Integration of ecological, hydrological and socio-economic data into a Bayesian Network model for the sustainable utilization of papyrus wetlands

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Introduction…

Occurrance of papyrus dominated wetlands

- Lacustrine
- Riverine
- Floodplains

Introduction…





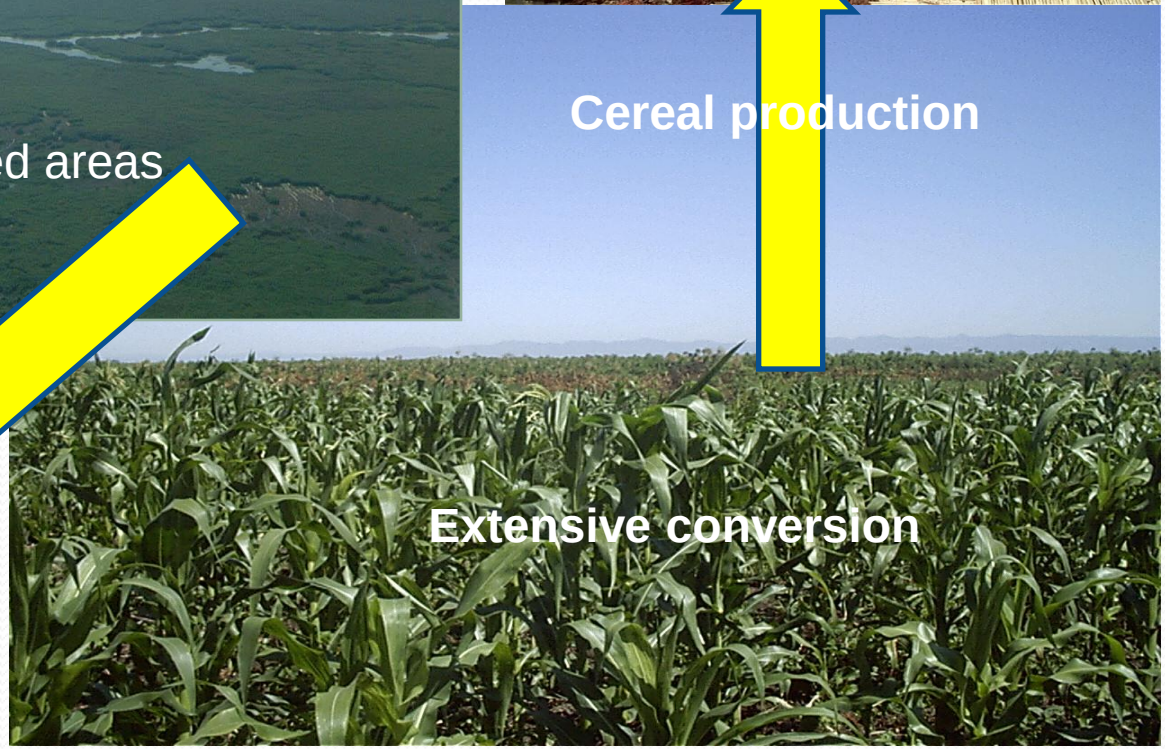


One resource-many interest

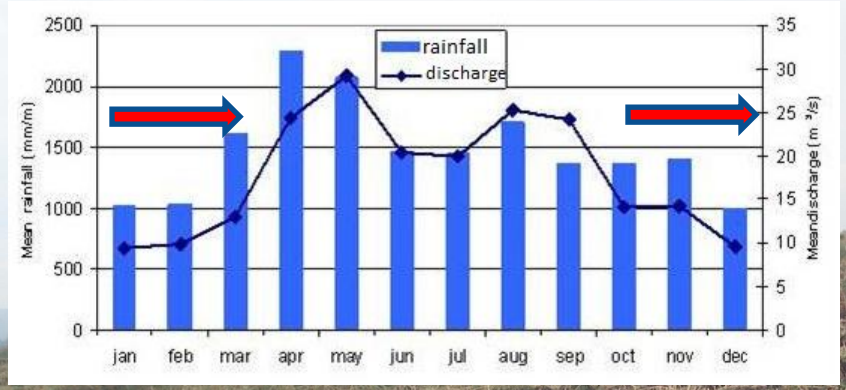
PAPYRUS WETLANDS

Exploitation for livelihoods

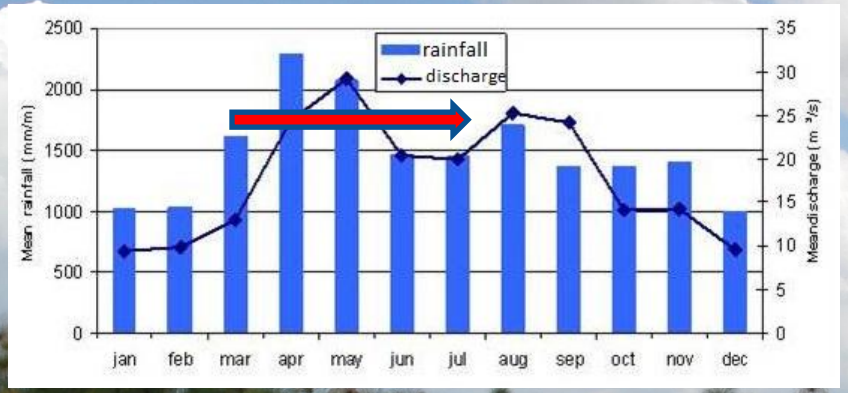
Cereal production

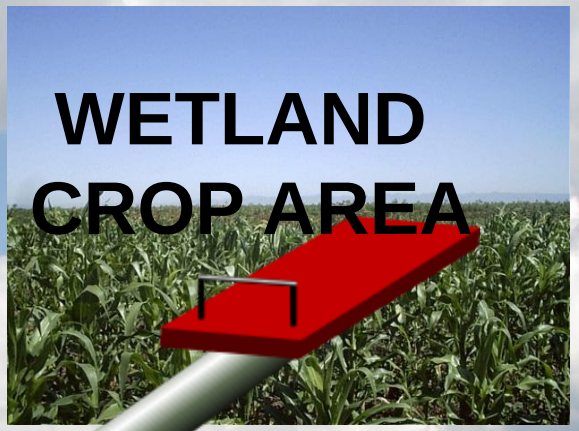


Seasonal dynamics: Dry season

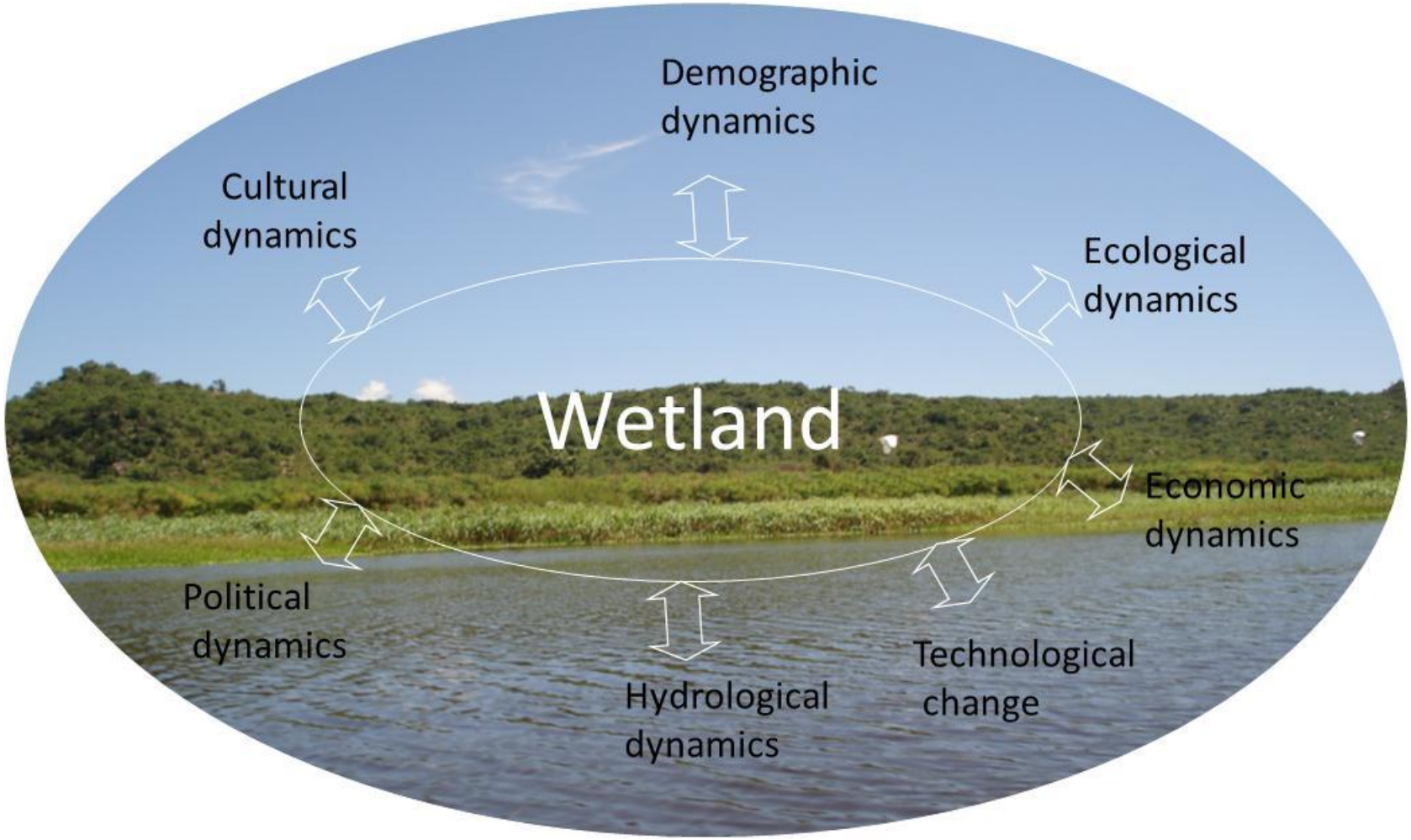


Seasonal dynamics: Wet season





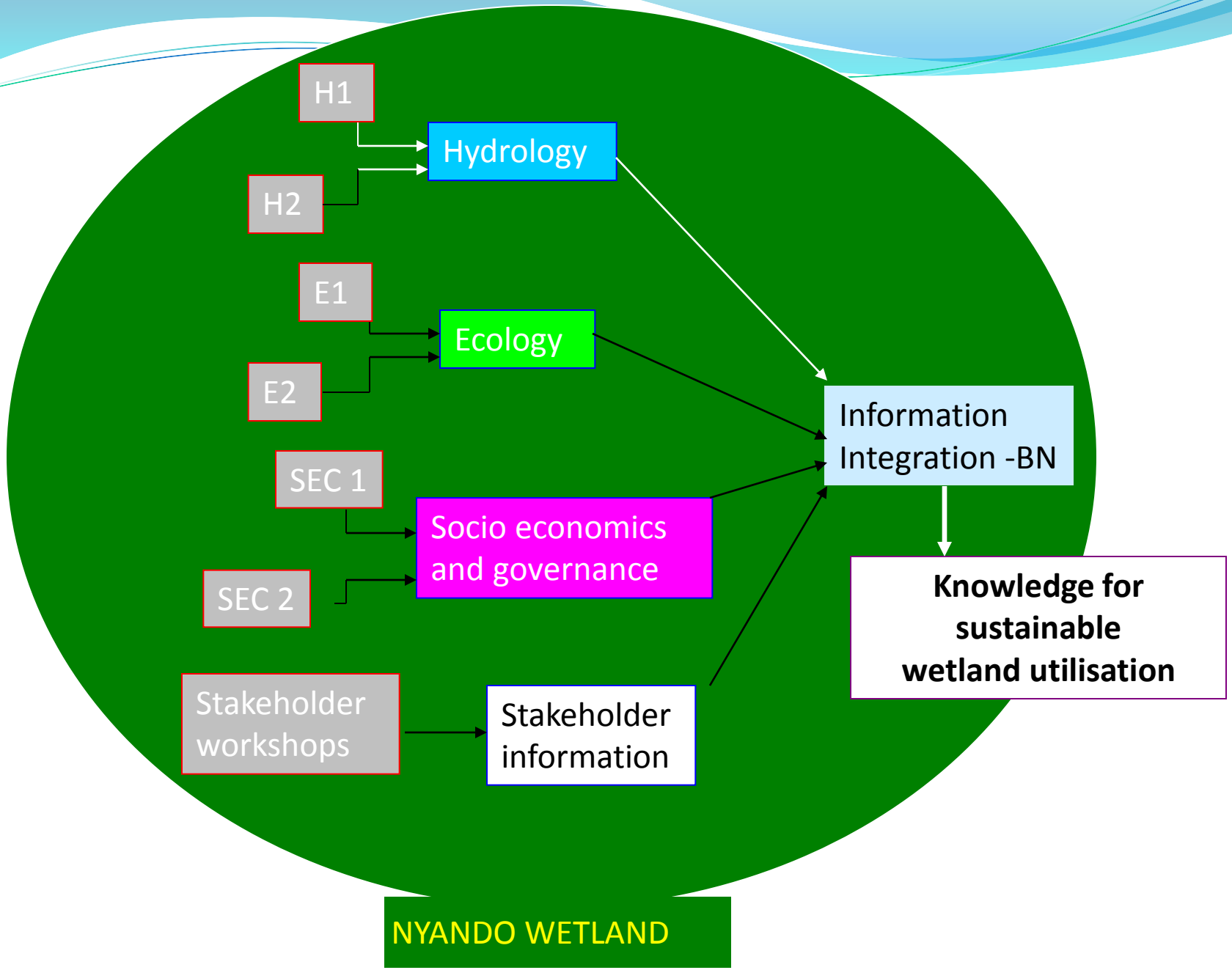
Multifaceted view of wetland use



Questions?

- Can papyrus wetlands be utilised for livelihoods while sustaining functions and services?
- How do drivers affect wetland livelihoods and ecosystem functions?
- How does uncertainty of flooding affect livelihoods?
- What if the river is regulated upstream?
- …

ECOLIVE PROJECT



Objectives

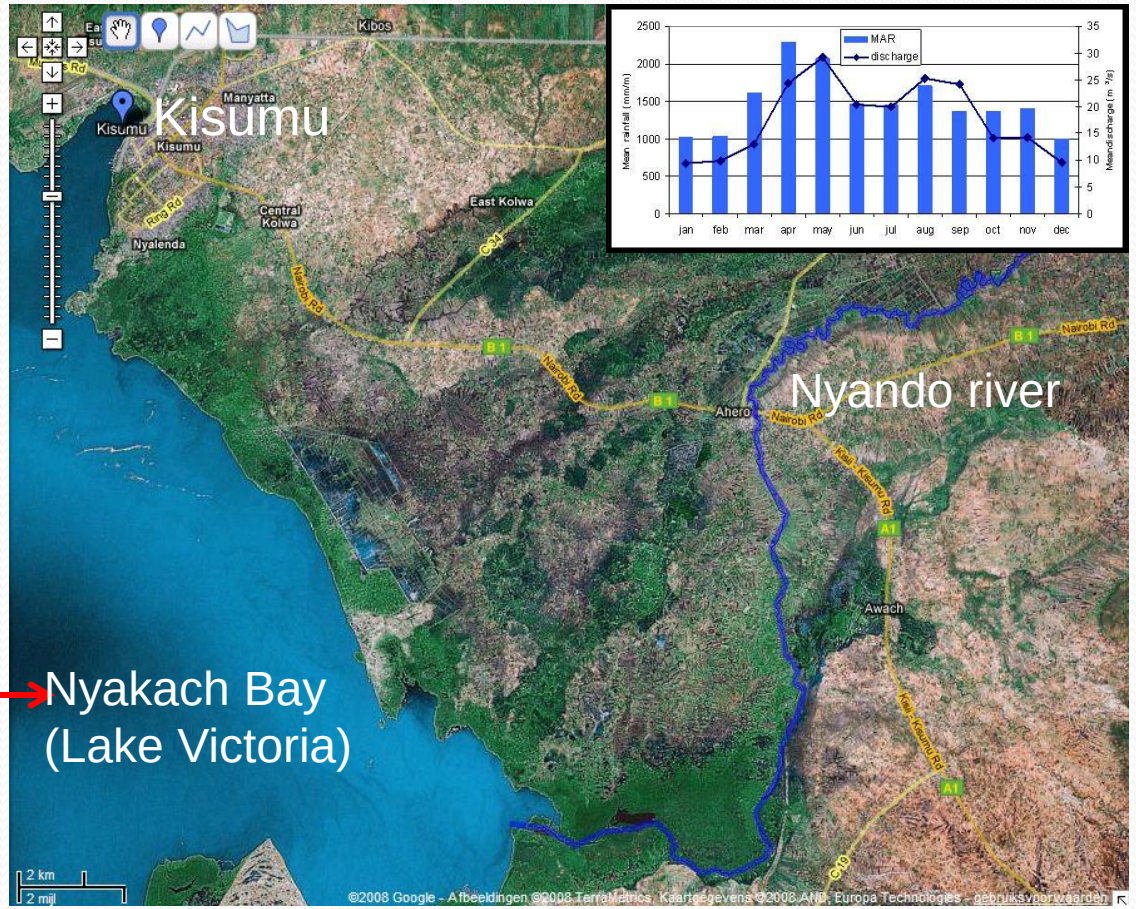
- Overall objective:
  - To develop a trans-disciplinary framework of Nyando wetland, Kenya.
- Specific objectives:

1. Identify drivers of change and carry out a functional analysis;
2. Formulate a causal network in the context of ecosystem services and functions;
3. Operationalize the DPSIR causal network using a Bayesian Network model;
4. Update the Bayesian network model with information from field data experts and stakeholders (resource users ,policy makers).

Methods

Study area: Nyando wetland, Kenya

Nyando basin: 3587 km^2
Nyando wetland: 50 km^2

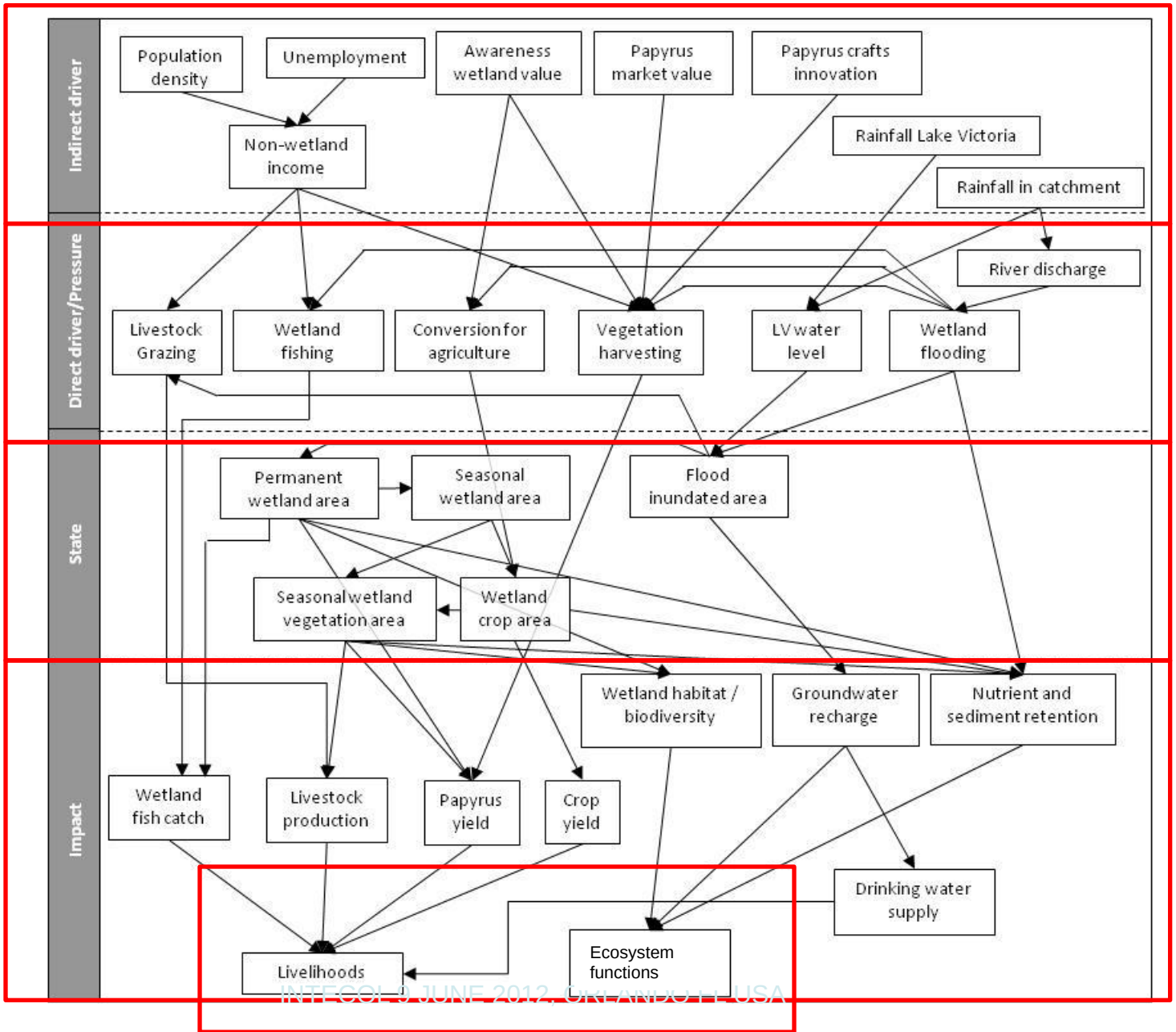


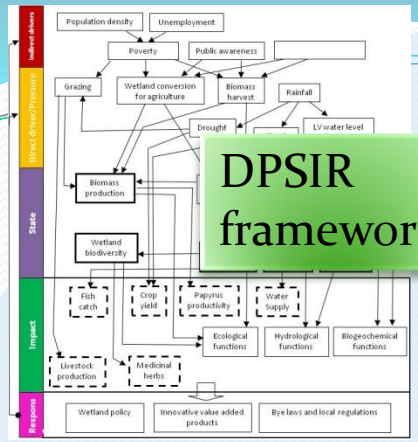
Nyakach Bay
(Lake Victoria)

Generating DPSIR

Driver (Indirect driver)	Pressure (Direct driver)	State (Ecosystem)	Impact (Service/function)	Response
Population Economy Governance Climate Rainfall in basin	Fishing Flooding	Area of natural papyrus vegetation, water quality	Fish yield	Economic, fishery and wetland policy
	Wetland conversion Flooding	Size of seasonal wetland	Crop yield	Economic, agricultural and wetland policy
	Flooding Grazing Wetland conversion Biomass harvesting	Area of natural papyrus vegetation	Livestock production	
			Papyrus yield	
			Biodiversity	
			Nutrient retention	
			Sediment retention	

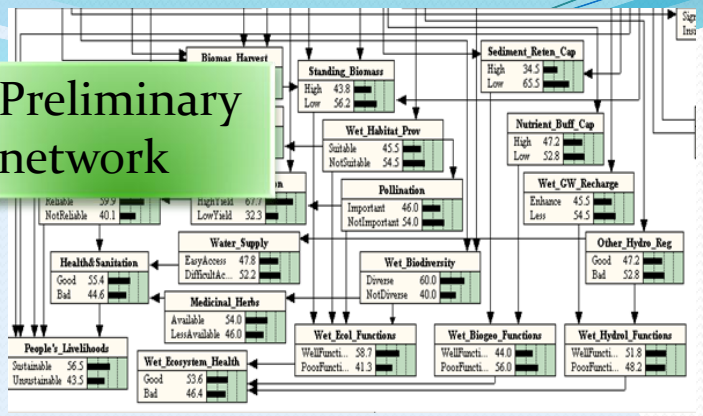
eDPSIR causal network for Nyando wetland





DPSIR framework

Consultation



Preliminary network

Stakeholder Participation

- Communities
- Government & NGOs
- Experts

Feedback

Scenarios and Decision making

Field research & modelling

- Ecological
- Hydrological
- Socio-economic

Data

Master network

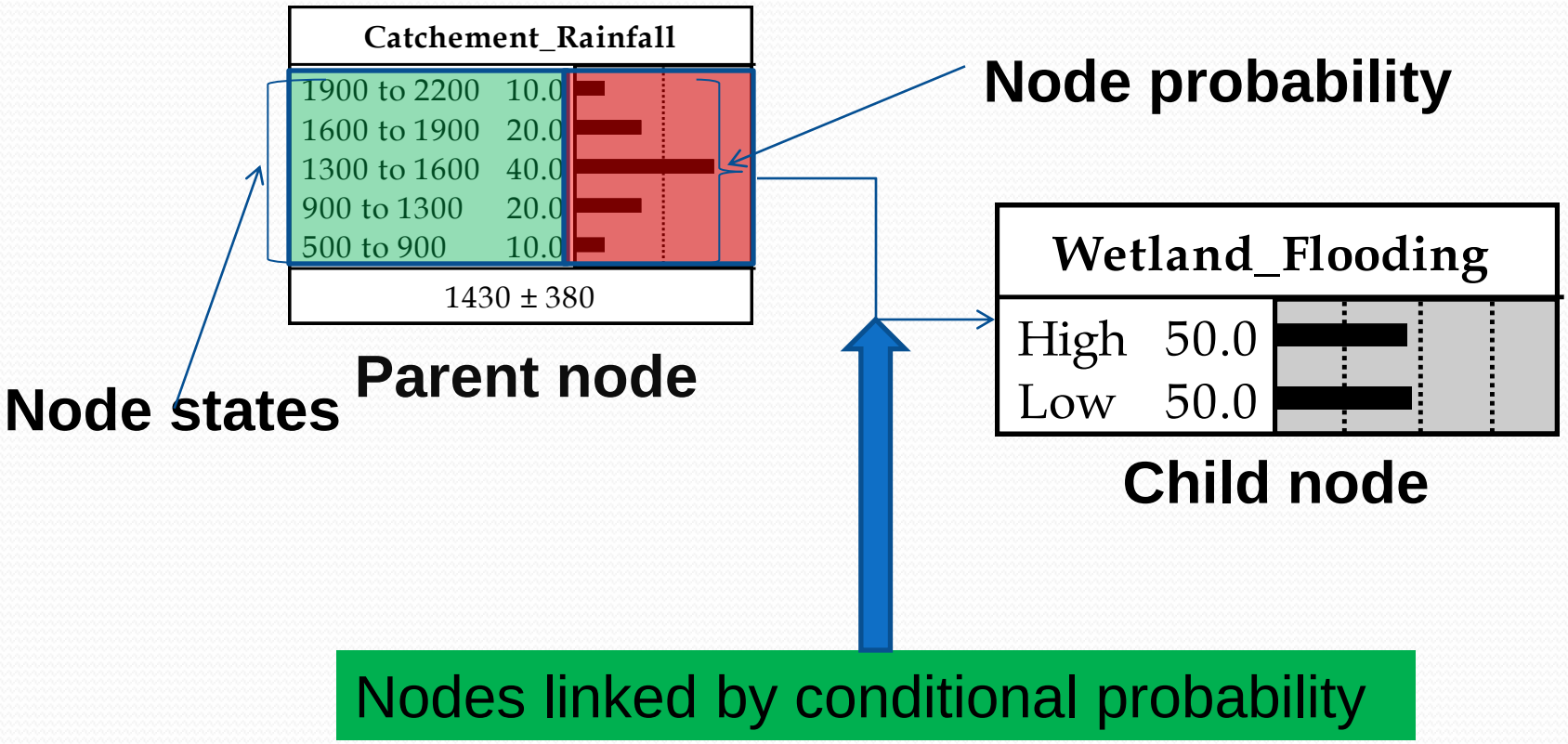
Updated network

Stakeholder consultation

- Nyando wetland community members
- Government and NGO involved in the wetland
- Experts

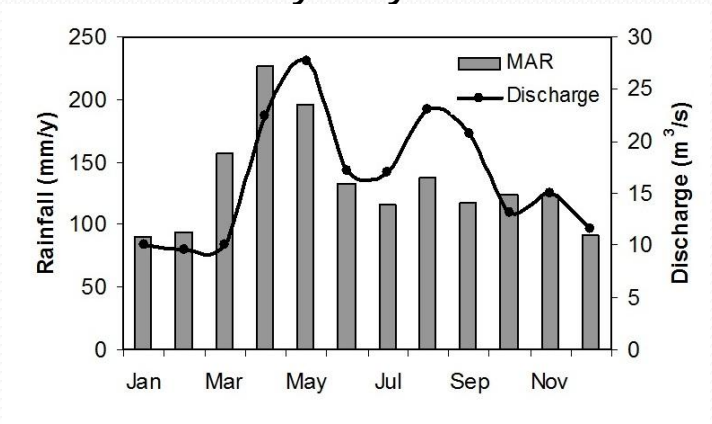
- ✓ **Variables sufficiency**
- ✓ **Relationships**
- ✓ **Definition of variables & states**
- ✓ **Information for CPT**

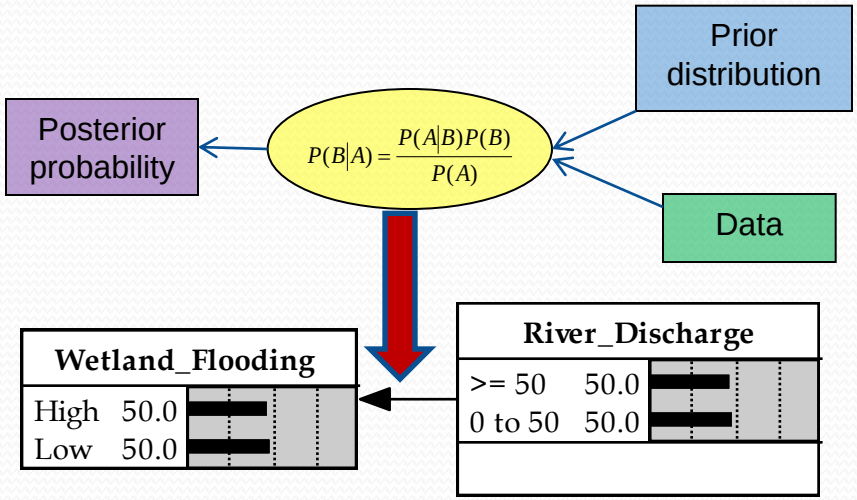
Nodes, states and links

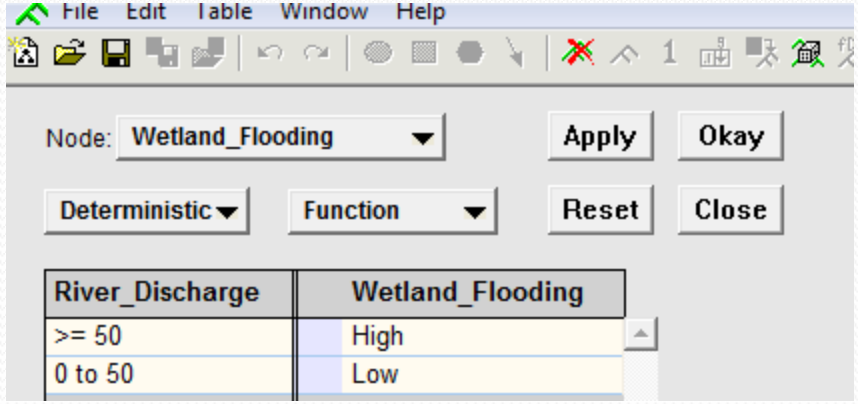


Links and CPT

The links between nodes are defined by Bayes Theorem







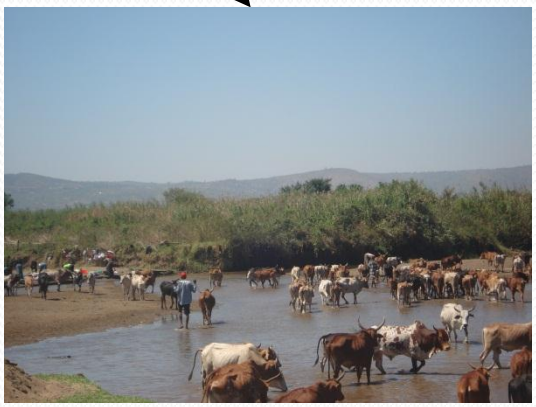
Results

- **Important indirect drivers:**

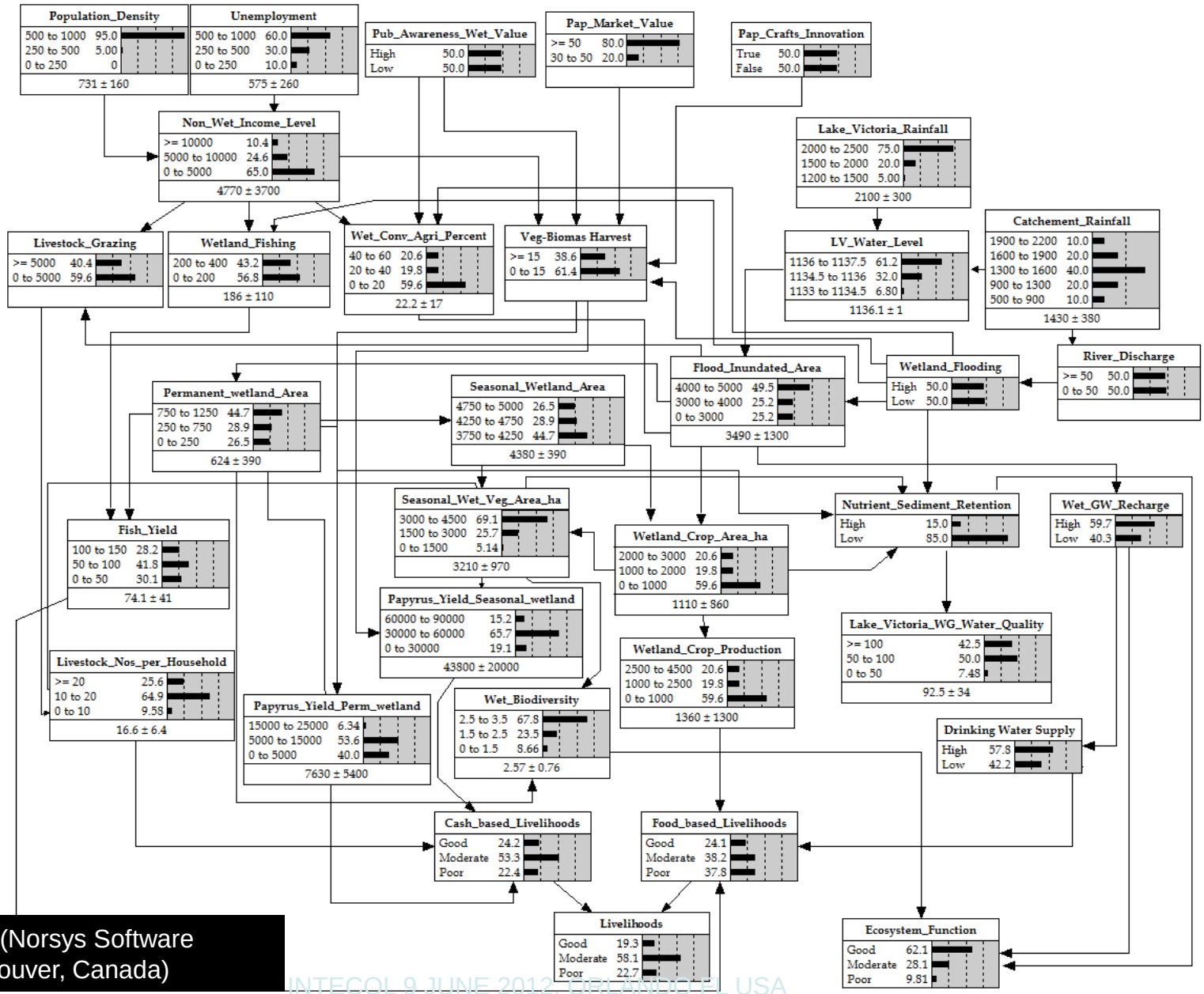
  Population density, unemployment/poverty , wetland policy, public awareness on sustainable use of wetlands among others.

- **Important direct drivers:**

  Lake Victoria water level, rainfall, land use change, Biomass harvest, grazing, flood, etc.

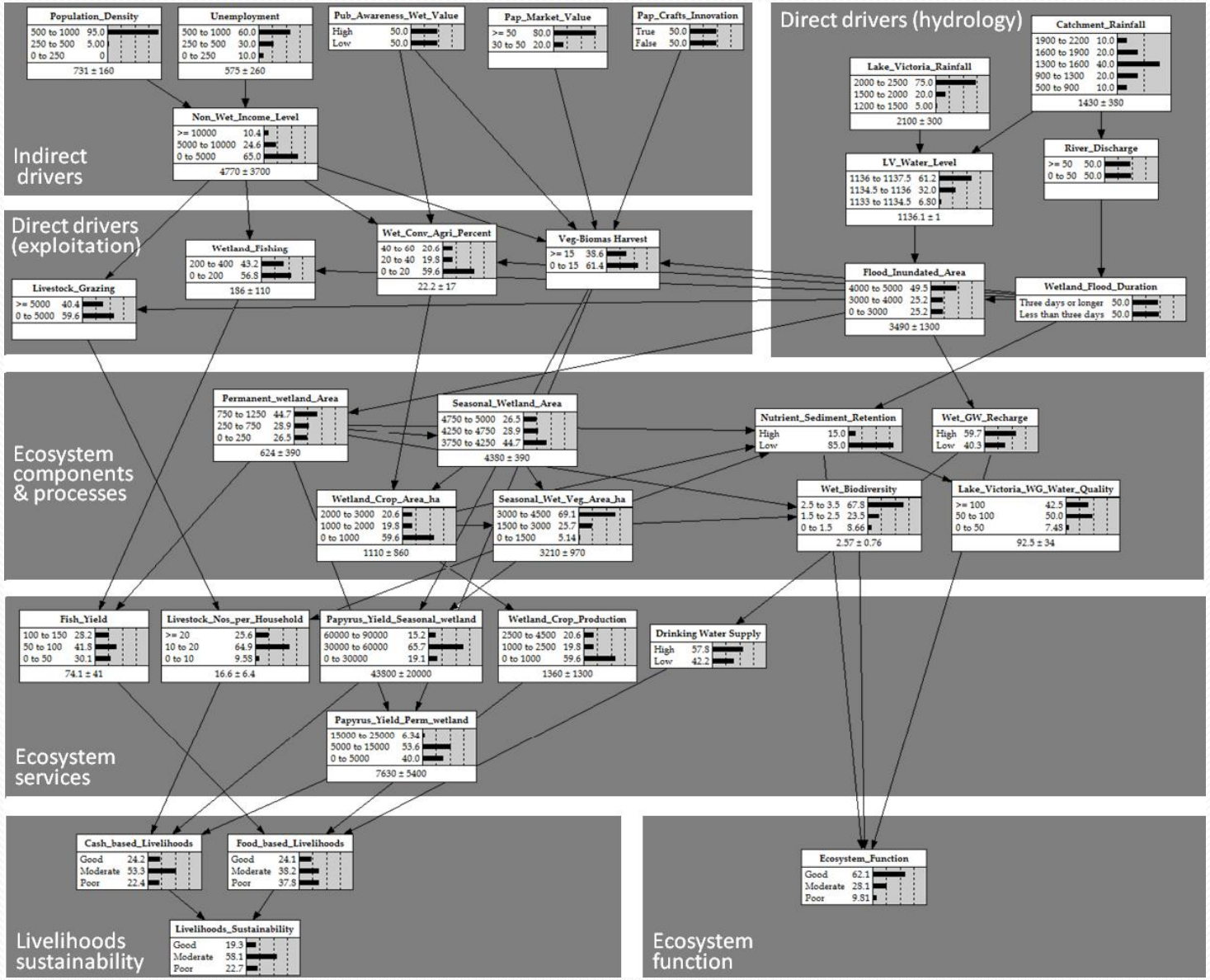


Bayesian Network model of Nyando wetland

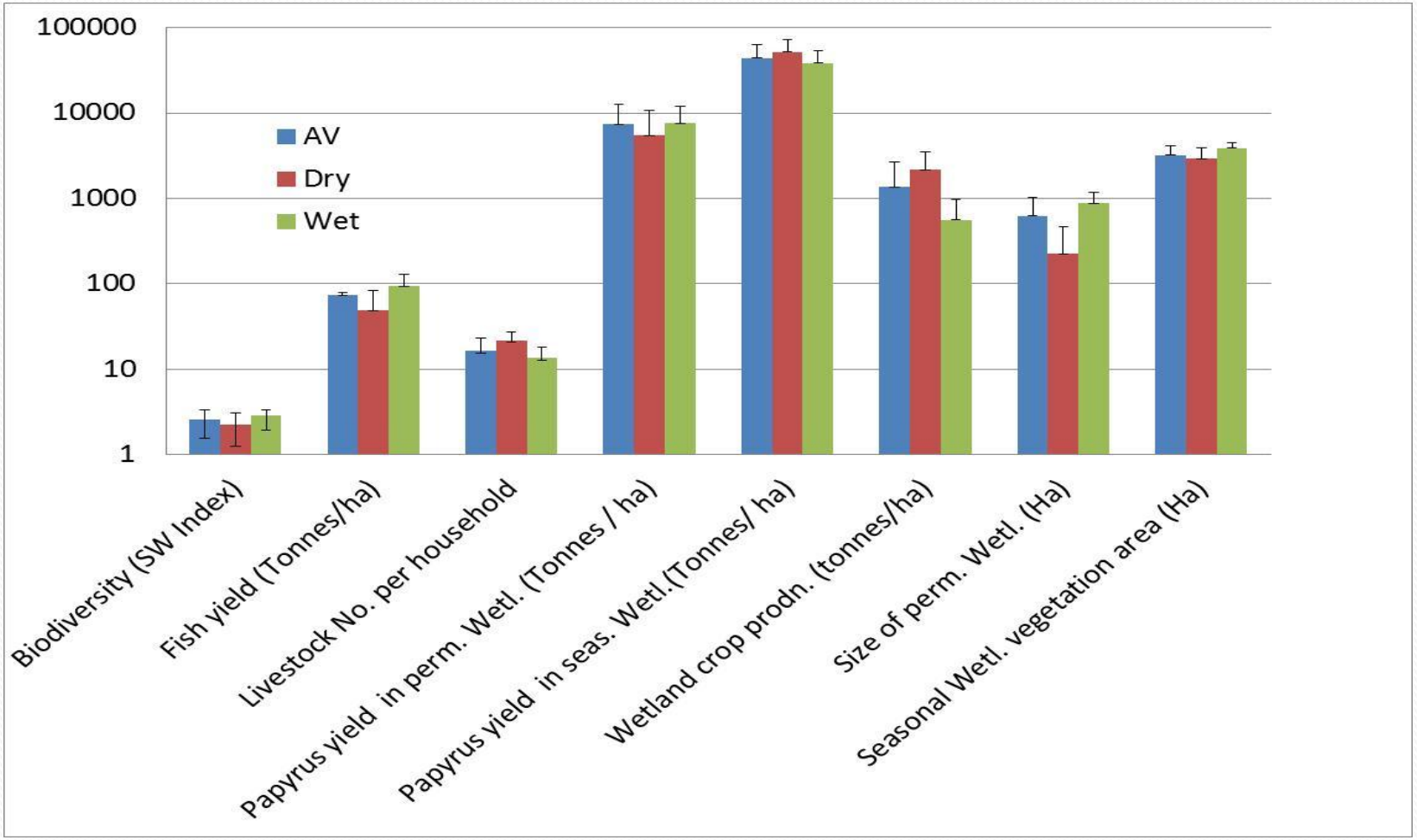


Netica 4.16 (Norsys Software Corp., Vancouver, Canada)

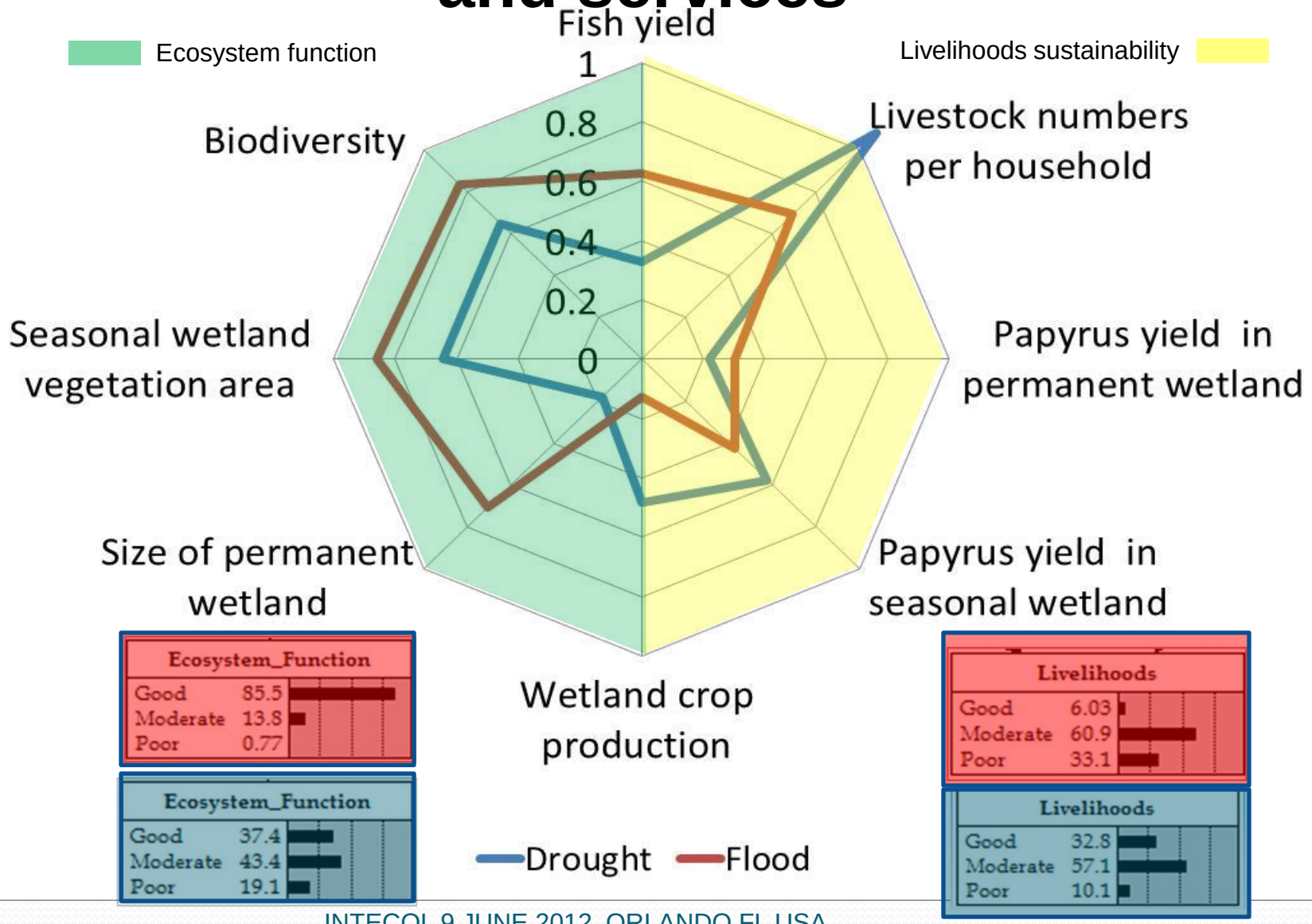
Bayesian Network model of Nyando wetland



Changes in selected ecosystem functions and services



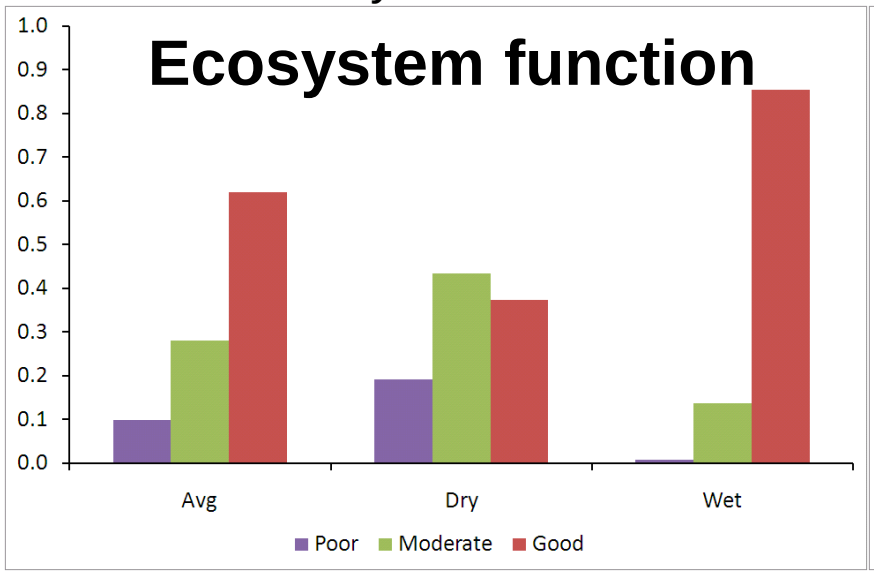
Selected ecosystem functions and services



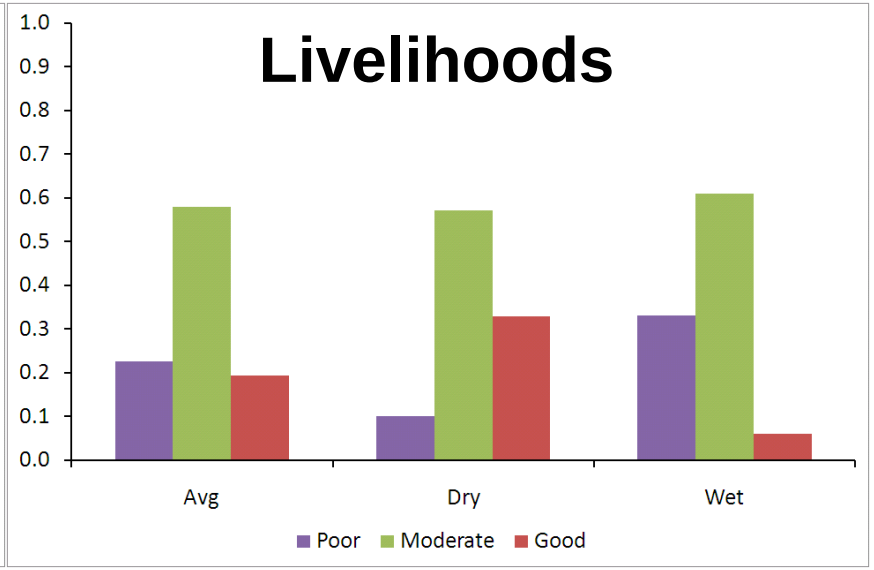
Ecosystem function and livelihoods during dry and wet conditions

Current situation

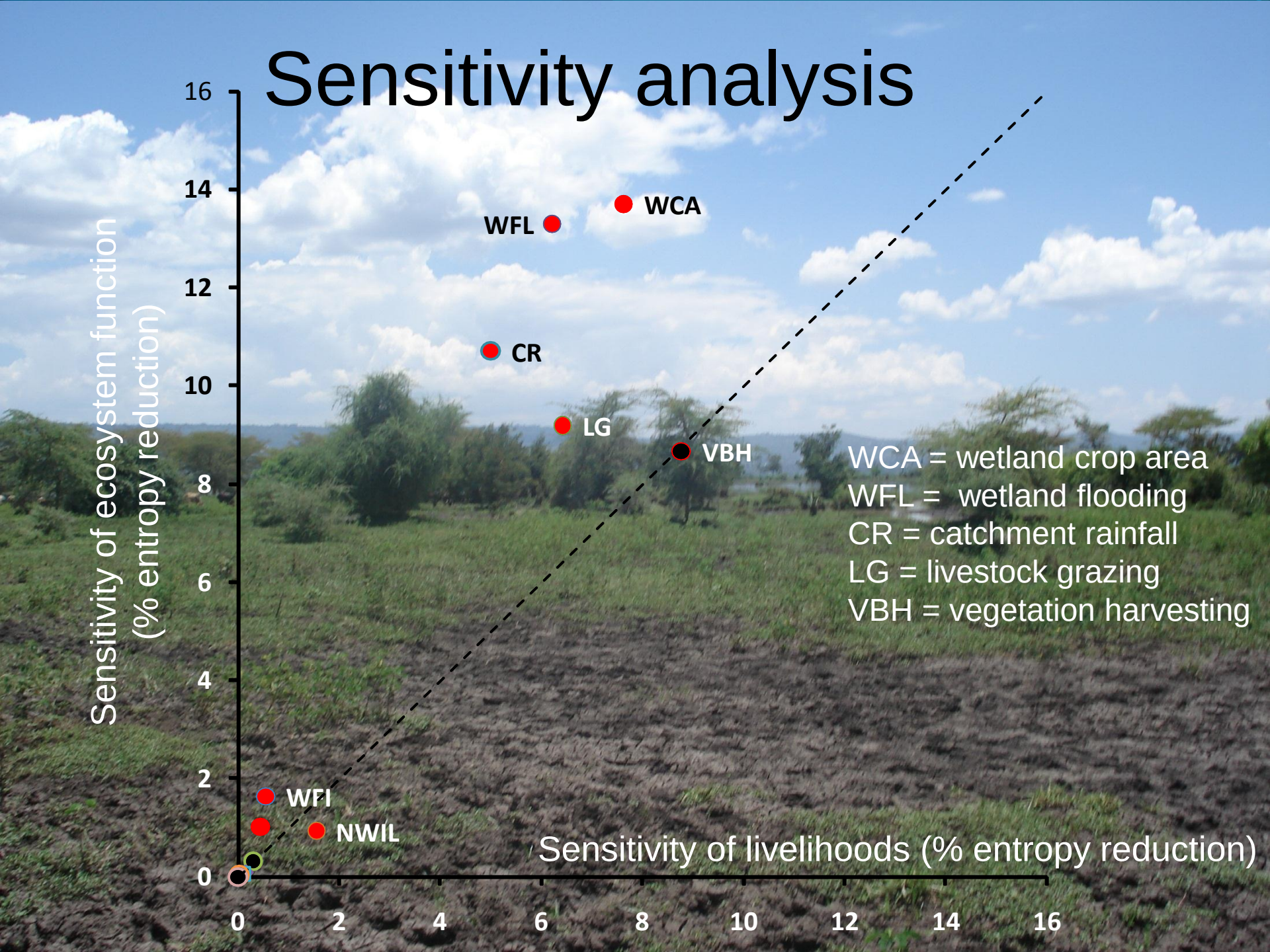
Ecosystem functions



Livelihoods



Sensitivity analysis



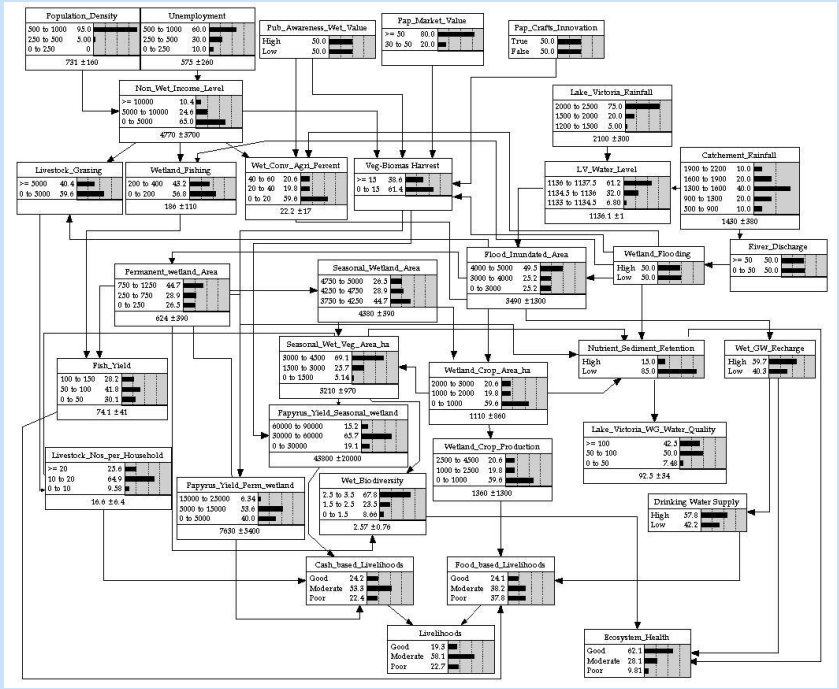
Further work

Stakeholder and expert input

Data on Socio-economics and governance

Hydrological Data or models(s) output

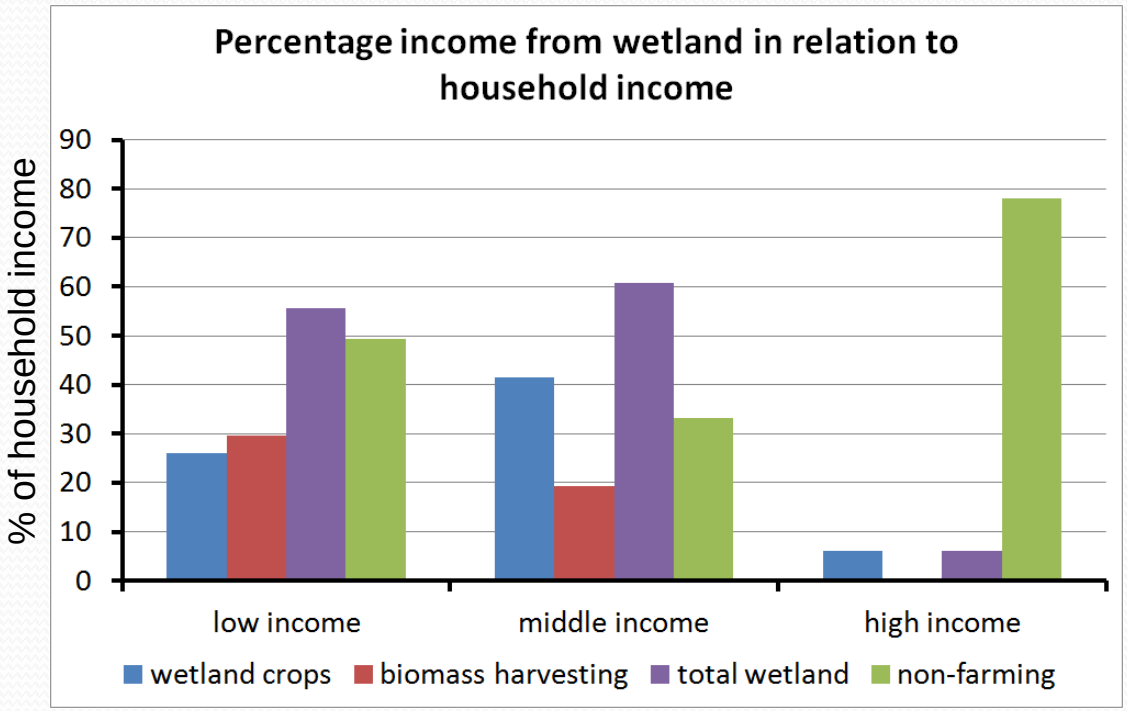
Ecological data



ECOLIVE framework

Data collection: livelihoods

- Nyando wetland households with higher incomes depend less on wetland
- Lowest incomes are most dependent on papyrus harvesting



Based on: Kipkemboi , J. et al. (2007) Geographical Journal 173, 257-272

Data collection: livelihoods

Importance of livelihoods activities in three communities in Nyando wetland, Kenya

- Wetland farming, livestock grazing, water and papyrus harvesting are most important activities
- Differences between communities in livelihoods activities

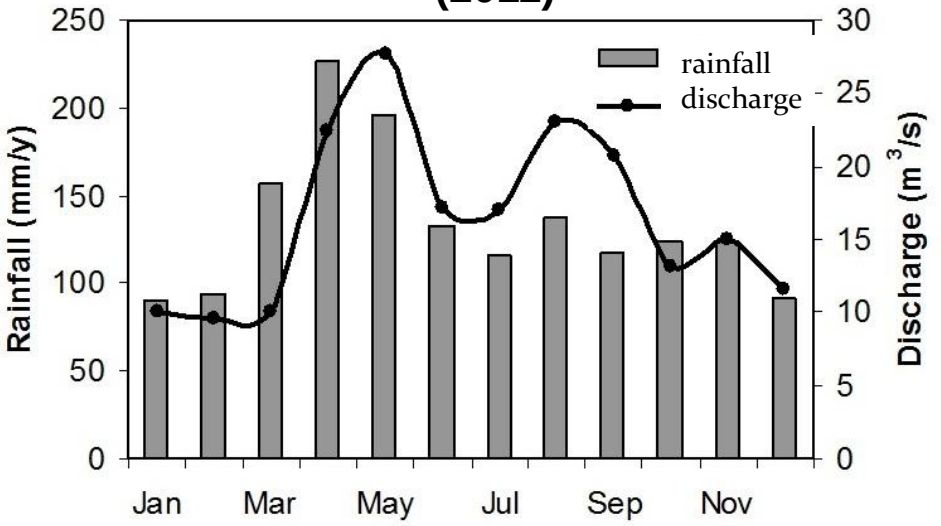
	Score*			Rank	
	Singida	Wasare	Ogenya	Avg	Overall
Wetland farming	7	9	7	2.0	1
Livestock Grazing	6	8	5	3.3	2
Water for Irrigation	4	7	8	3.3	3
Papyrus Harvesting	3	11	3	4.0	4
Collecting Firewood	1	10	6	4.0	5
Fishing	5	5	4	5.0	6
Harvesting med. plants	0	5	0	6.0	7
Fish farming	0	4	0	8.0	8
Sand Harvesting	0	3	2	8.0	9
Harvesting grass	2	1	1	8.3	10
Hunting	0	0	0	9.7	11
Liquor brew	0	3	0	10.0	12

*Scores are from cumulative pairwise importance ranking; Nasongo & Rongoei (2011) Unpublished results

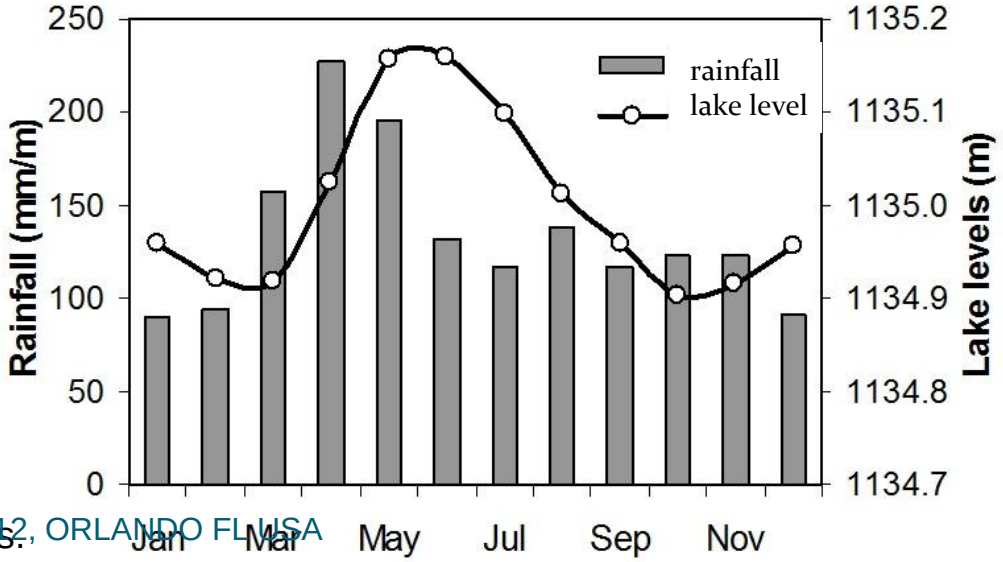
Data collection: hydrology

- Seasonal variation in rainfall, river discharge and lake level
- River and wetland mostly disconnected (flooding only 1-2 times per year when > 50 m^3/sec
- Daily flooding from lake

Monthly rainfall and river discharge (2011)



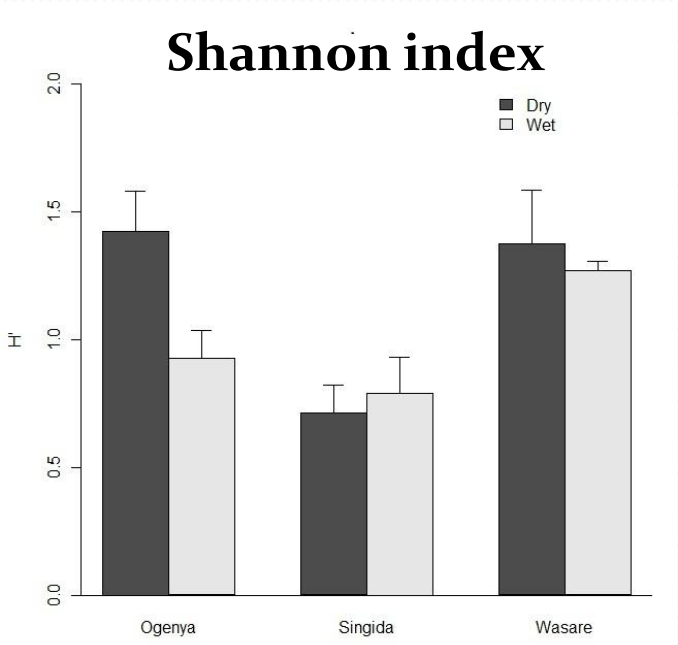
Monthly rainfall and lake level (2011)



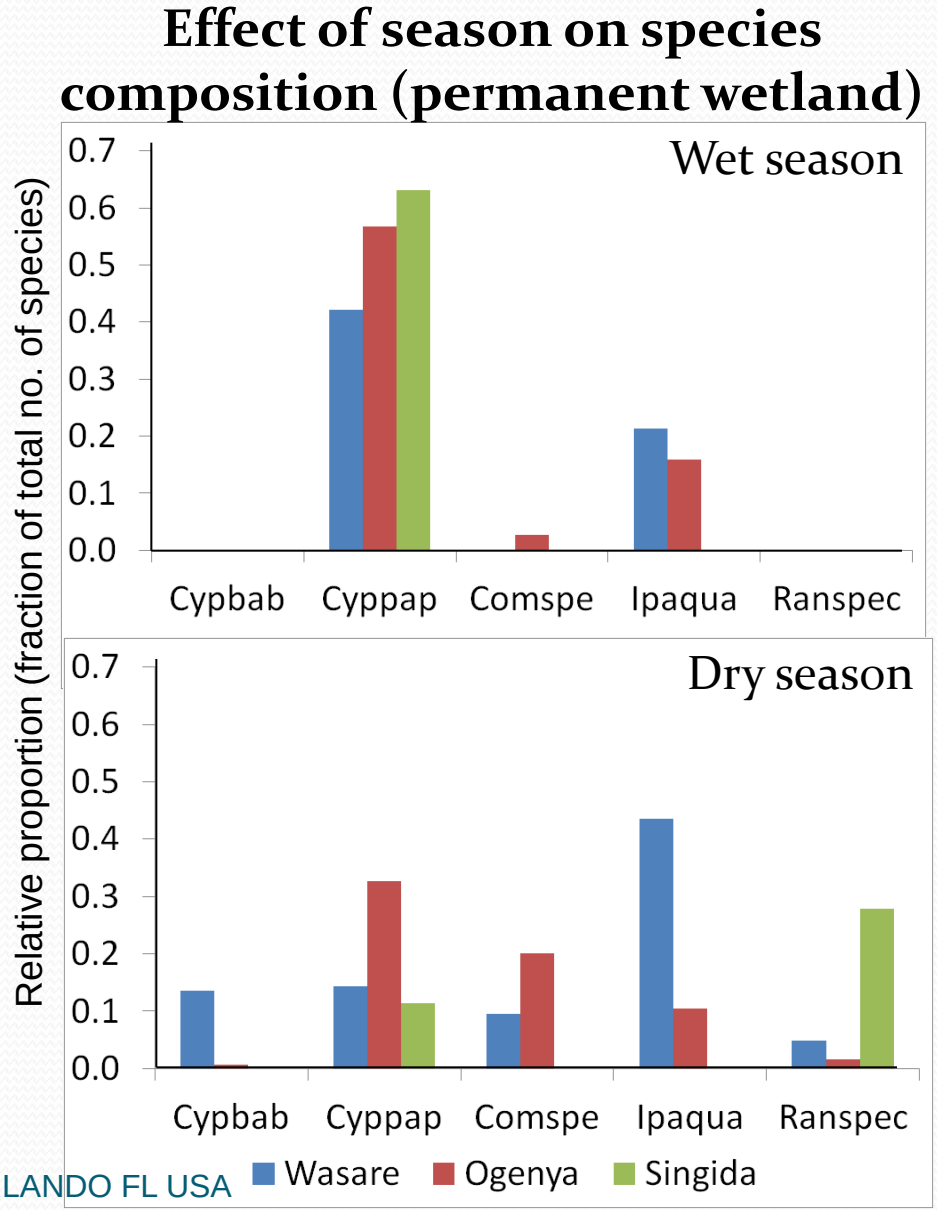
Source: Khisa, P. et al. (2011) Unpublished results.

Data collection: ecology

- Strong effect of flooding conditions on species composition and diversity



Source: Rongoei, P. et al. (2011) Unpublished results.



Summary

- BN provides integration of diverse qualitative and quantitative data in a model
- Flooding regime in the wetland seems to have considerable effect on ecosystem function and livelihood activities
- Wetland ecosystem functions are better off when the wetland is flooded whilst livelihoods are on average moderate due to the adaptive nature of the local communities.

Summary

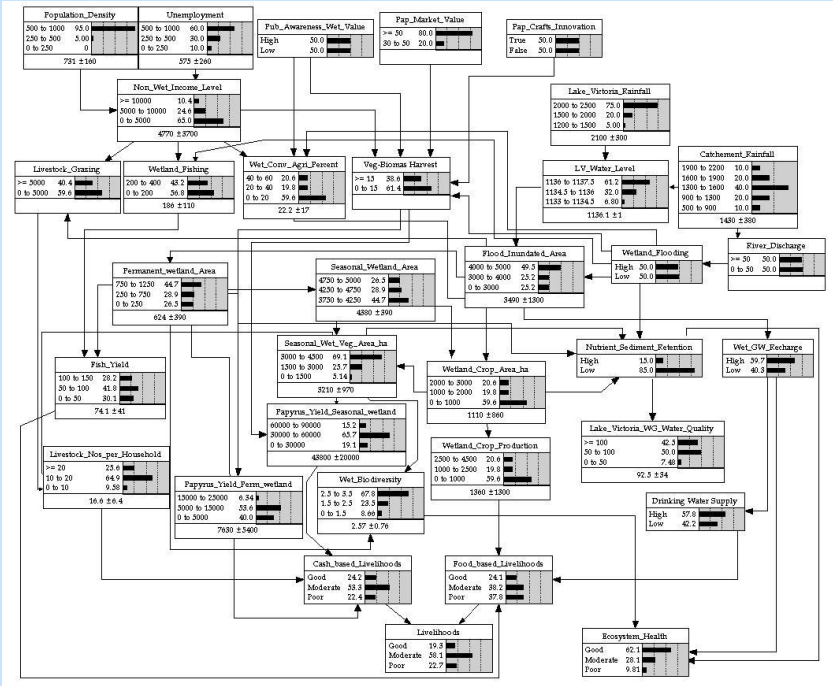
- Trade-off between provisioning and regulating services
- Model is adaptive and will be further improved using on-going research, including socio-economic, hydrological and ecological model output
- Stakeholder involvement is important for model quality and for subsequent use of model in management

Application

Stakeholder and expert input

Information on Socio-economics and governance

Hydrological data



Ecological data

- Qualitative and quantitative value of the objective variables
- Evaluation Scenarios and management options

Guidelines for wise use
Policy recommendations

THANK YOU

www.unesco-ihe.org/ecolive

VIRED

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