# BBN models as trade-off tools for ecosystem services
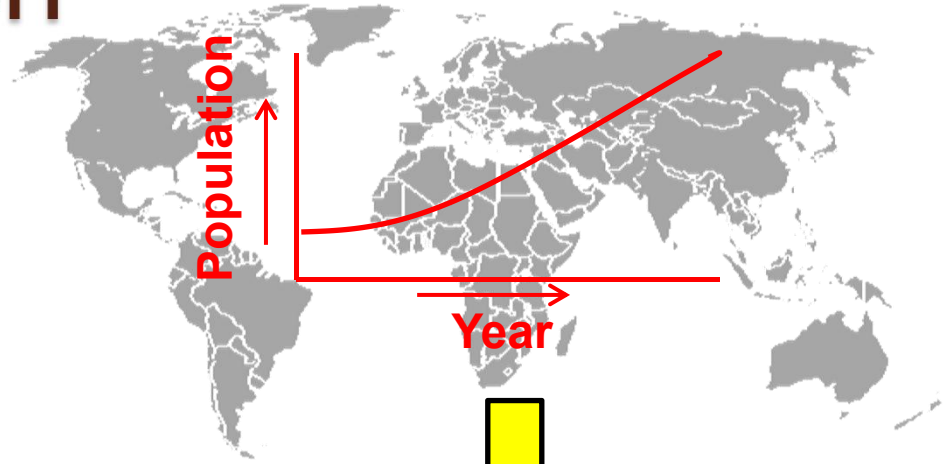
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# Introduction

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- Ecosystem services – benefits humans obtain from ecosystem
  - Supporting services (nutrient recycling, soil formation)
  - Provisioning services (food, raw materials, energy)



  - Regulating services (pollination, pest and disease control)
  - Cultural services (ecotourism, therapeutic)

# Introduction

- Application of ecosystem services in water management
- Problem:
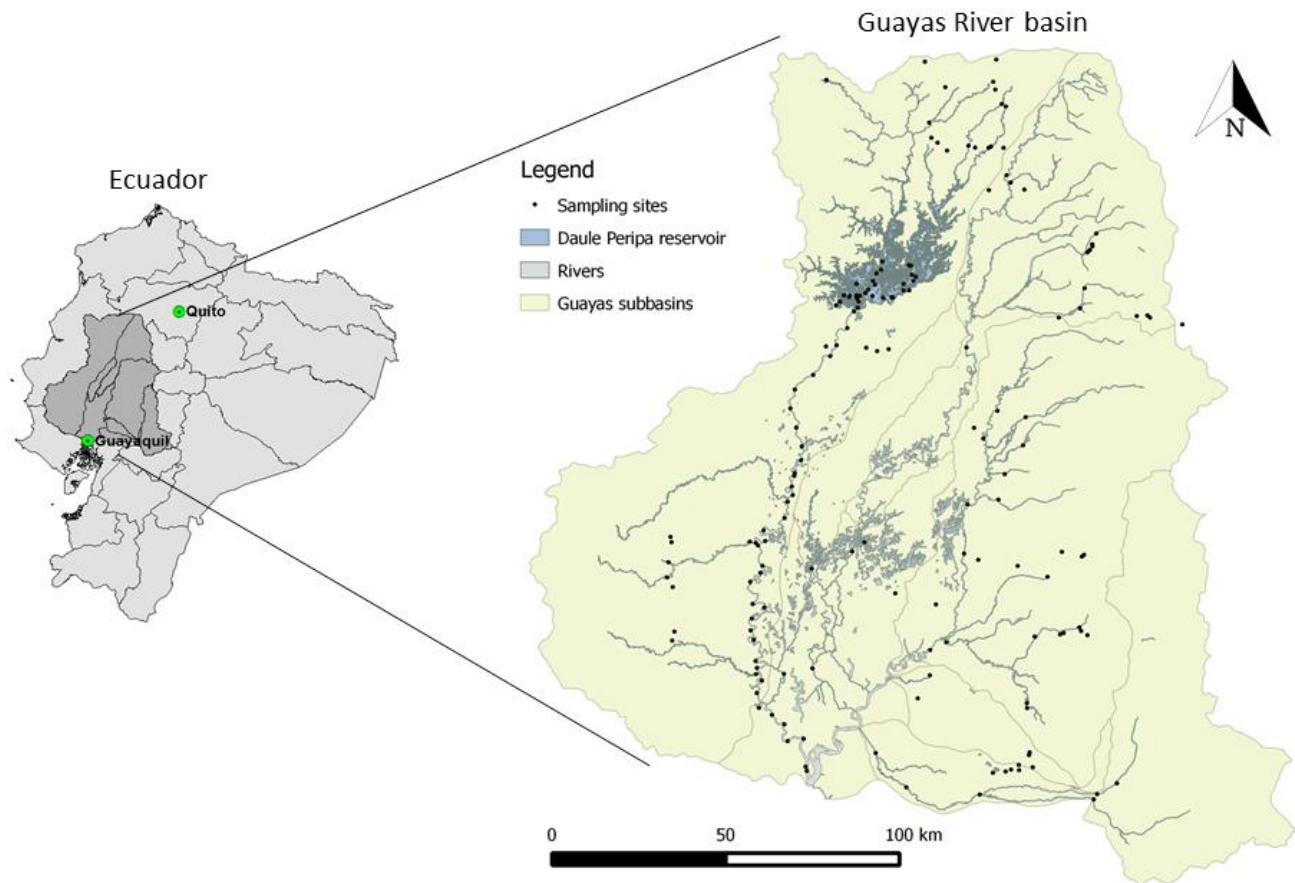  - exploitation of one ecosystem service may lead to the deterioration of another
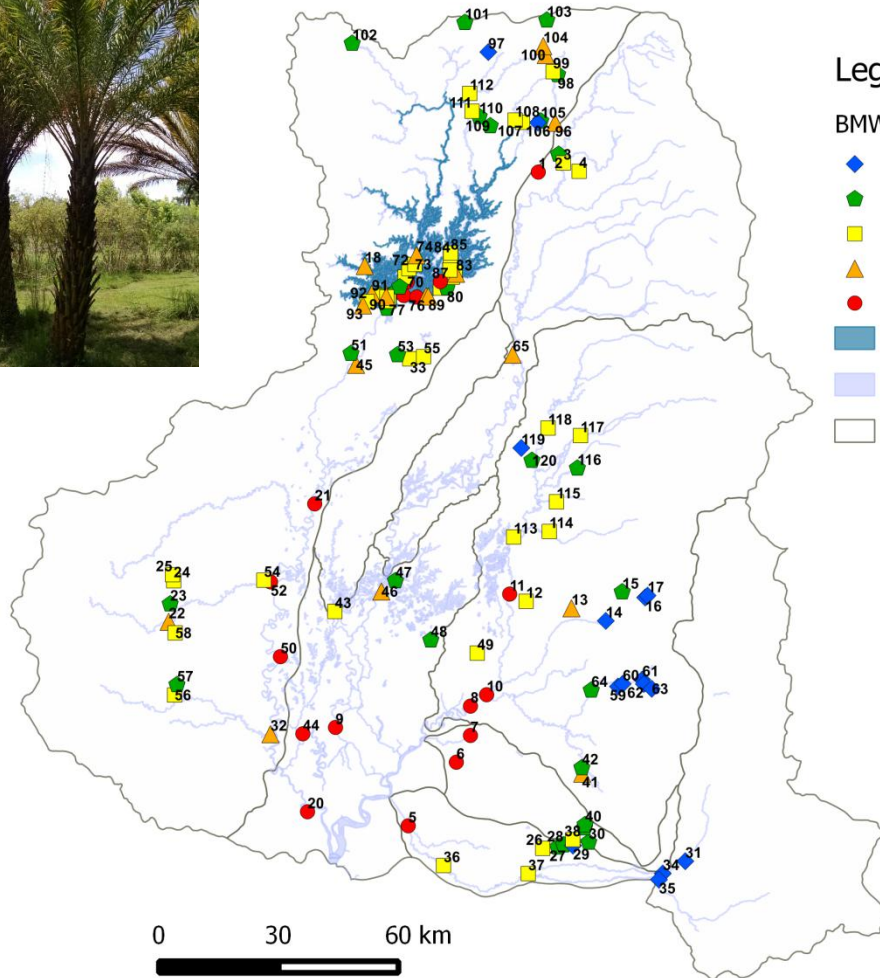
# Objectives

- To identify the link between water management options and ecosystem services
- Determine how the ecosystem services change when certain management actions are applied
- To develop a trade-off tool using Bayesian belief network

# Materials and methods

○ Study area

# Study area
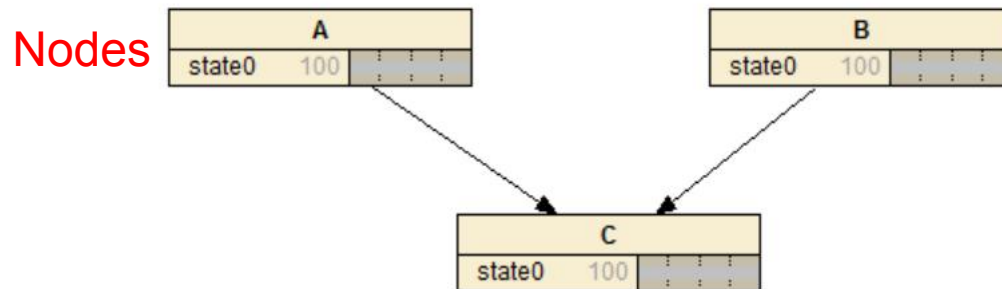
# Estimating ecosystem services through modeling

○ Bayesian belief networks (BBNs)

- Probabilistic graphical model
- Presented as directed acyclic graph
- Nodes represent discrete(ized) variables
- Arrows indicate causal relations
- Conditional probability table displays conditional probabilities of a single variable *wrt* others
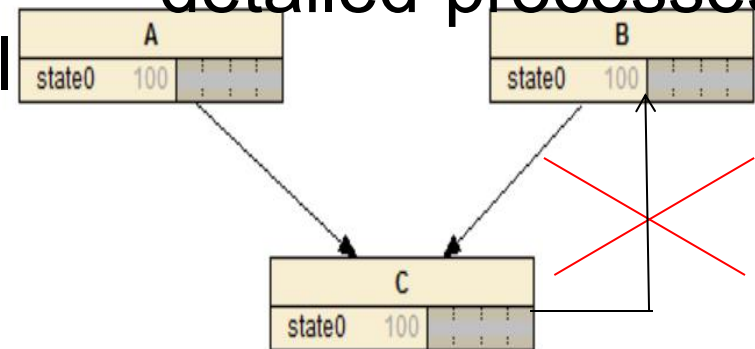
# BBNs in estimating ecosystem services (ESS)

○ Advantages
- Easy interpretation, visualization
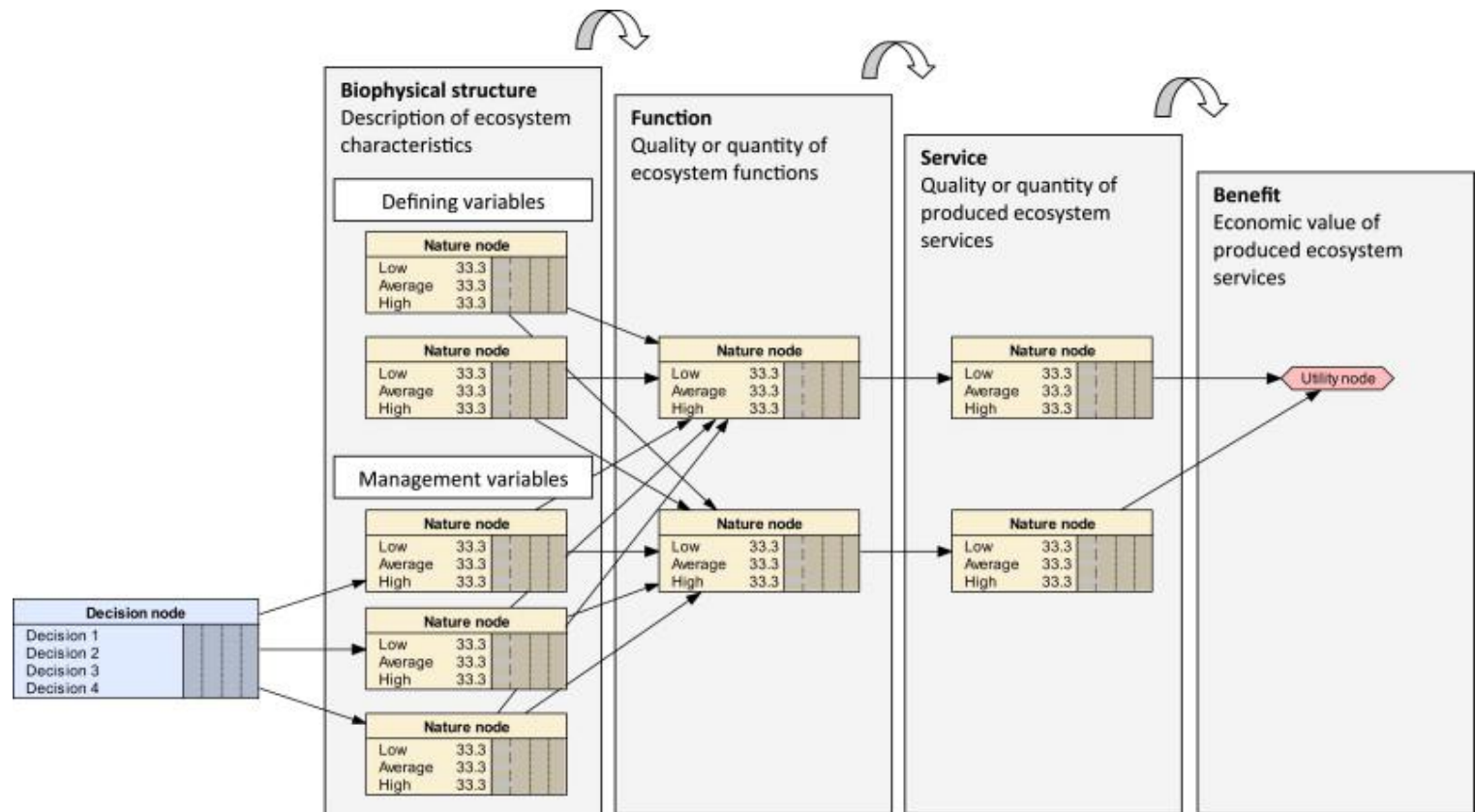- Flexible with available data
- Can be applied as a trade-off tool

○ Disadvantages
- Feedback loop not allowed
- Discretization needed
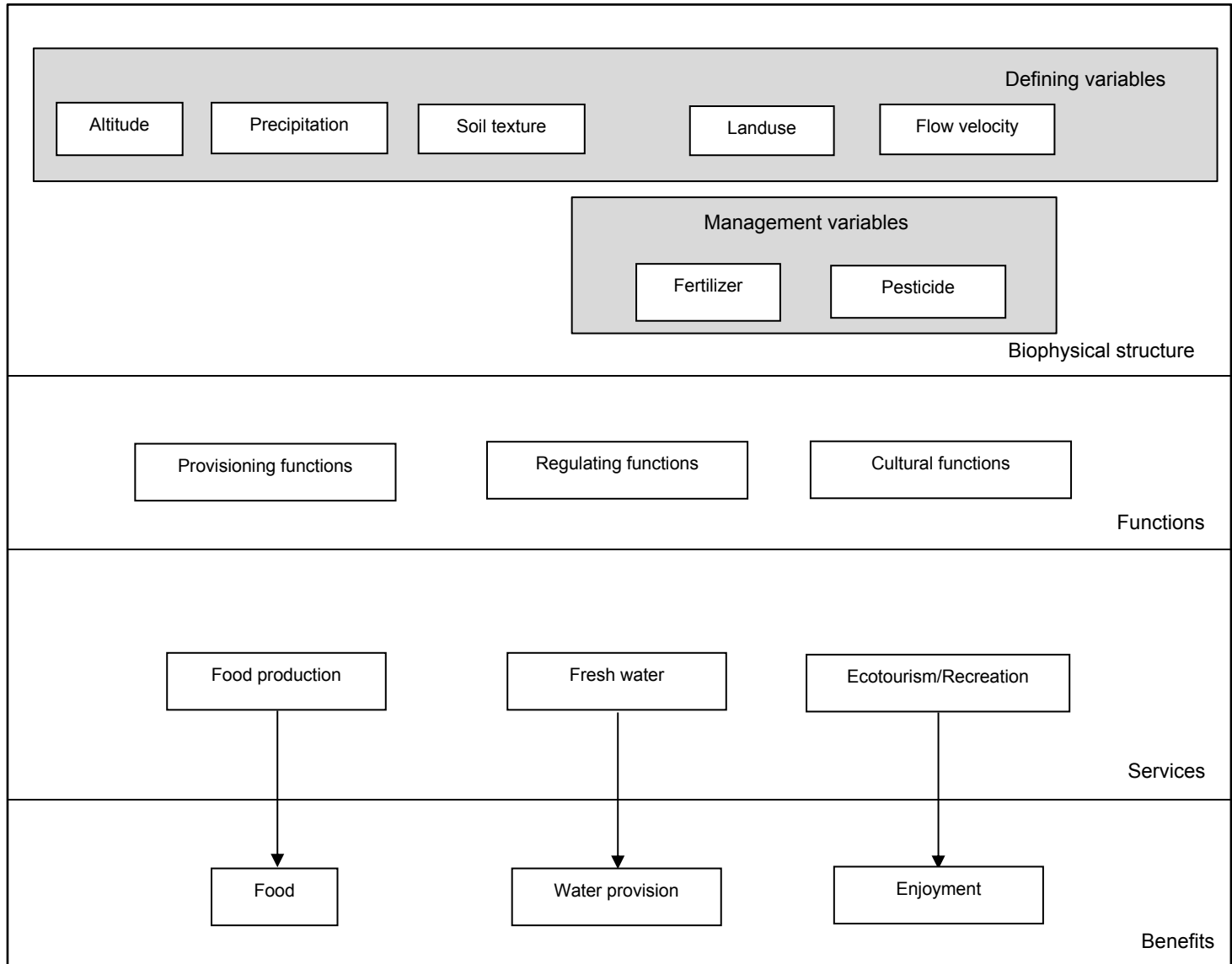- Incorporation of detailed processes

# Modelling

○ General layout of BBN for ESS



Landuyt et. al, 2013

# Modelling ESS

# Input data

| Nodes | Input |
|---|---|
| Altitude | Data (shape files) |
| Precipitation | Data (shape files) |
| Soil texture | Data (shape files) |
| Land use | Data (shape files) |
| Flow velocity | Data (field work) |
| Fertilizer | Data & expert knowledge |
| Pesticide | Data & expert knowledge |
| Crop | Literature |
| Chemical water quality | Data (measured pesticide residue & chemical attributes of water) |
| Biological water quality | Data (field work) |
| Food production | Literature & expert knowledge |
| Water provision | Expert knowledge (rule-based) |
| Ecotourism/recreatio | Expert knowledge (rule-based) |

# Data collection

- Physical–chemical variables (e.g. velocity, pesticide)
- Biological data (macroinvertebrates)
- Shape files (ministry)
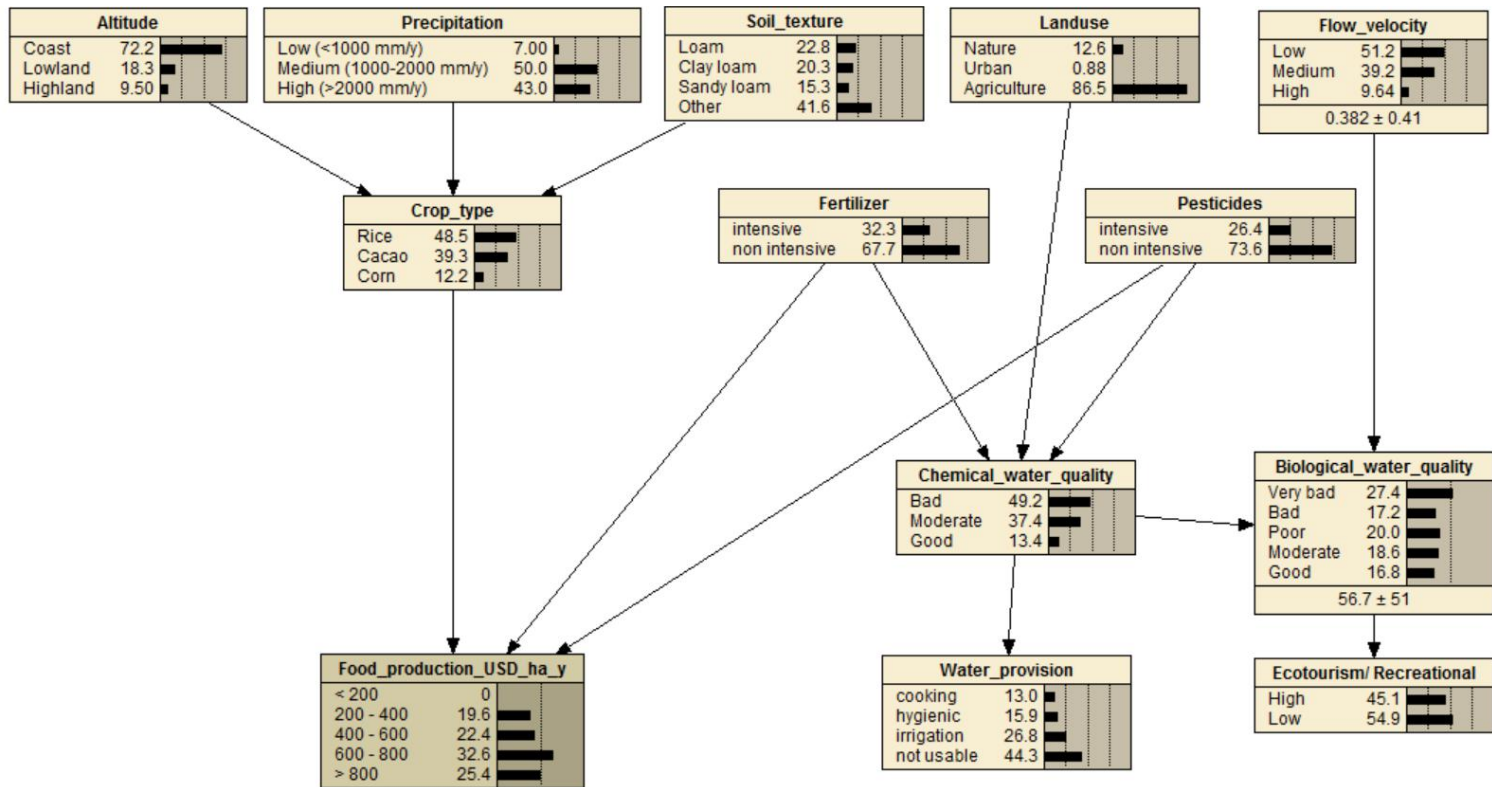- Other information (documents)
- Literature
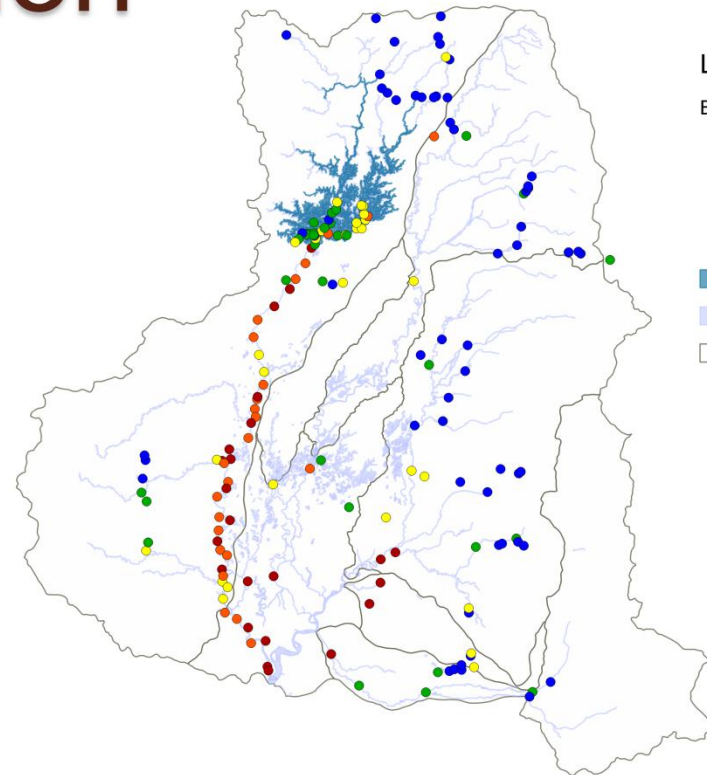


Legend

BMWP-Col water quality classes
- very bad
- bad
- poor
- moderate
- good
- Daule Peripa resservoir
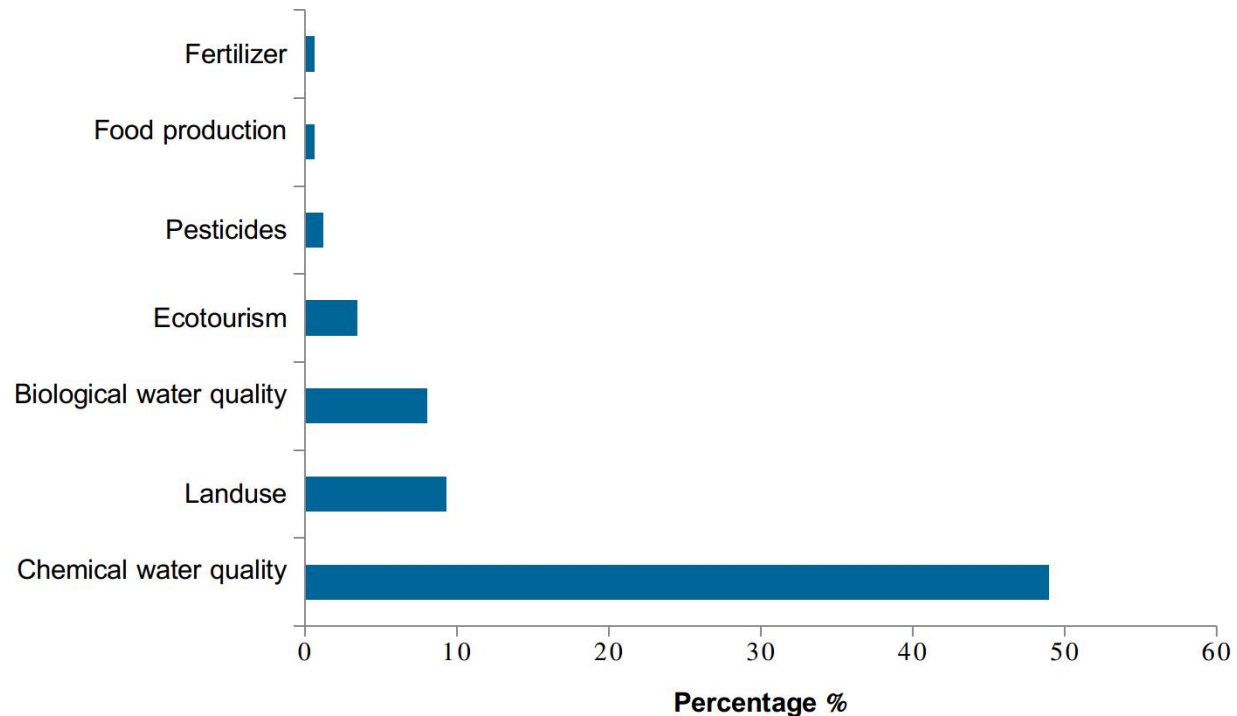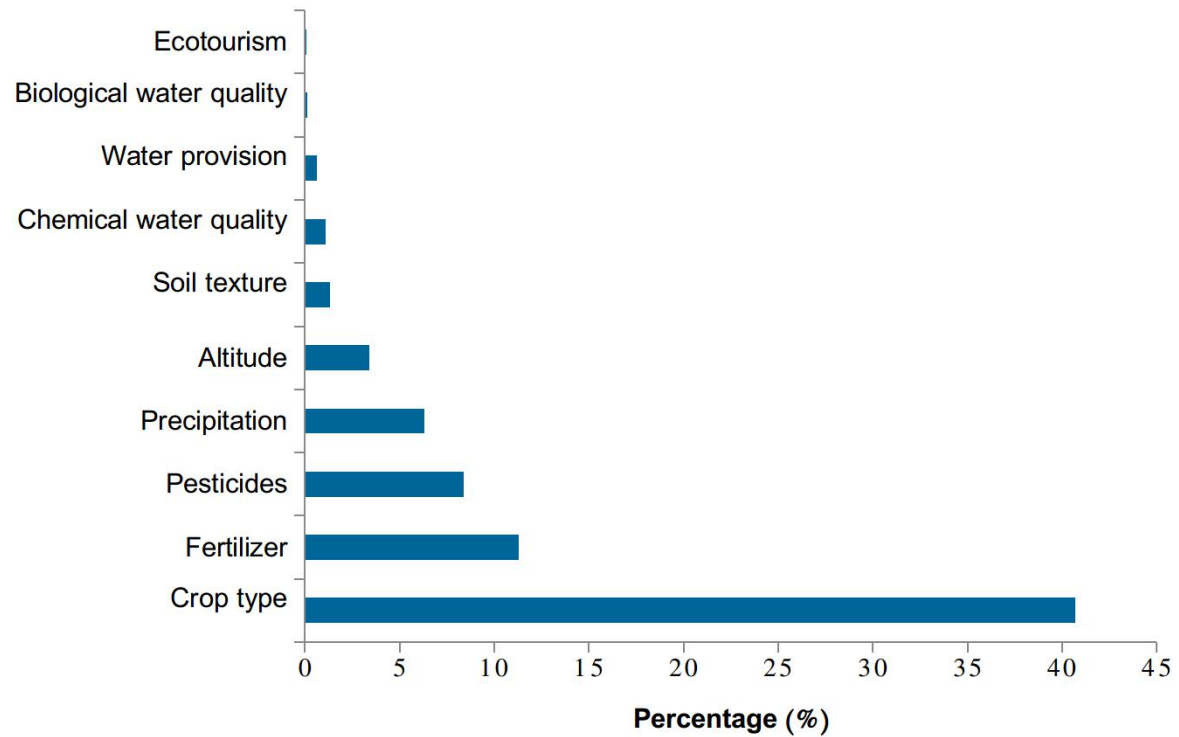- Rivers
- Guayas subbasins

# Model development

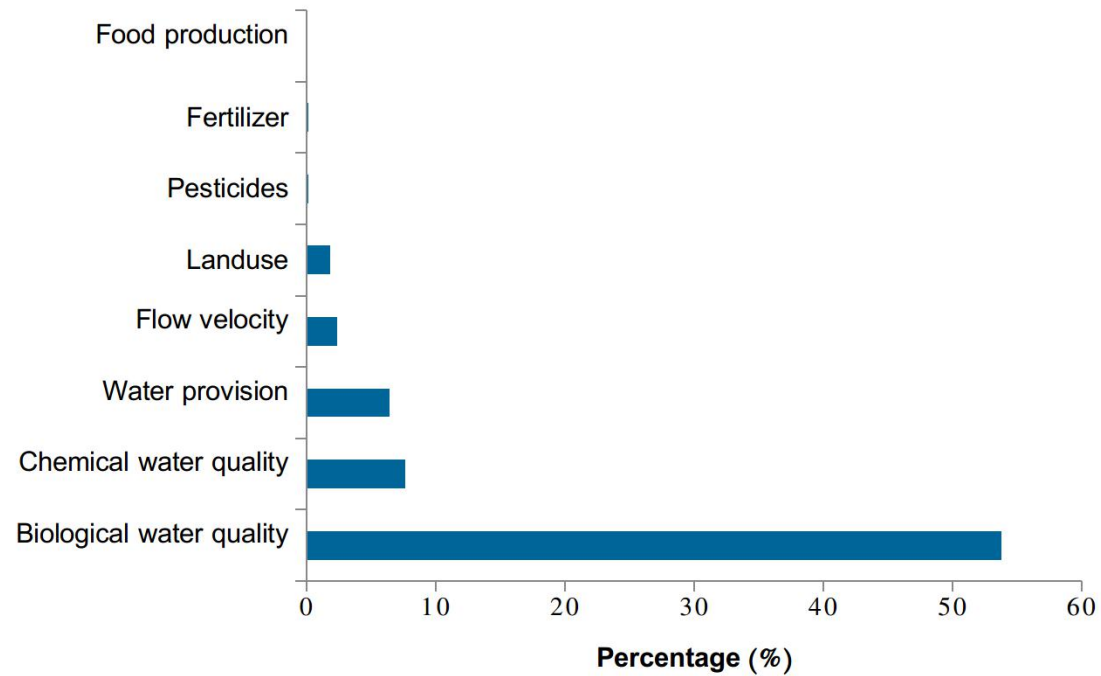# Sensitivity analysis

○ Water provision

# Sensitivity analysis
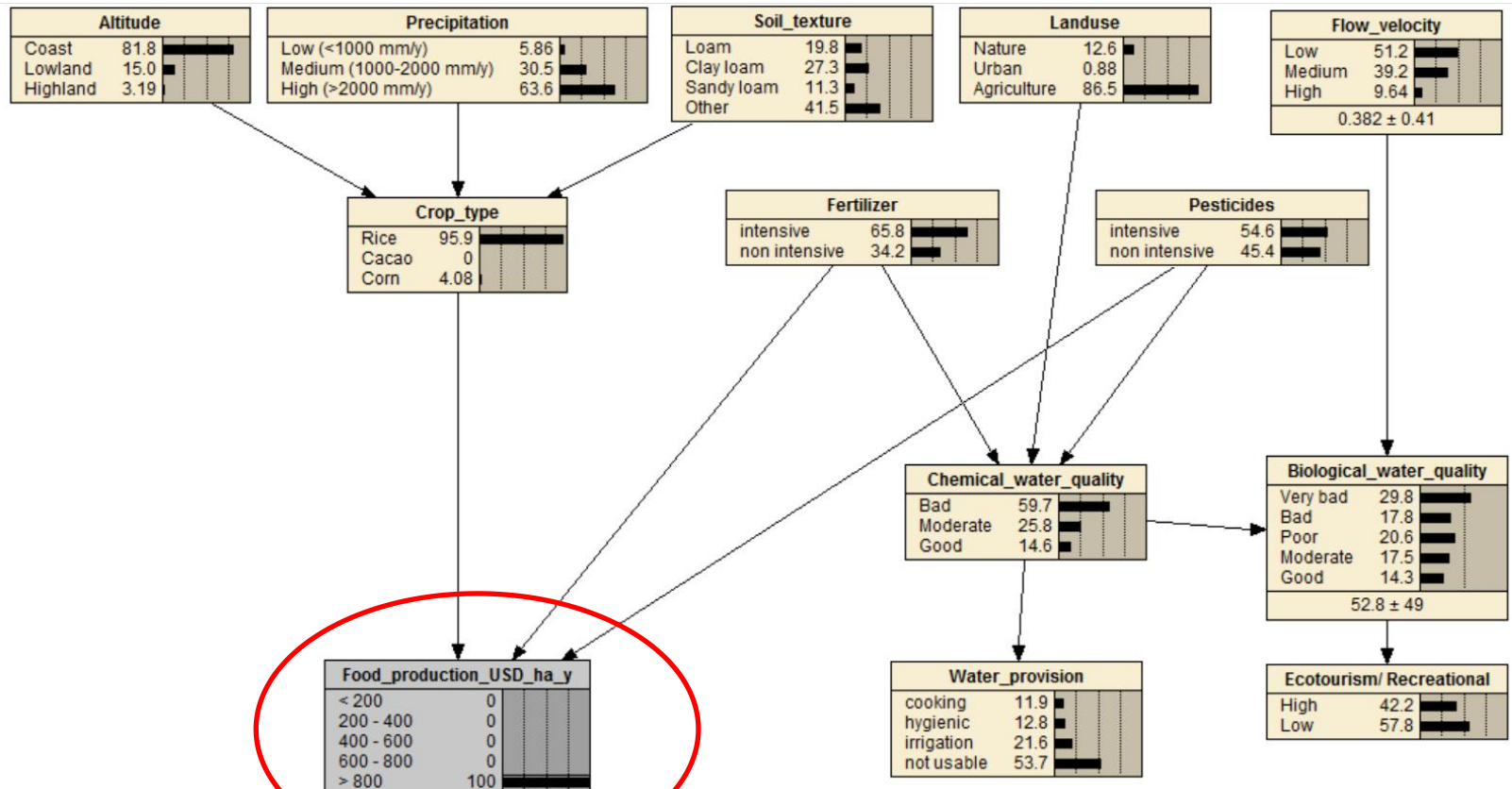
○ Food production
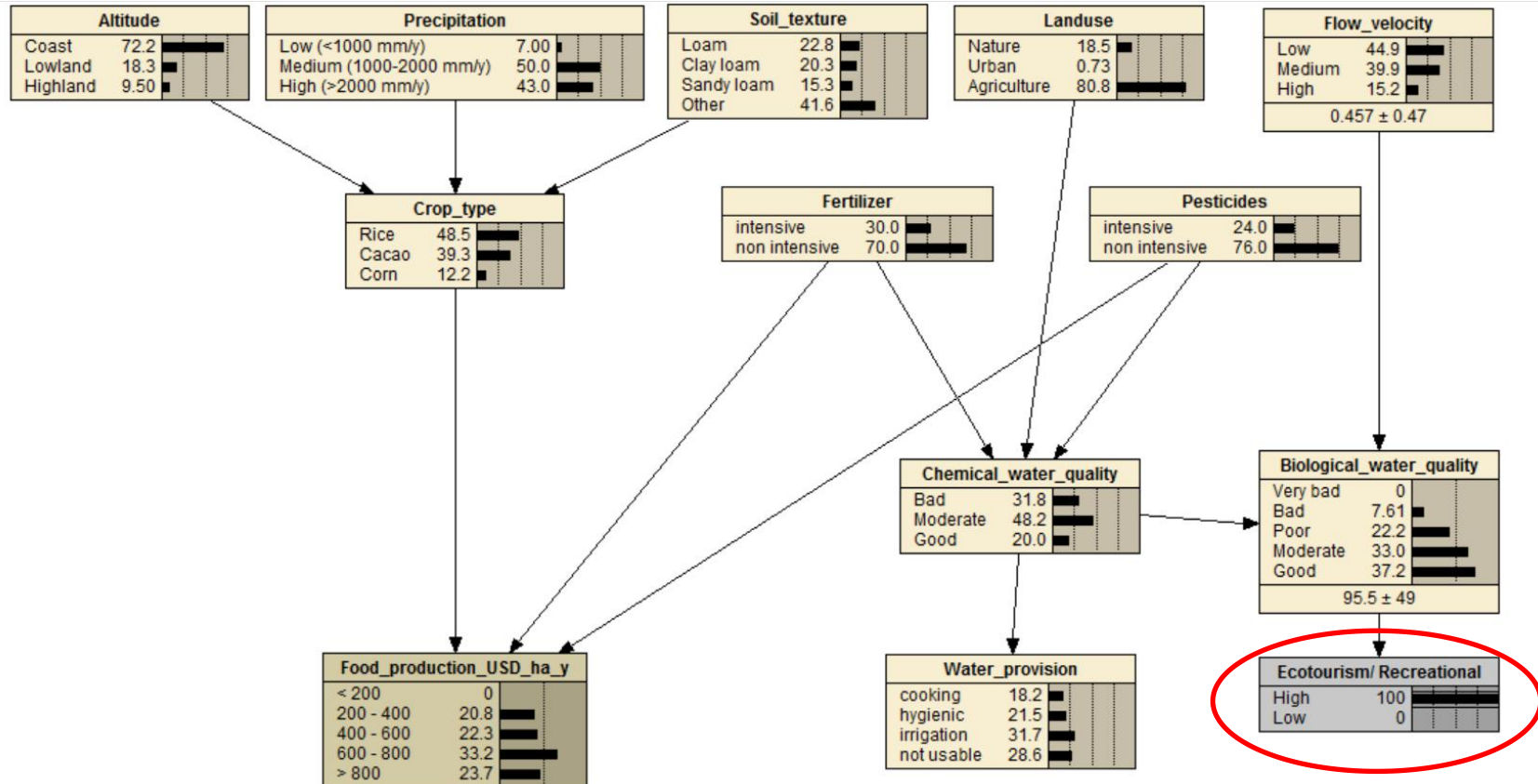
# Sensitivity analysis

○ Ecotourism/recreation

# Management options

# Management options

# Conclusions

○ A trade-off tool was developed using BBN
○ The developed model was able to identify the link between water management options and ecosystem services
○ The model facilitate the determination of changes of ecosystem services when certain management actions are applied

# Further studies

- Incorporation of other crops (e.g. Banana and palm)
- Addition of other ecosystem service (e.g. energy production, wood production)
- Model validation
- Incorporation of other defining variables for pesticide and fertilizer (farm size, farming type)

# Thank you for your attention

## Questions ?