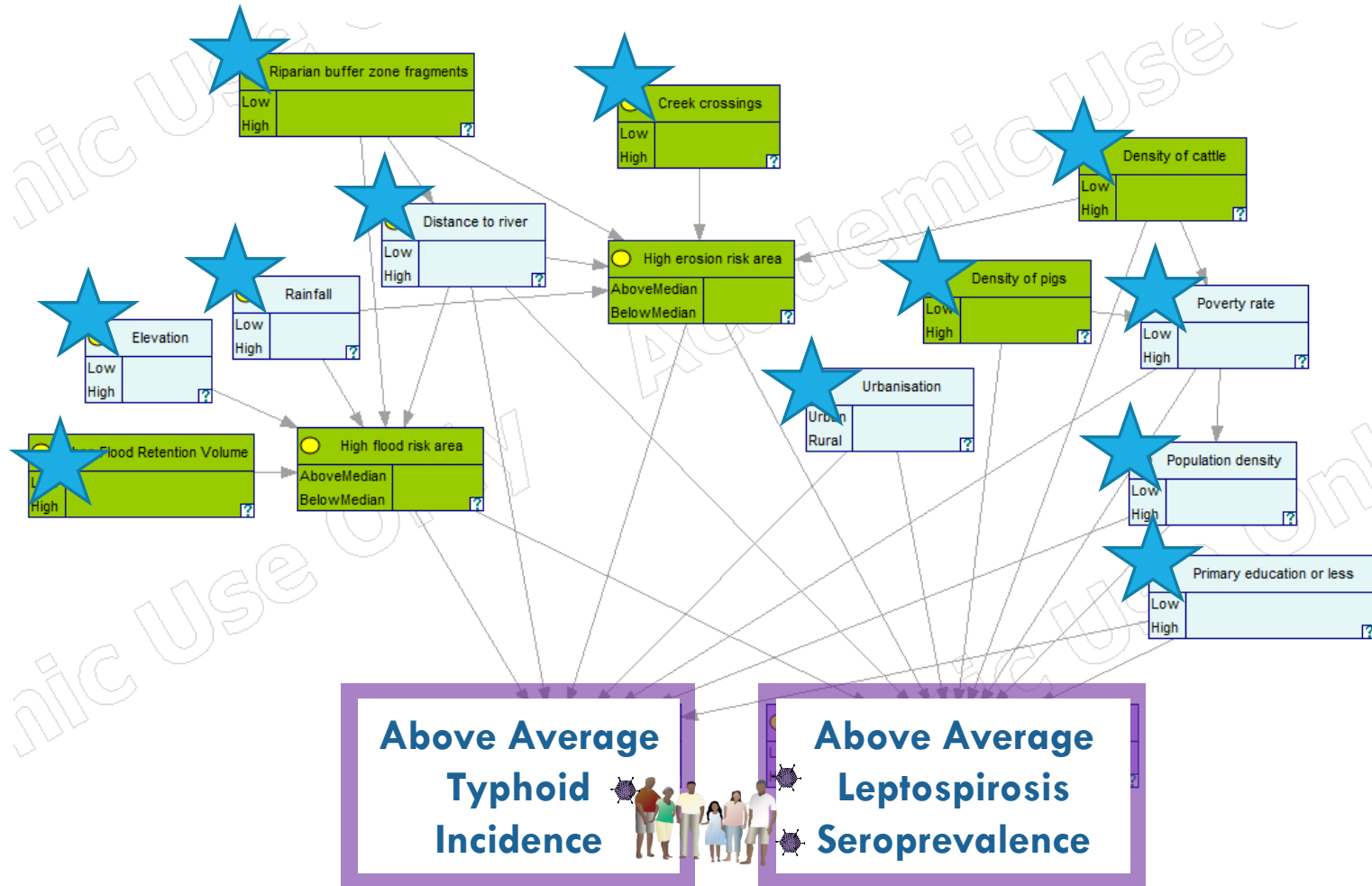# Disease model: Bayesian belief network

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# Disease model: Bayesian belief network
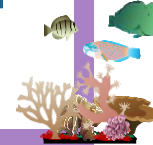
# Identifying high-risk sub-catchments in Fiji

Rank sub-catchments by finding

- Above average levels of typhoid;

- Above average levels of leptospirosis; &
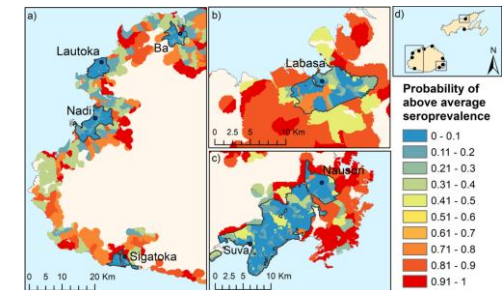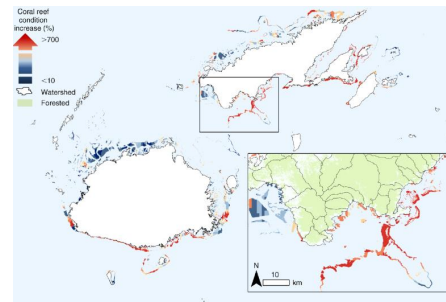
- Reductions in coral reef condition.

# Thank you!

**Land-cover (type and "crop factor")**, rainfall, and soil data

Population data

**Sediment and nutrient load**
(InVEST)

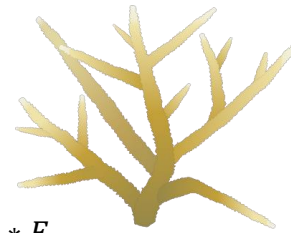$$\text{Sediment Export} = \text{USLE} * \text{SDR}$$
$$\text{Nutrient Export}_p = modified\ load_p * NDR_p$$

**Fishing Pressure**
(Tulloch et al., 2016)
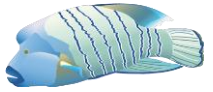
$$F_p = \delta_h - (1 - \delta_h)e^{-y_h f_p}$$

**Coral Reef Condition ***

$$Q^{hp} = \frac{e^{(\alpha_h^S - \beta_h^S S_p)}}{1 + e^{(\alpha_h^S - \beta_h^S S_p)}} * \frac{e^{(\alpha_h^S - \beta_h^S N_p)}}{1 + e^{(\alpha_h^S - \beta_h^S N_p)}} * F_p$$

**Land-cover**
**Current VS. "Natural"**



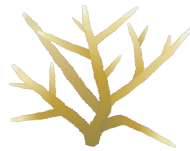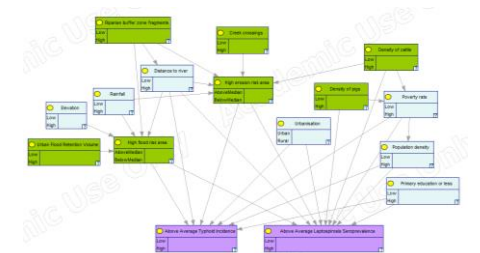**Leptospirosis & Typhoid**

**Δ Coral Reef Condition**

$$Q^{hp} = \frac{e^{(\alpha_h^S - \beta_h^S S_p)}}{1 + e^{(\alpha_h^S - \beta_h^S S_p)}} * \frac{e^{(\alpha_h^S - \beta_h^S N_p)}}{1 + e^{(\alpha_h^S - \beta_h^S N_p)}} * F_p$$

| High priority | > average increase in coral reef cover; & <br> > average increase in probability of below average leptospirosis seroprevalence; & <br> > average increase in probability of below average typhoid incidence |
|---|---|
| Moderate priority | Only two of the above |
| Low priority | Only one of the above |
| Limited potential benefit | < average increase in coral reef cover; & <br> < 50% probability of below average leptospirosis seroprevalence; & <br> < 50% probability of below average typhoid incidence; & |

# Identifying high-risk sub-catchments in Fiji

Ranking sub-catchments by comparing change in disease and coral reef condition within each sub-catchment to the overall average change

| High risk | > average increase in coral reef condition; & |
|---|---|
| | > average decrease in leptospirosis metric; & |
| | > average decrease in typhoid metric |
| Moderate risk | Only two of the above |
| Low risk | Only one of the above |
| Limited potential benefit | ≤ average increase in coral reef condition; & |
| | ≤ average decrease in leptospirosis metric; & |
| | ≤ average decrease in typhoid metric |
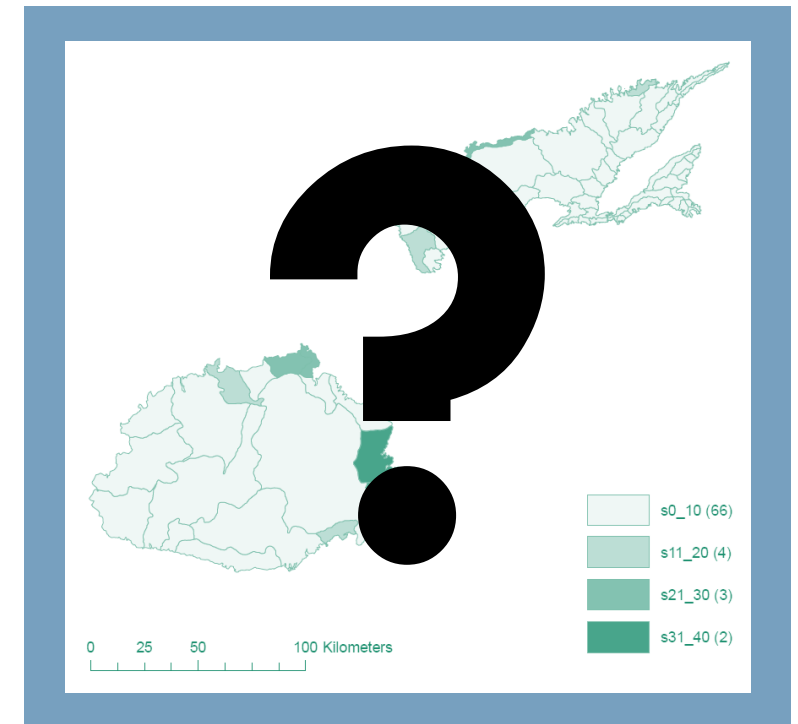
# Opportunity for co-management!

Global
- International negotiations

**Watershed**
- **Protection & restoration**
- **Agricultural best practices**

Household
- Infrastructure improvements
- Health surveillance

Individual
- Individual behavior change