FEWS – Food, Energy, Water Security in Cambodia

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CONSERVATION INTERNATIONAL

MacArthur Foundation

Agenda

1) Introduction – Boston University team
2) Our modeling framework
    1) Big data analysis – FEWS in MIDAS
    2) Ecosystem based approach – MIMES (agent-based)
    3) Larger teams – McCarthur Funding/Conservation International
    4) Data sources
3) Synergies across teams – Open access & Open data

FEWS Context for Cambodia

1) FEWS research will provide foundational support in the application of ecosystem based-management decision-making and design, yielding tools necessary to **improve lives of people(sustainable livelihoods) and futures in Cambodia**
2) New and faster data algorithms developed will be generally applicable in other systems and will be a **useful tool** to help local fishers/farmers, NGOS, international development organizations, state, and federal agencies to design and implement sustainable management plans.
3) State and federal agencies can formulate sustainability plans and make informed decisions on land cover change, biodiversity, deforestation, and development.

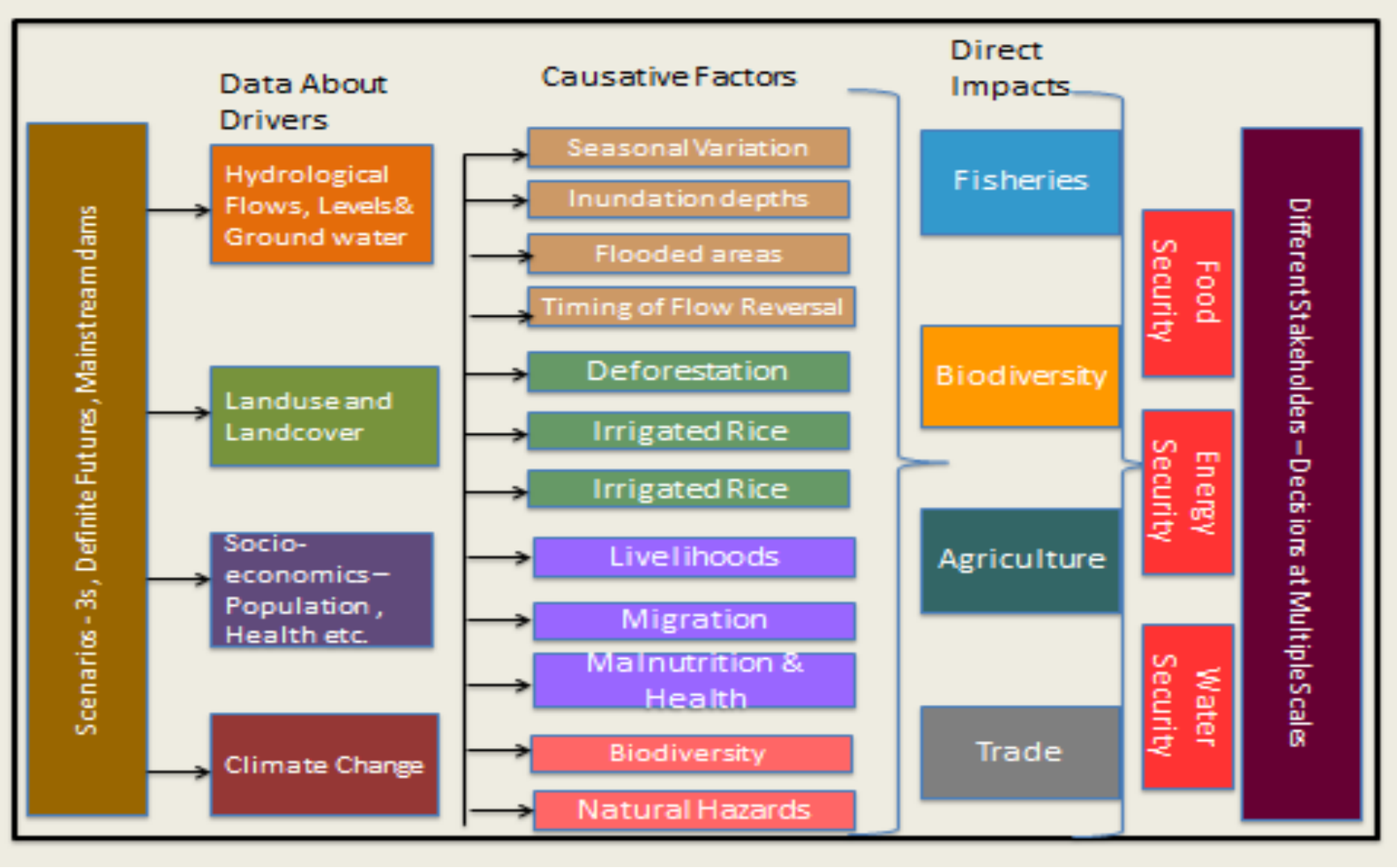
FEWS Modeling – Challenges and Solutions

1) FEWS requires understanding and modeling **systems level interactions**. - integrative, complex, and multi-scale interdependencies across space and time, and the dynamics of their interactions

2) The nexus approach seeks to optimize trade-offs, maximize synergies, and identify mutually beneficial options (i.e. "win wins") across various **stakeholders including different human-use sectors, management bodies, civic groups, and public–private partnerships**.

3) Understanding FEWS nexus depends on knowledge and integration of **georeferenced datasets**, ecological, economic, and social processes. Using quantitative approaches, these data can inform models of ecosystem service flows and tradeoffs to demonstrate what is lost and what is gained under alternative decision-making scenarios.

FEWS Modeling Framework

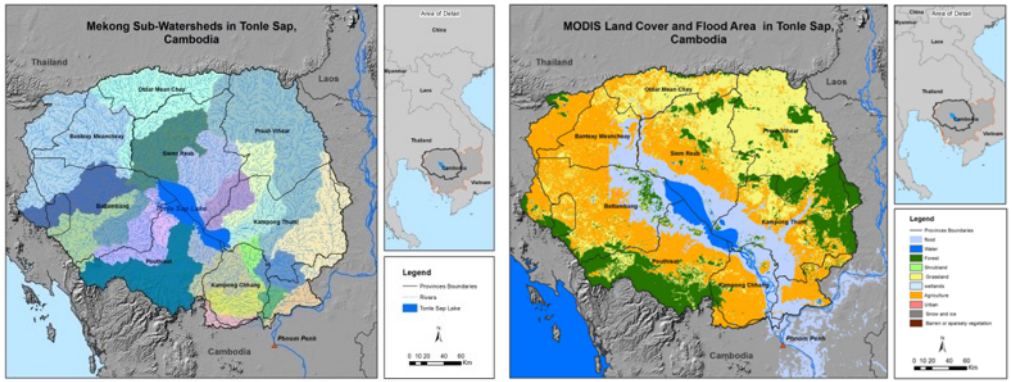


FEWS Approach

- Big data – volume, quality, collection
- Data mining – processing and validation
- Data insights – how does it help decision making
- User stakeholder groups – understanding

FEWS Data Framework

Satellite	Sensor(s)	Dates	Spatial Resolution
Landsat 1-3	MSS	1972 - 1983	80 meter
Landsat 4 and 5	Landsat TM	1982 - 2013	30 m (120 m thermal band)
Landsat 7	Landsat ETM+	1999 - present	15 m panchromatic, 30 m multispectral, 60 m thermal
Landsat 8 (LDCM)	Operational Land Imager (OLI), Thermal Infrared Sensor (TIRS)	2013 - present	15m panchromatic; 30m multispectral; 100m thermal
Terra, Aqua	MODerate Resolution Imaging Spectroradiometer (MODIS)	2000 - present	250 – 5600 meter
Terra	ASTER (VNIR & TIR) SWIR	2000 – present 2000 – 2008	15m VNIR; 90m TIR 30m SWIR
EO-1	Hyperion, Advanced Land Imager (ALI)	2000 - present	10-30 meter
Suomi NPP	Visible Infrared Imager Radiometer Suite (VIIRS)	2013 - present	375-750 meter
Space Shuttle Endeavour	Shuttle Radar Topography Mission (SRTM)	2000	30 meter (1 Arc-Second Global)



Ecosystem Service Tradeoff Analysis to Support Decision Making in the Tonle Sap Basin

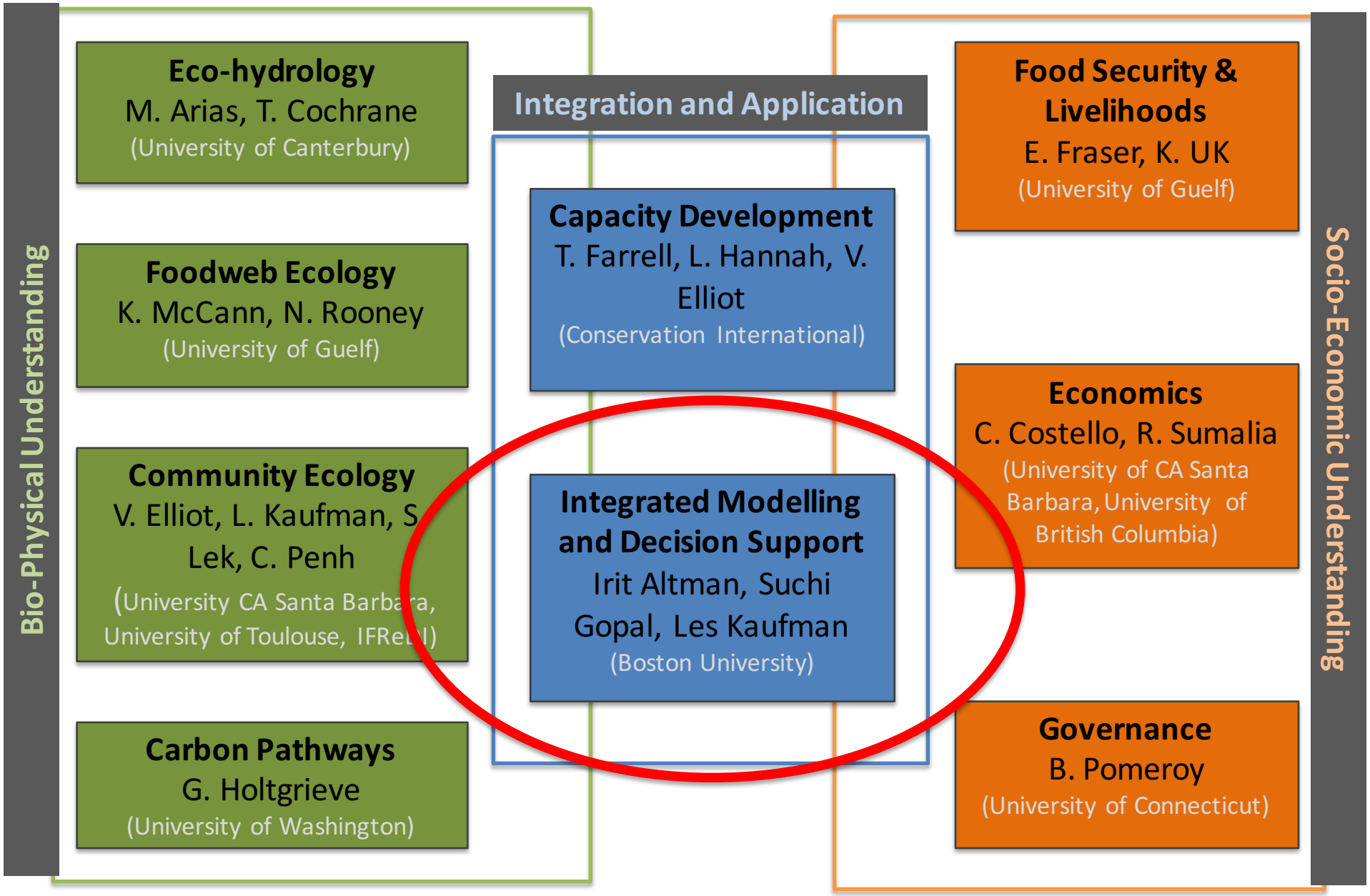
Project: The Tonle Sap is critically important to Cambodia and the larger region because the system plays a direct role by

- Securing food and supporting livelihood strategies'
- Generating income
- Maintaining high biodiversity and unique species
- Providing flood protection

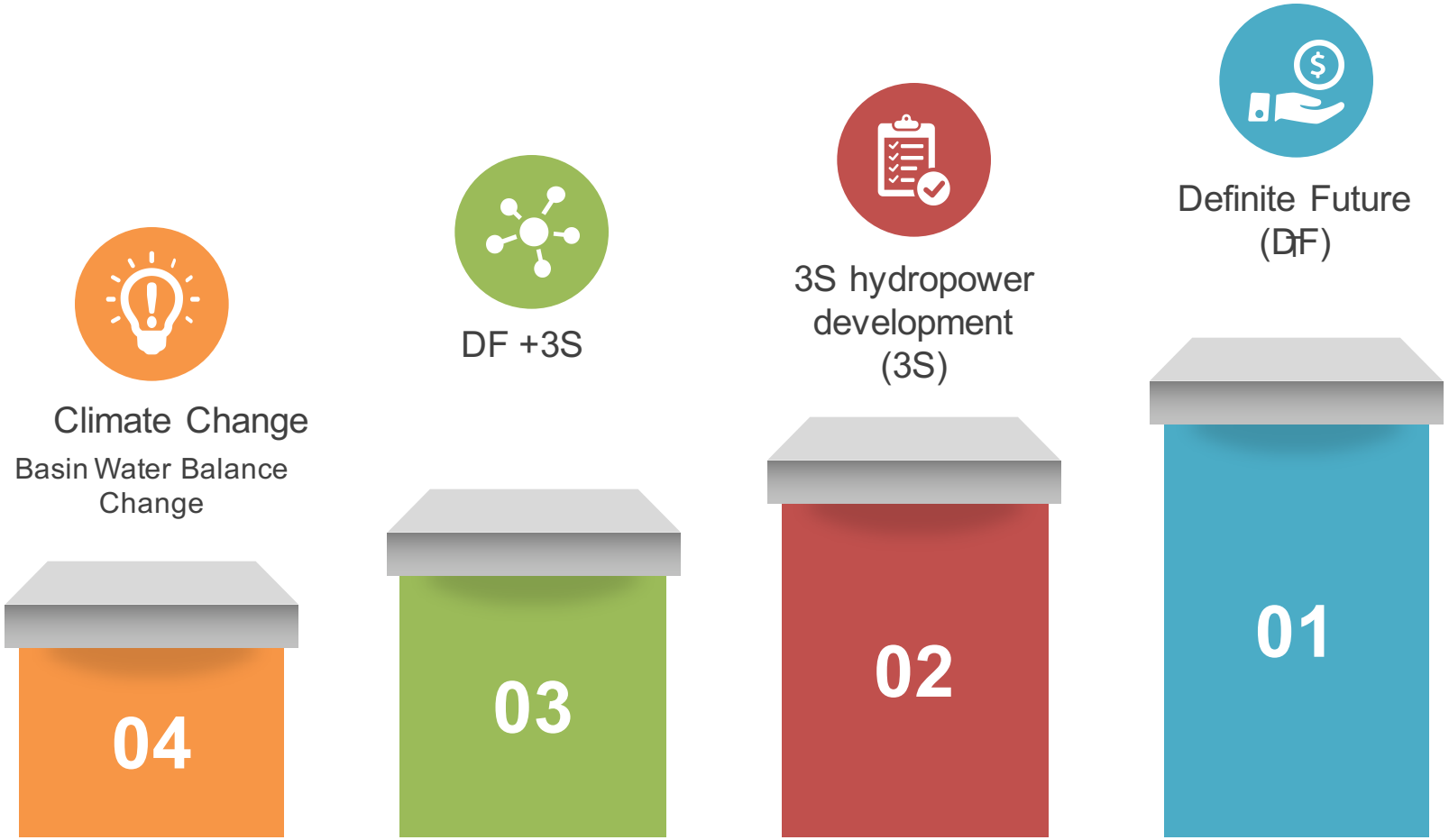
The Mekong Basin is in experiencing rapid changes in its human population, economies, and environmental character. Nowhere are these changes more apparent or important than in the area of Tonle Sap Lake.

- As a result of decisions made within and outside the lake system, the Tonle Sap sits at an important crossroads. Alternative decisions about responding to change will have consequences on human wellbeing, natural resource flows, and protection of the biological and cultural heritage of the Lake

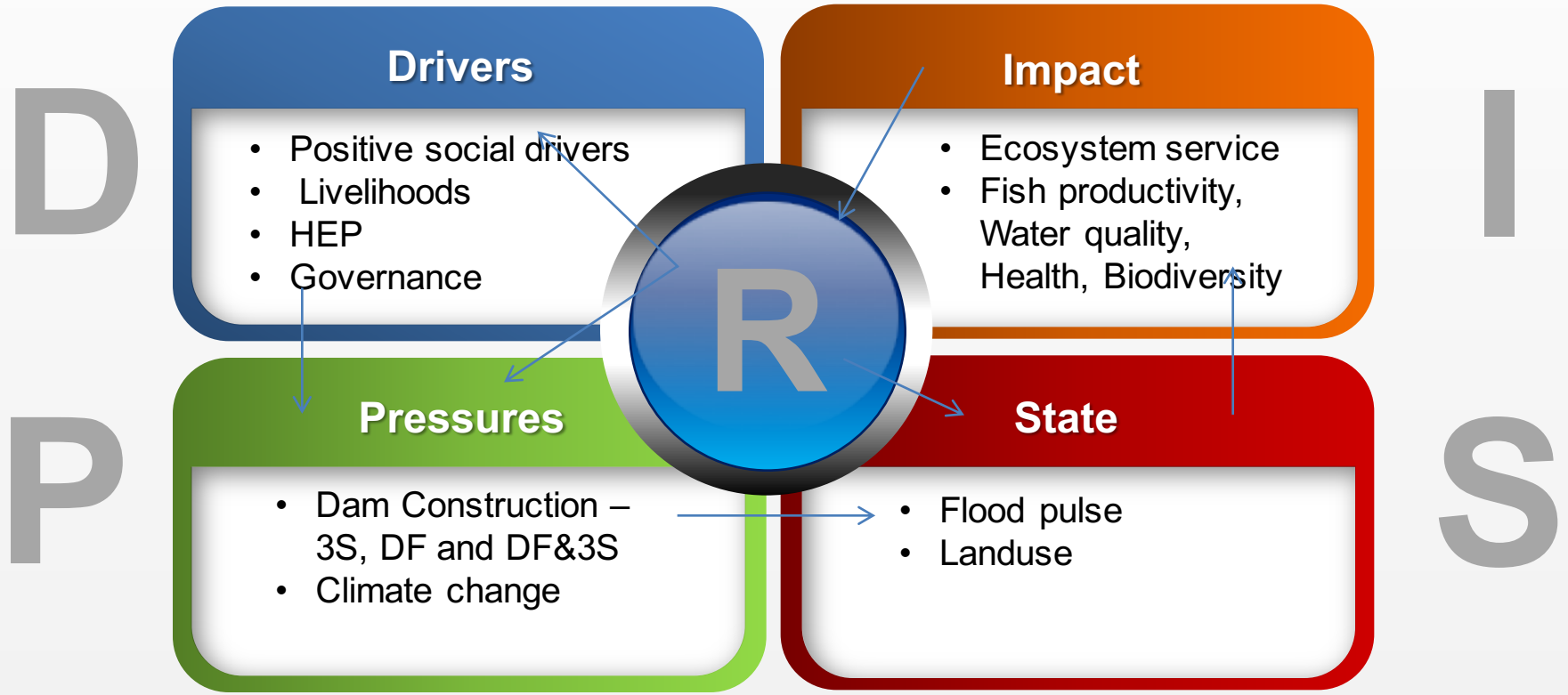
Tonle Sap Integrated Modeling: Connections To The Larger Research Initiative



Different Scenarios (4-1 in order of priority)



DPSIR Framework



Response – Change in Economic Prosperity of 4 User Groups

Measure response of each group on their economic status and social status . Use a tripartite indicator of well being.

Fishers
Commercial and small

Service Sector
Service category

Fishers and Farmers
Small

Farmers
Commercial and small

Tonle Sap Integrated Modeling: Approach

Ecosystem Services 12 (2015) 30–41

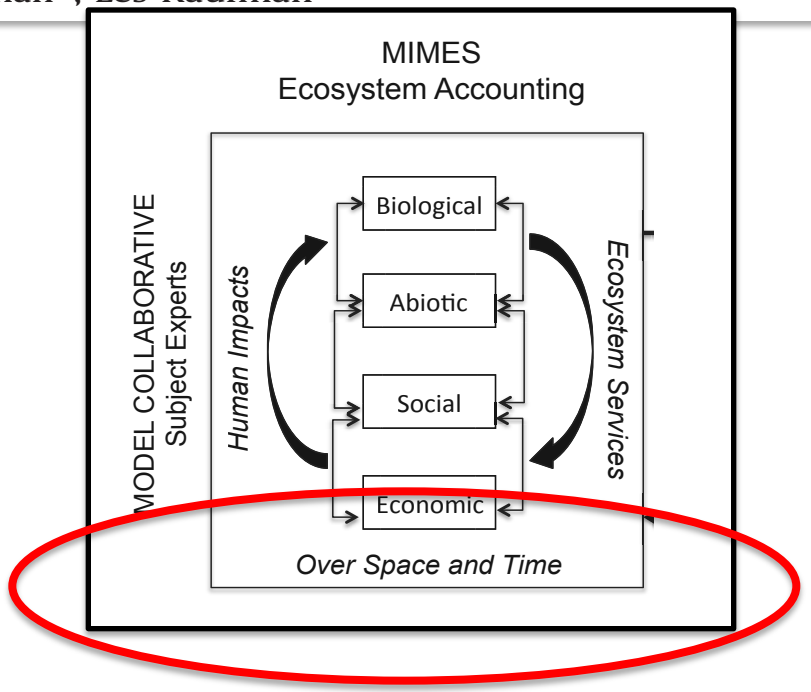
Contents lists available at ScienceDirect

Ecosystem Services

journal homepage: www.elsevier.com/locate/ecoser

The Multiscale Integrated Model of Ecosystem Services (MIMES): Simulating the interactions of coupled human and natural systems

Roelof Boumans [a,*], Joe Roman [b], Irit Altman [c], Les Kaufman [c,d]



Tonle Sap Integrated Modeling: Design and Methods

Water Levels

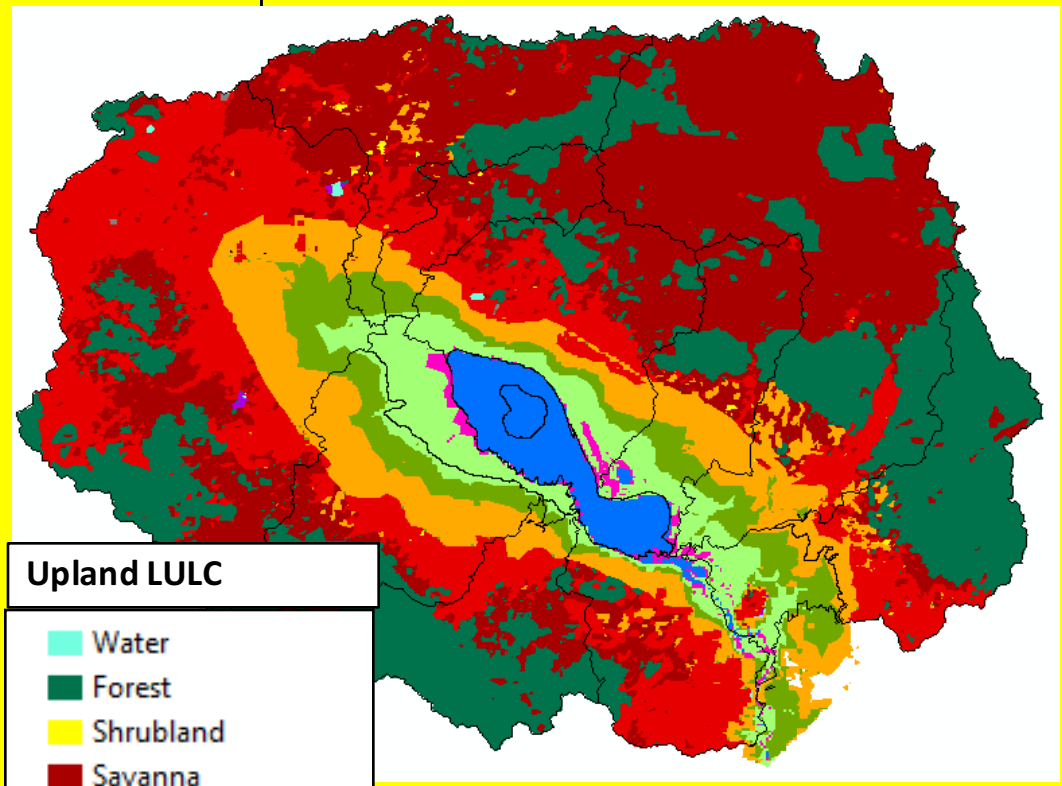
- Kampong Luong flows

Hydrological Units (n=30)

-Area and geography
-Elevation distribution

Landcovers (n=13)

-Min elevation
-Max elevation
-Elevation bins
-Sedimentation rates
-NDVI



Floodplain Landuse/Landcover

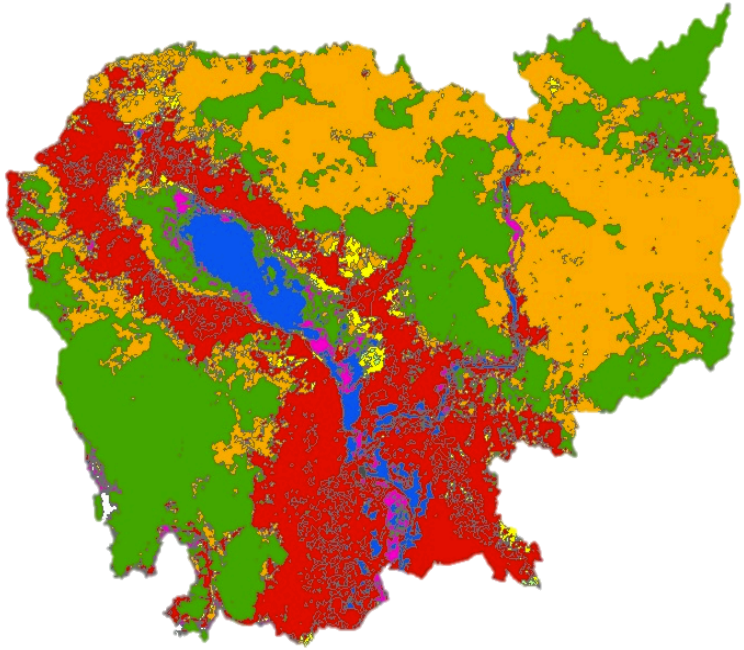
- Rainfed Habitat
- Transitional Floodplain Habitat
- Seasonally Flooded
- Gallery Forest
- Open Water Lake

Upland LULC

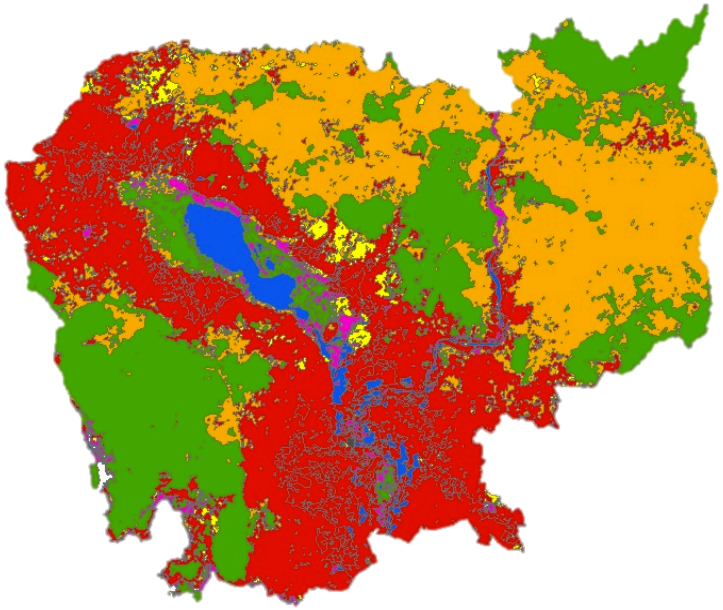
- Water
- Forest
- Shrubland
- Savanna
- Grassland
- Wetlands
- Upland Agriculture
- Nonvegetated

MODIS Landcover/Landuse

(Friedl et al. 2002)

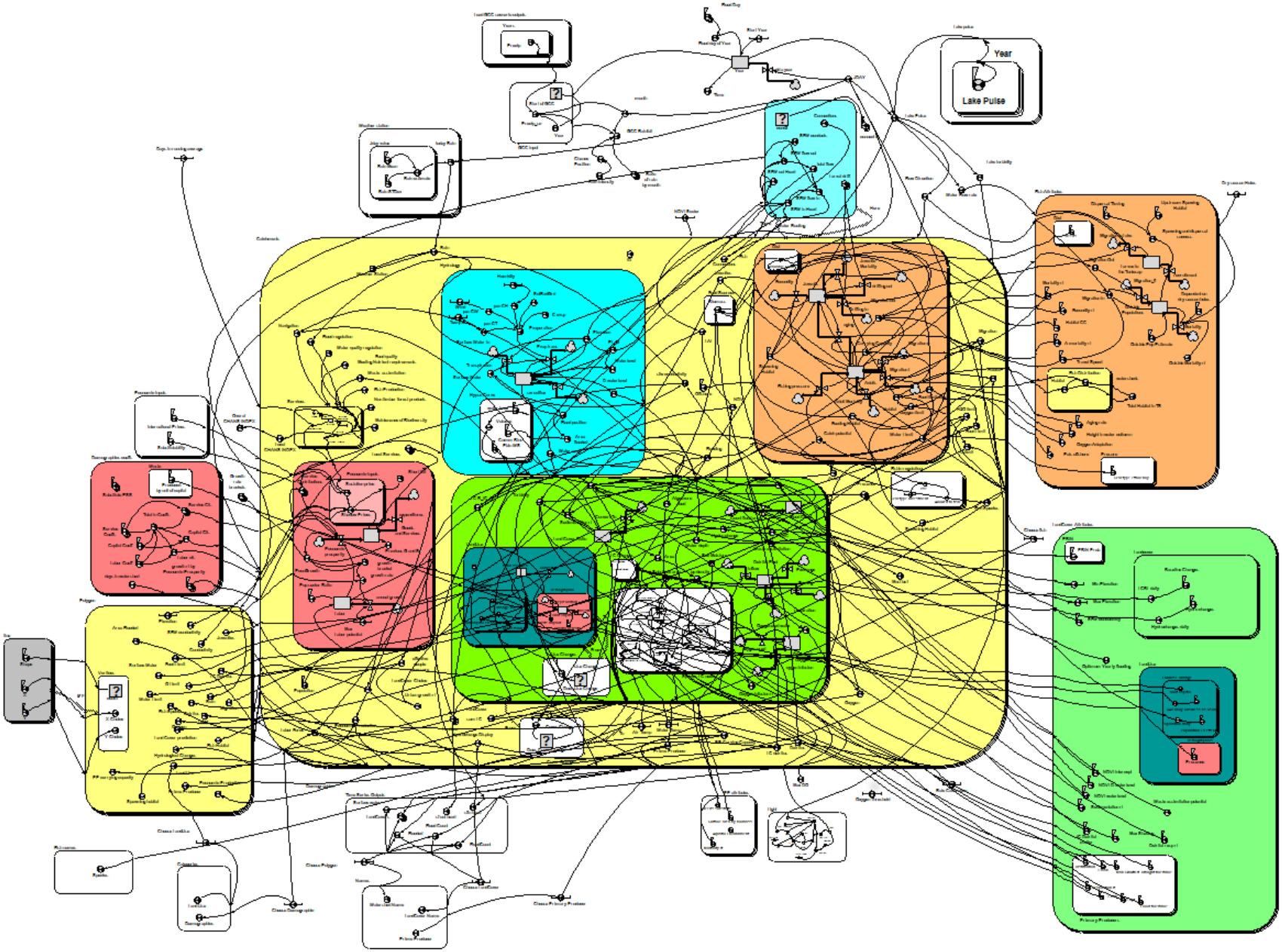


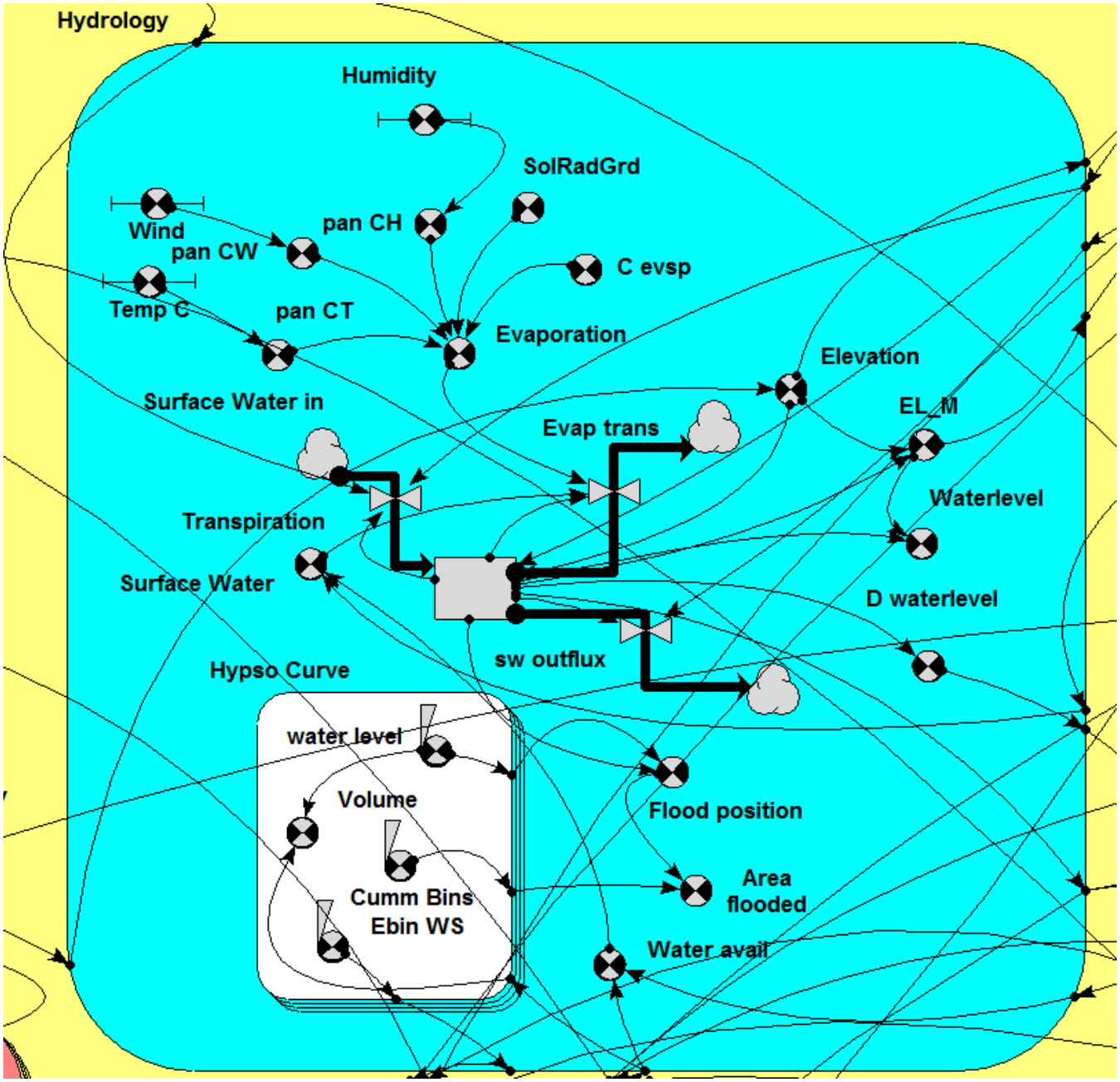
2001



2011

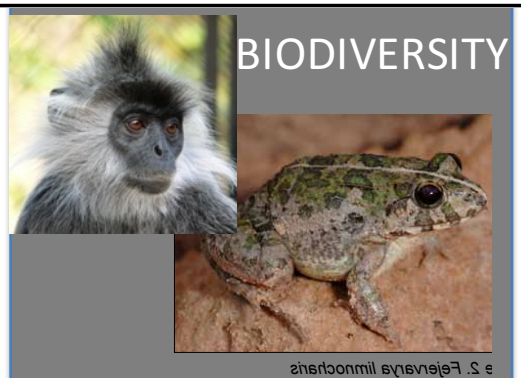
Color Key	Landuse/ Landcover	2001 (thousand km2)	2011 (thousand km2)	Change (%)
	Agriculture	23.4	35.5	52%
	Savannas	28.3	20.6	-27%
	Forest	24.6	19.3	-22%
	Water	3.9	3.4	-13%
	Grassland	1.4	2.6	79%


Year
Lake Pulse


Hydrology
Humidity
SolRadGrd
Wind
pan CH
pan CW
C evsp
Temp C
pan CT
Evaporation
Elevation
Surface Water in
EL_M
Evap trans
Waterlevel
Transpiration
Surface Water
D waterlevel
sw outflux
Hypso Curve
water level
Volume
Flood position
Area
flooded
Cumm Bins
Ebin WS
Water avail

Tonle Sap Integrated Modeling: Design and Methods

DATA/INFORMATION TYPE	CURRENTLY USED	FUTURE UPDATES
Water levels	Water guage (Kampong Luong), *MRC water levels, 3S water levels (Arias 2014)*	
Landuse/Landcover - Floodplain	Arias 2012 (Floodplain landuse rules)	
Landuse/Landcover - Upland	MODIS 2001-2013, *Land Concessions (Open Development)*	
Fish Community	BayFish (Expert opinion combined probabilities)	Fish sampling program (V. Elliot)
Fish Ecology		Foodweb theory (K. McCann, S. Lek), Carbon pathways (G. Holtgrive, B. McMeans), Morphmetrics and functional ecology (L. Kaufman)
Tetrapod Community	IUCN derived habitat maps	
Human Pop Change and Demographics	Cambodia Census, Landscan	Asiapop data
Health and Nutrition	IFReDI food and nutrition survey data	Micronutrients (G. Holtgrieve)
Livelihood Structure and Security	Keskiken and Varis work	Livelihood security surveys (E. Fraser)
Governance		Community fishing surveys (R. Pomeroy)



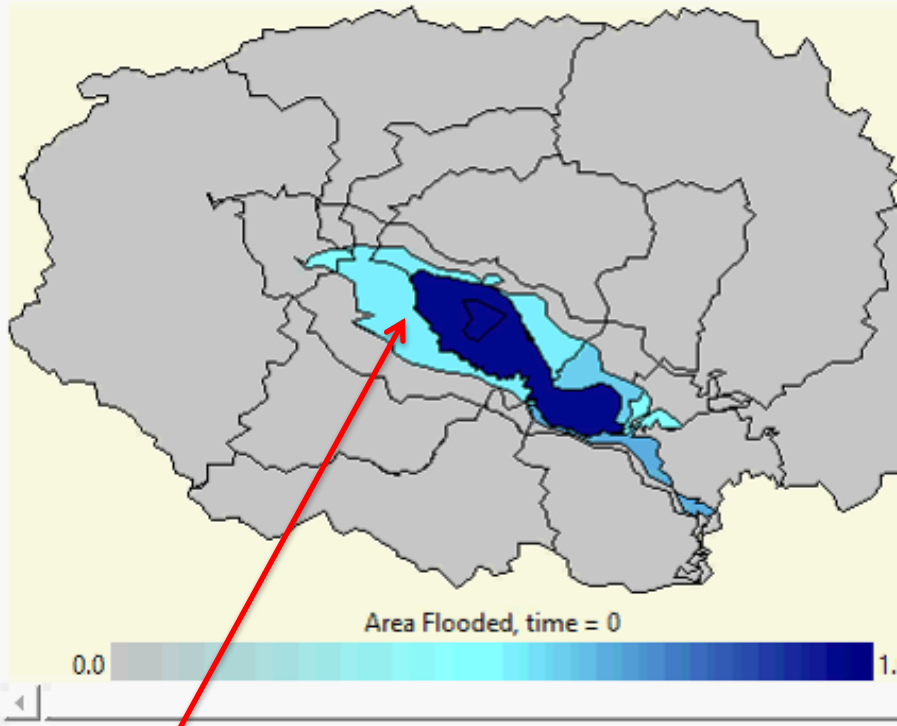
his value cannot be set by sliders, check boxes or pulldown lists. Note that
hese tools cannot be used on derived values, constants or multidimensiona
arameters.

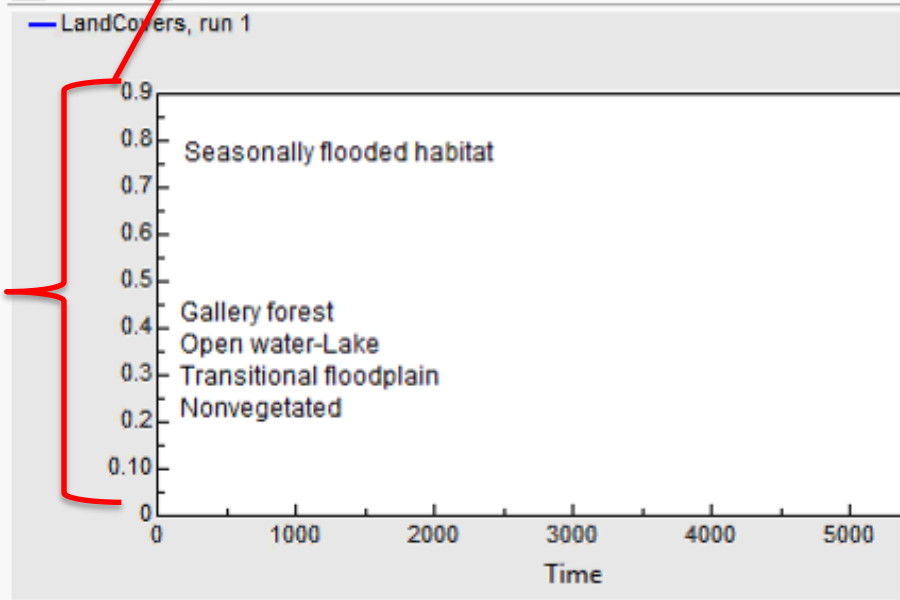
TOP LEVEL:

Choose LandCove
1
0 2 4 6 8 10 12 14

Choose Polygon
14
0 10 20 30

Name	LandCover Name
	Rainfed habitat





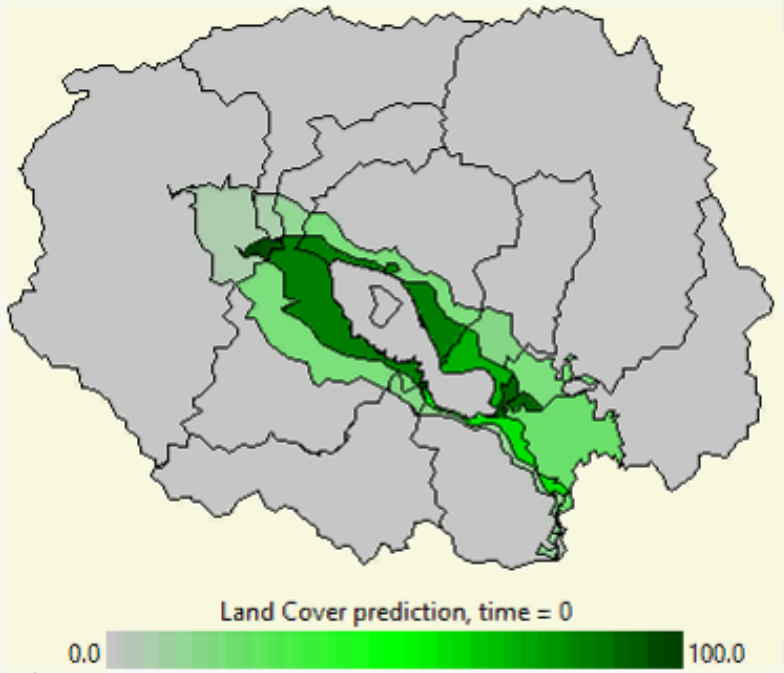
TOP LEVEL:

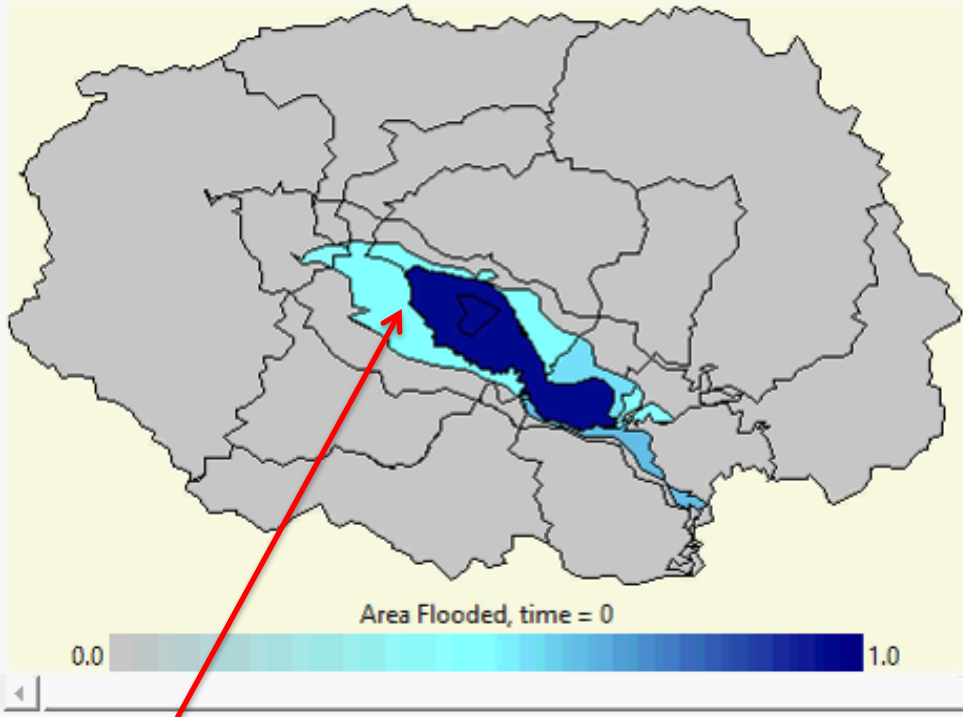
Choose LandCove

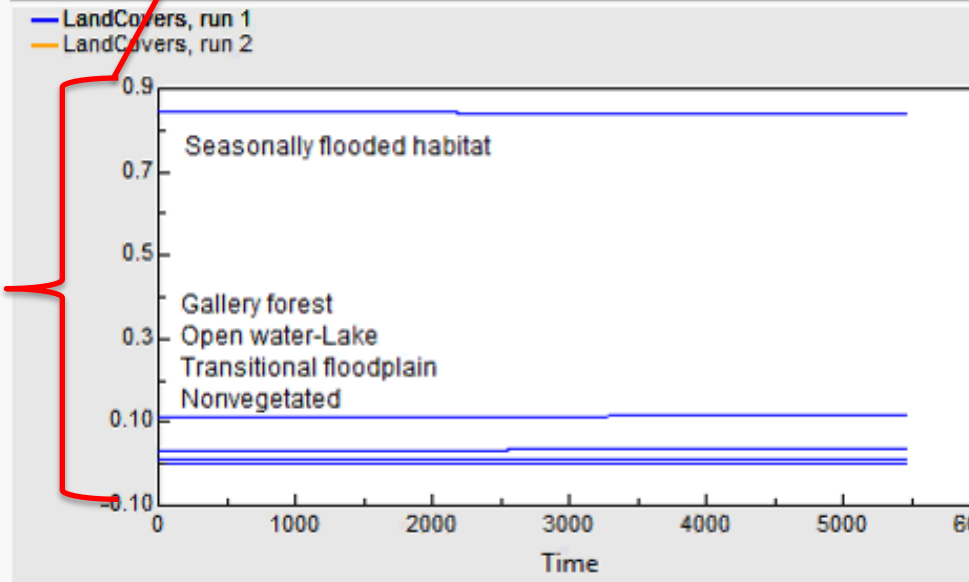
2

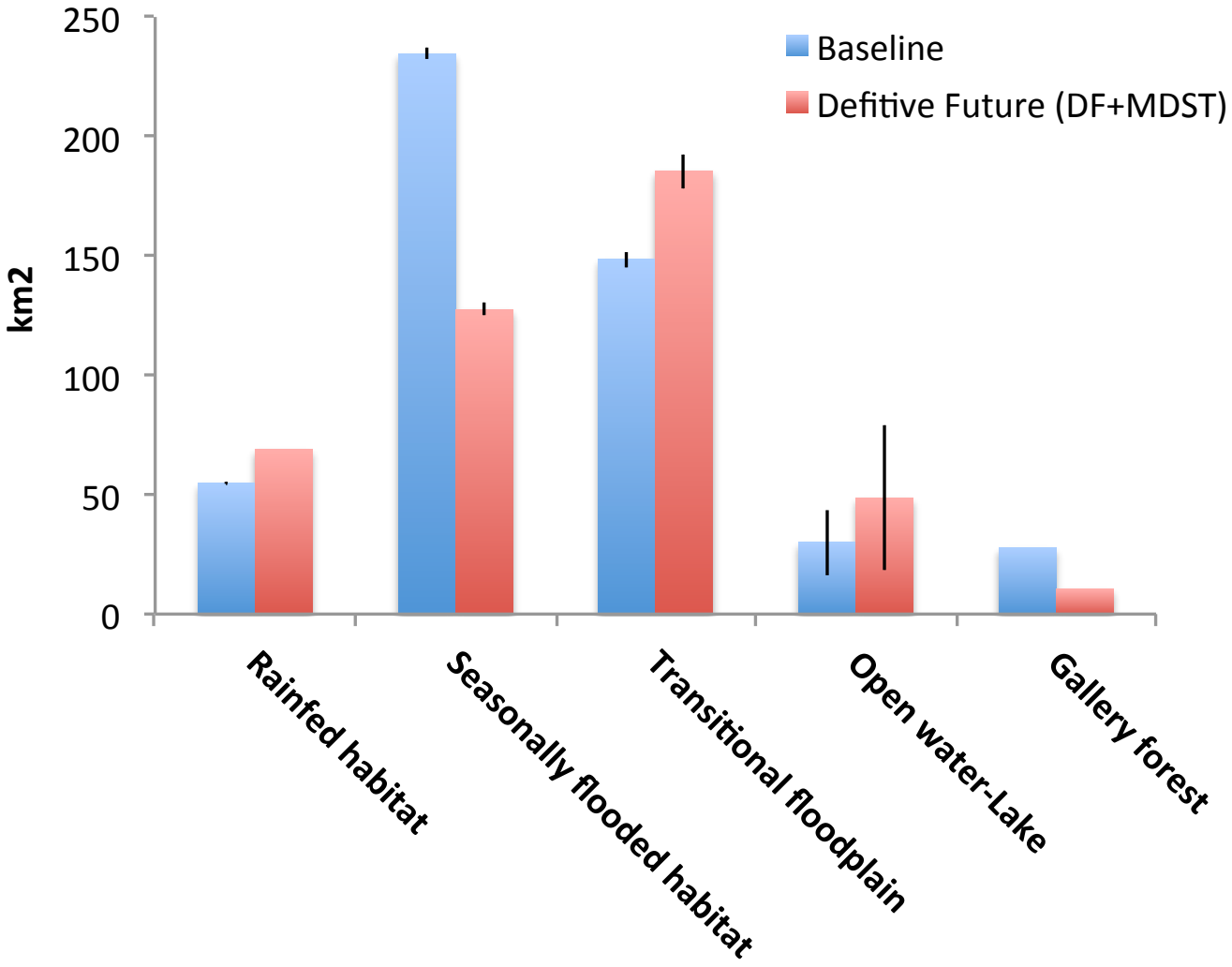
0 2 4 6 8 10 12 14

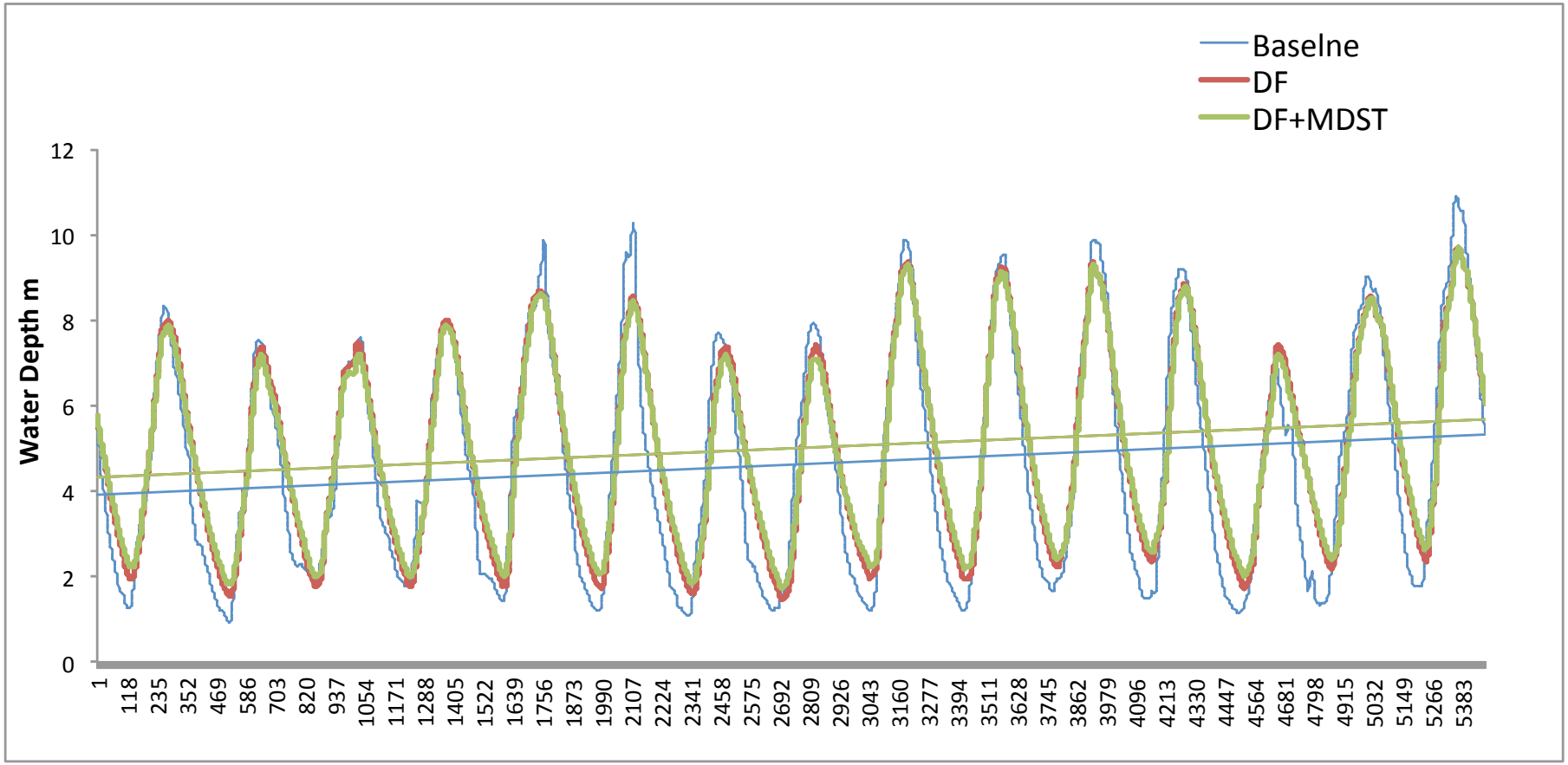
Name	LandCover Name
	Seasonally flooded habitat








250
200
150
100
50
0
km2
Baseline
Defitive Future (DF+MDST)
Rainfed habitat
Seasonally flooded habitat
Transitional floodplain
Open water-Lake
Gallery forest


Baselne
DF
DF+MDST
Water Depth m
0
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4
6
8
10
12
1
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235
352
469
586
703
820
937
1054
1171
1288
1405
1522
1639
1756
1873
1990
2107
2224
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2458
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2809
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3043
3160
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3394
3511
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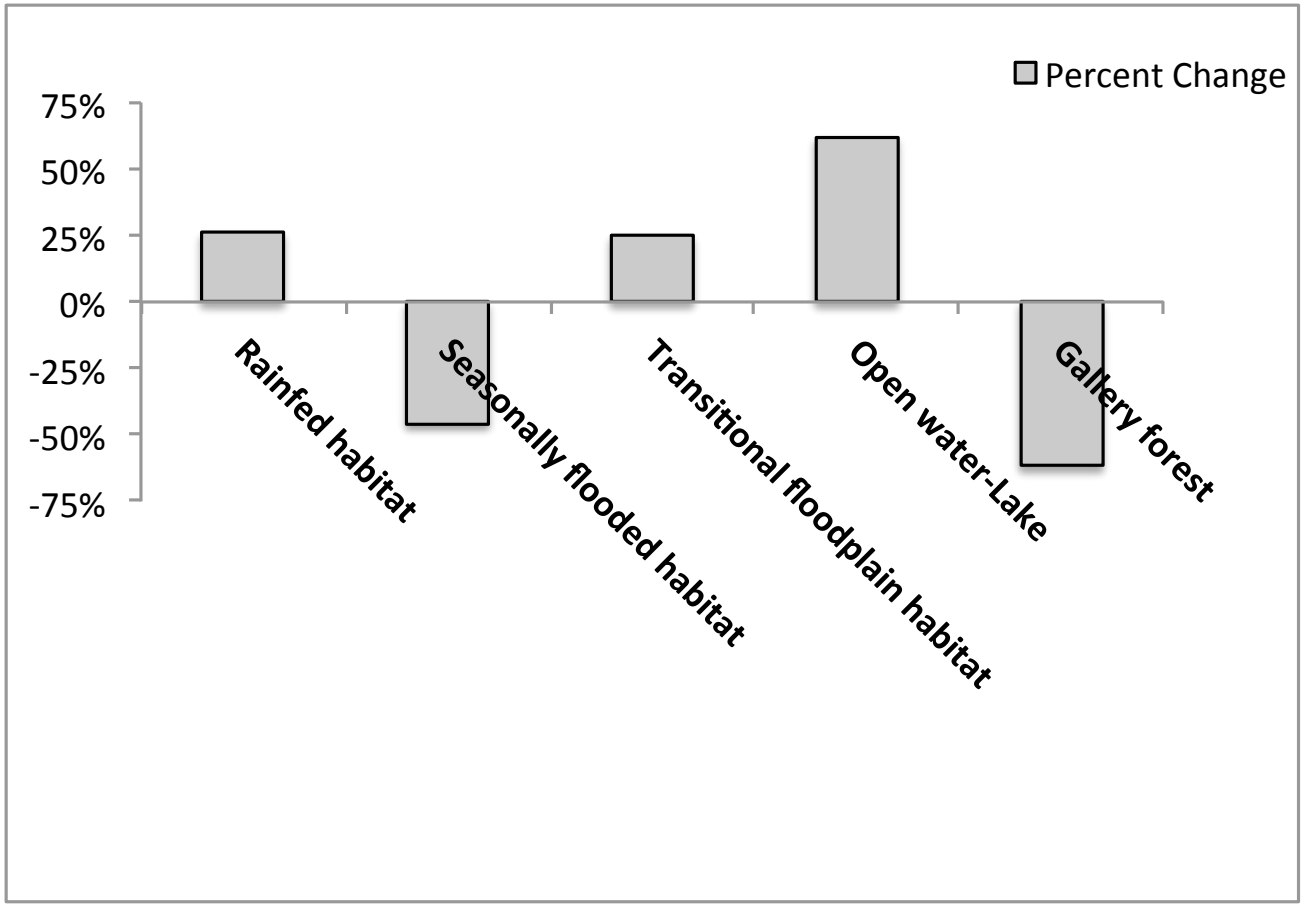

Percent Change
75%
50%
25%
0%
-25%
-50%
-75%
Rainfed habitat
Seasonally flooded habitat
Transitional floodplain habitat
Open water-Lake
Gallery forest

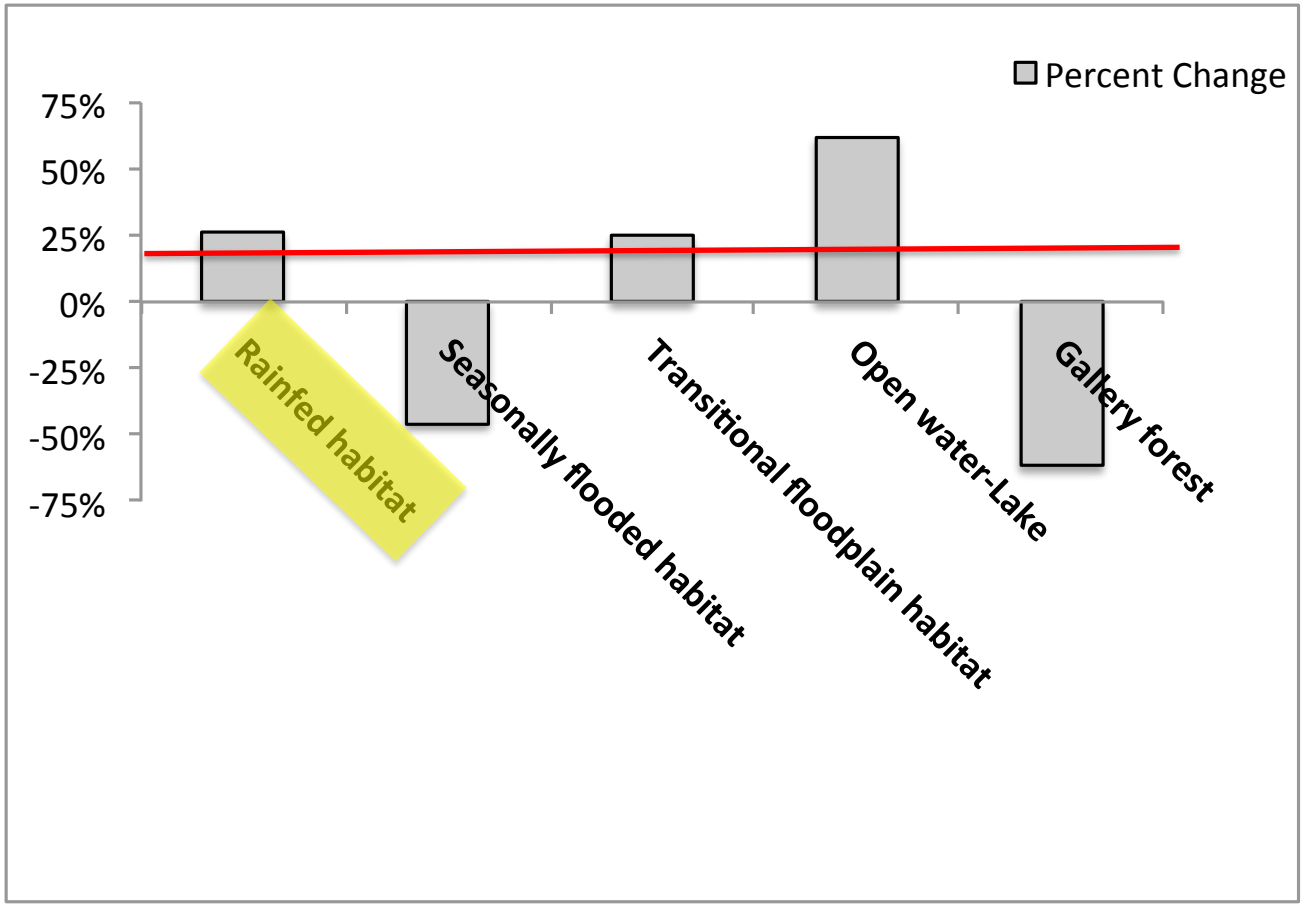
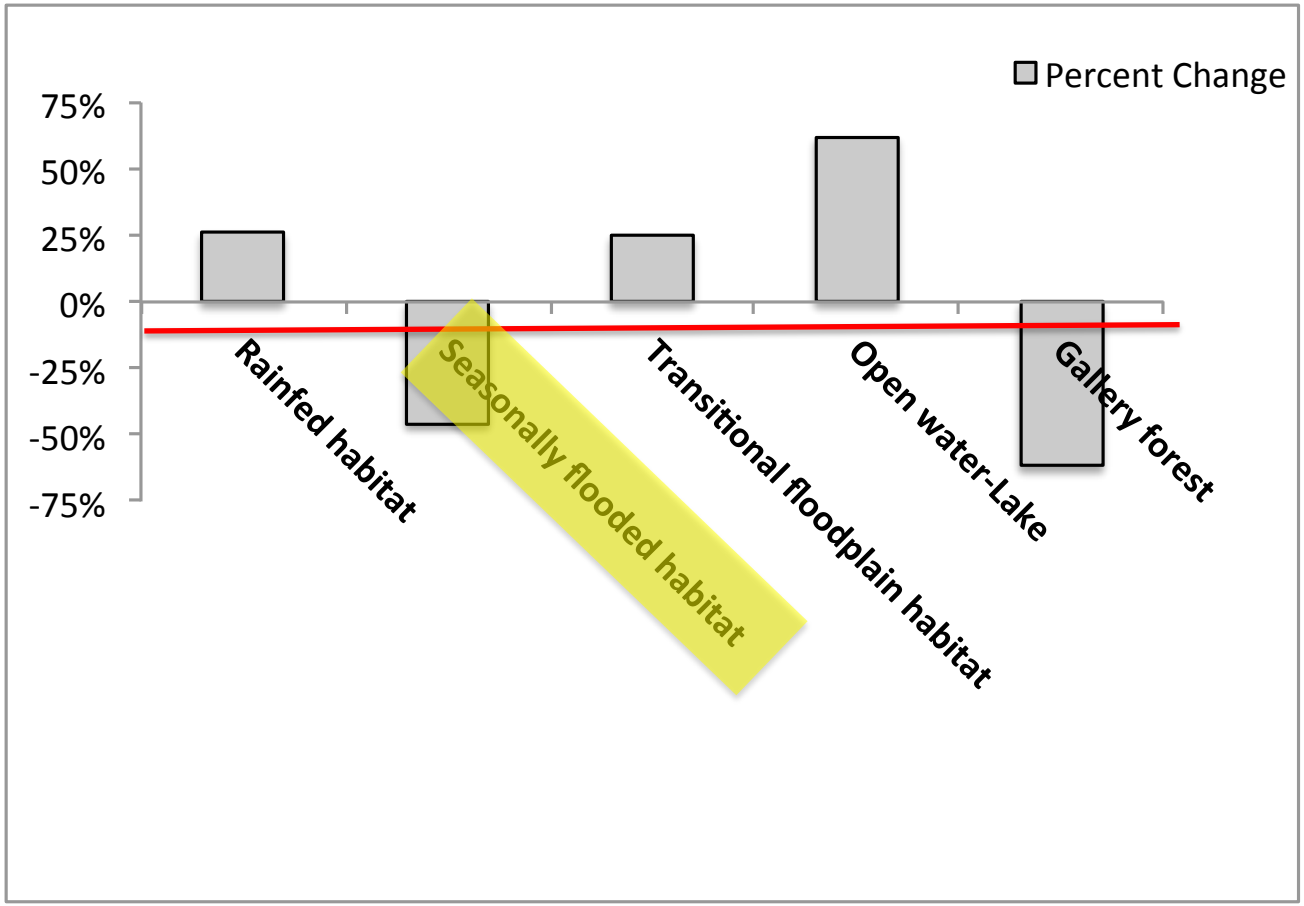


Table 3
Area change from baseline (modeled) habitat cover as a response to different future scenarios.

Model scenarios	Rainfed habitats		Transitional habitats		Seasonally flooded habitats		Gallery forest		Open water	
	km^2	%	km^2	%	km^2	%	km^2	%	km^2	%
UMD	813	10	−189	−4	−612	−13	−537	−82	525	21
2030DEV	1061	13	−281	−6	−810	−17	−536	−82	567	22
2060DEV	1215	14	−133	−3	−1041	−22	−495	−75	454	18



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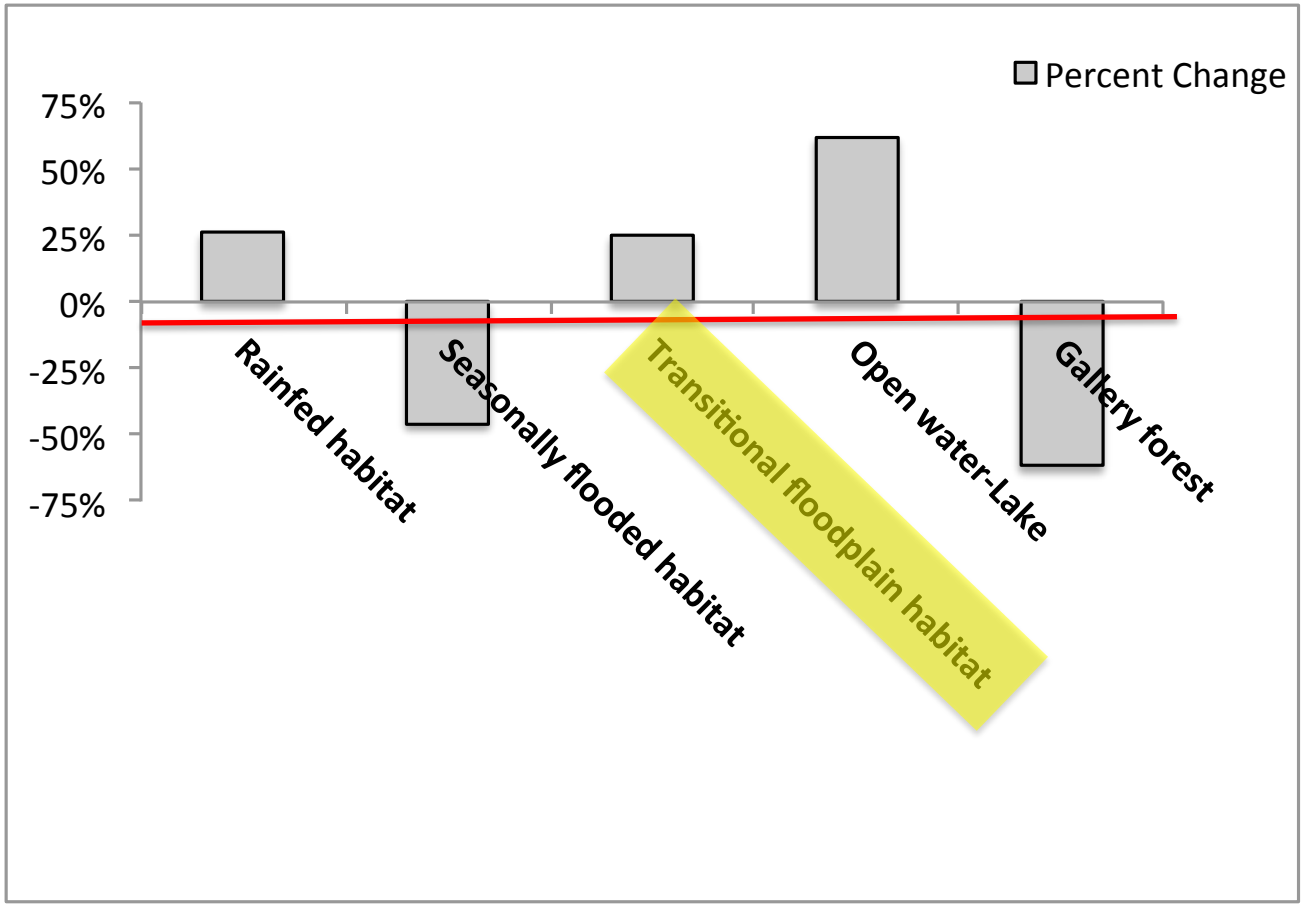

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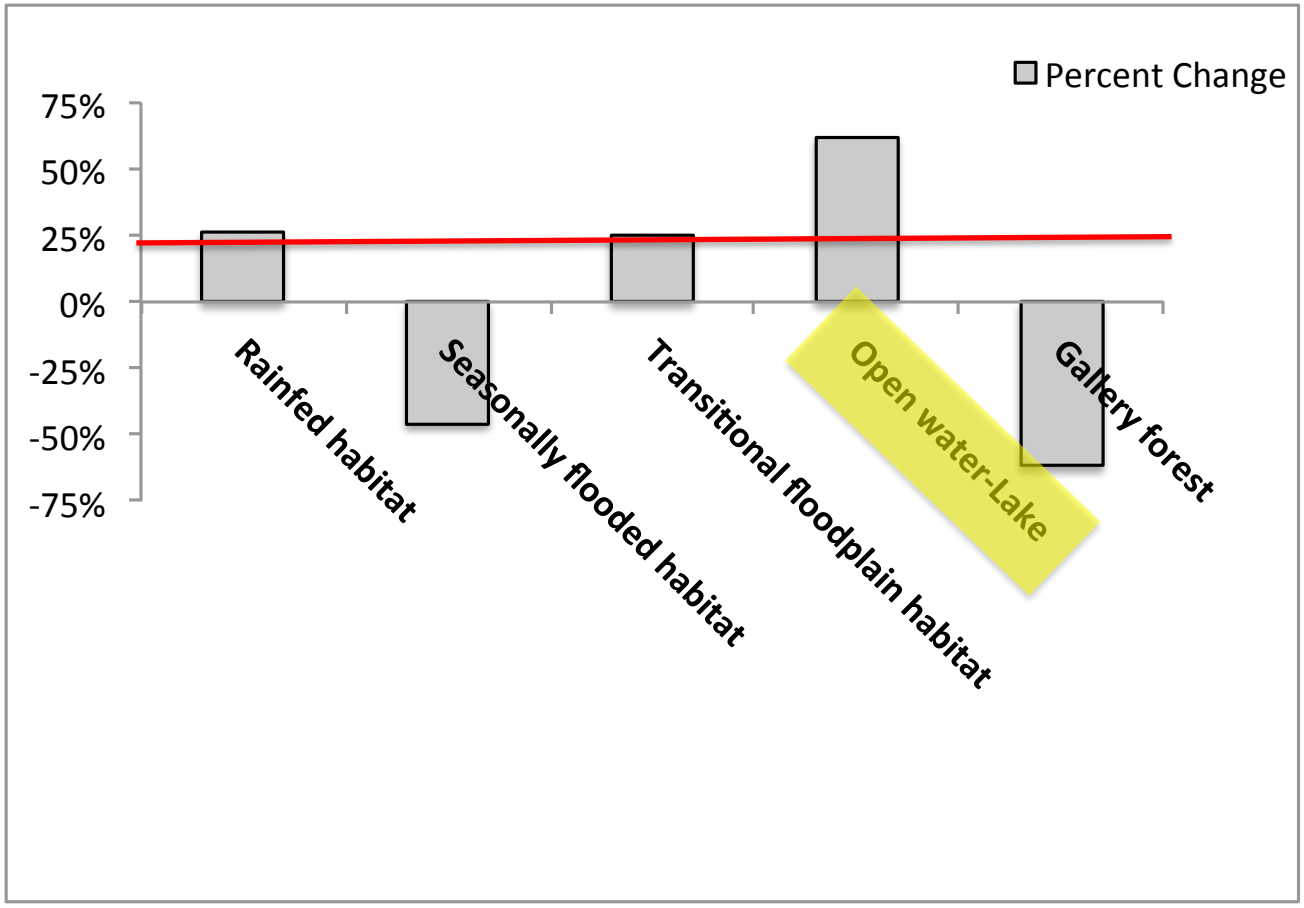

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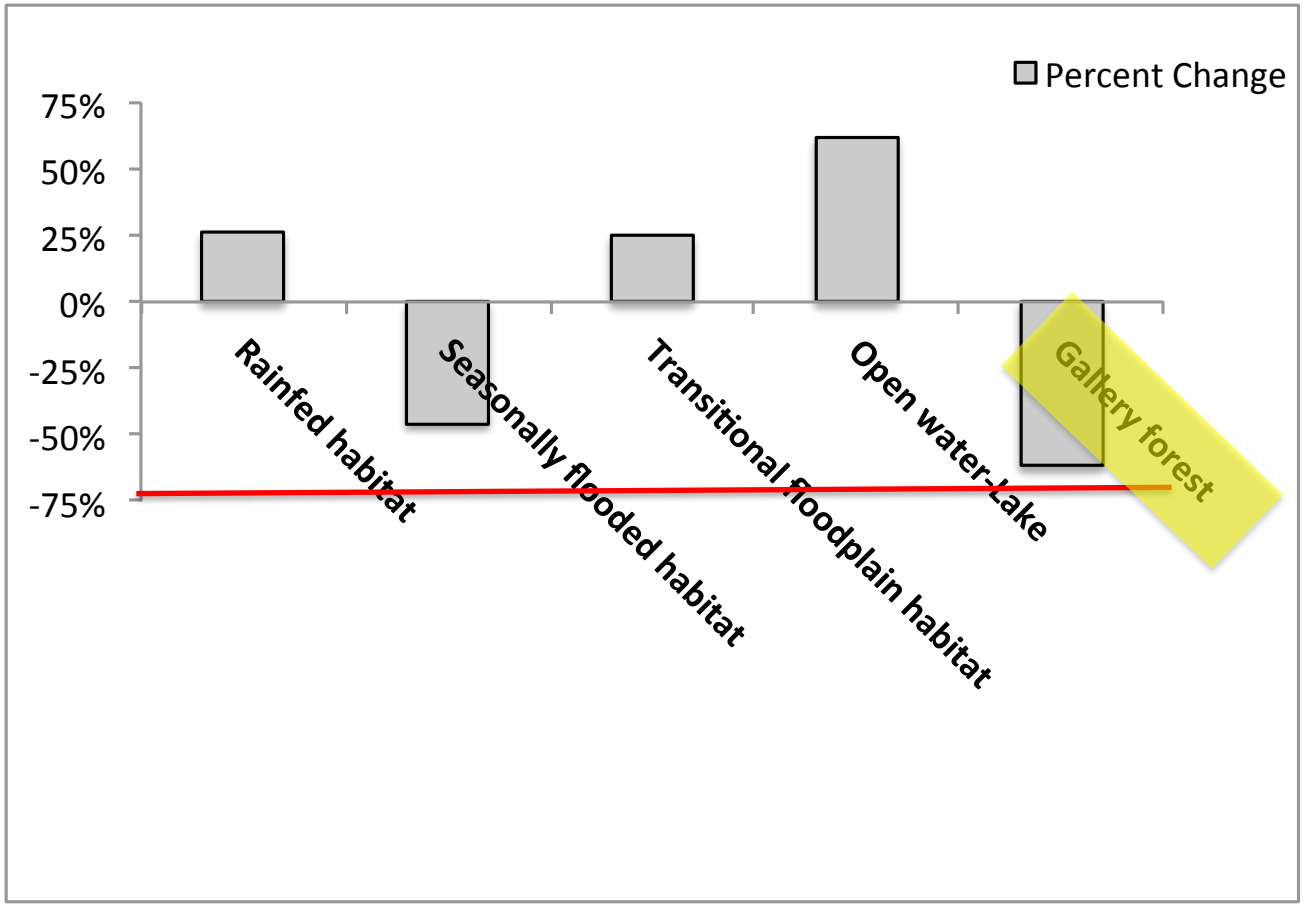

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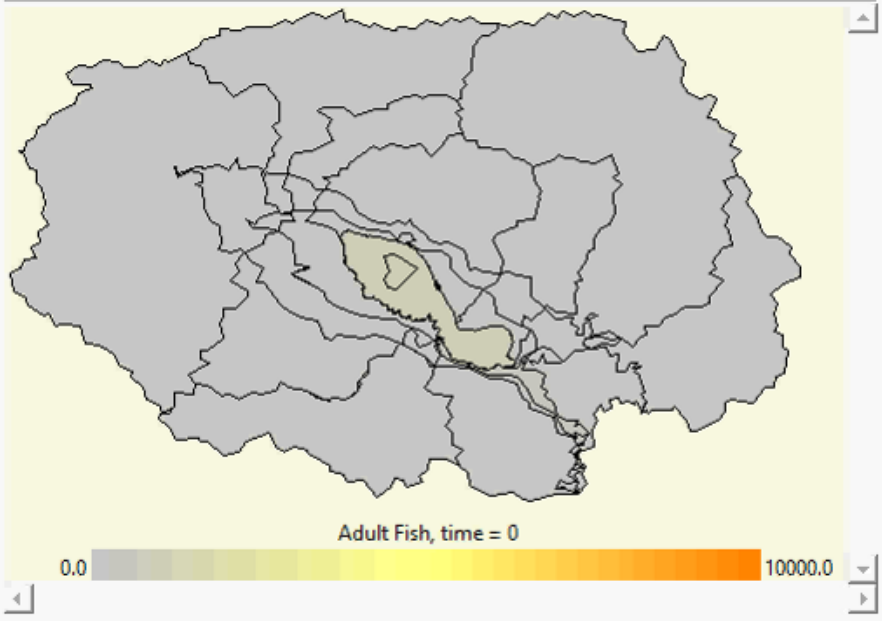
TOP LEVEL:

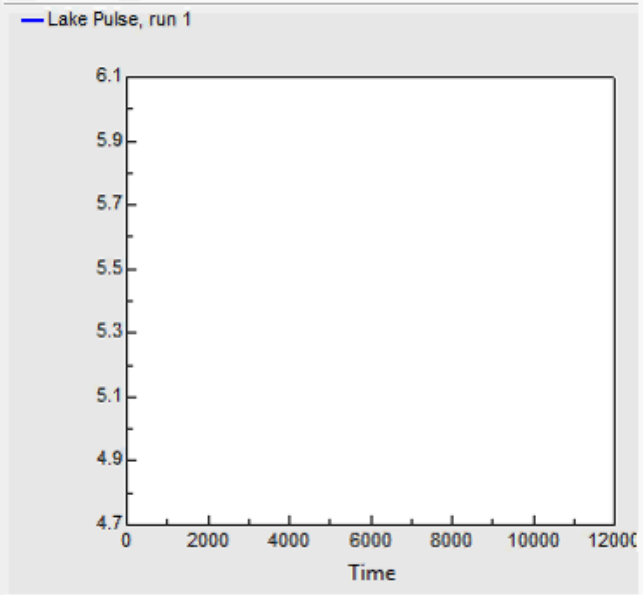
Choose fish

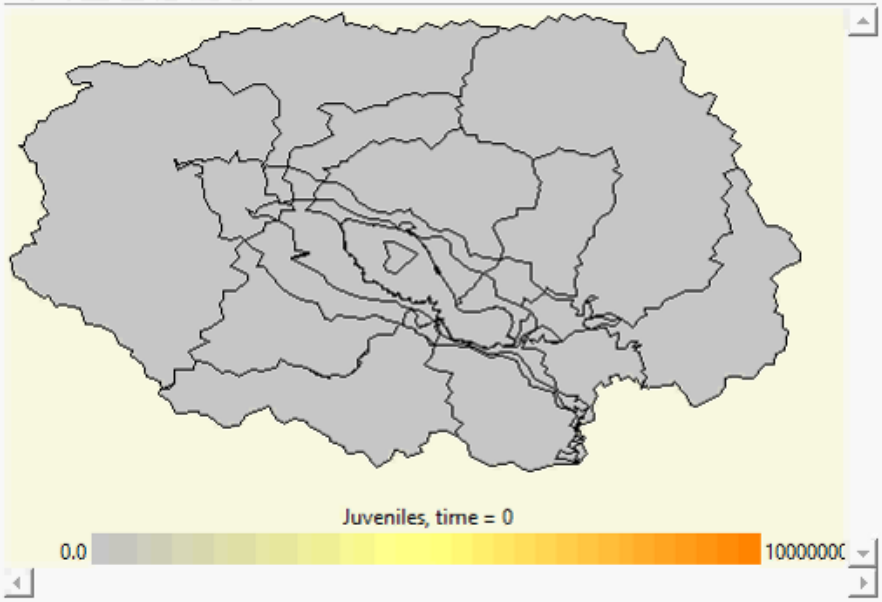
2

0 10 20 30

Name	Species
	Bagarius bagarius







TOP LEVEL:

Choose fish

22

0 10 20 30

Name	Species
	Pseudolais pleurotaenia

Lake Pulse, run 1

4.7805
4.7803
4.7801
4.7799
4.7797
4.7795

0 1000 2000 3000 4000 5000 6000

Execution of "TonleSap" - Simile

File Add Window Edit Help

Run control | Run settings

Execute for: 5474 unit

Current time: 0 unit

Display interval: 1 unit

Time step #2 (1) 1

- Catchments
  - Cover Change
    - Cover Change
    - Does Cover Change
  - Demographics
    - Economic Inputs
      - Shadow Prices
      - Sustution price
    - annual growth
    - EconGrowth
    - Economic prosperity
    - expenditures
    - Goods and Services
    - growth bracket
    - growth rate
    - Labor
    - Max Labor potential
    - Pop sector Ratio
    - Previous G and S
    - Service Contributions
    - Short fall
  - Fish
    - Diet
      - Available Food
    - Feeding Habitat
    - Adult Mortality
    - Adults
    - aging
    - Carrying Capacity

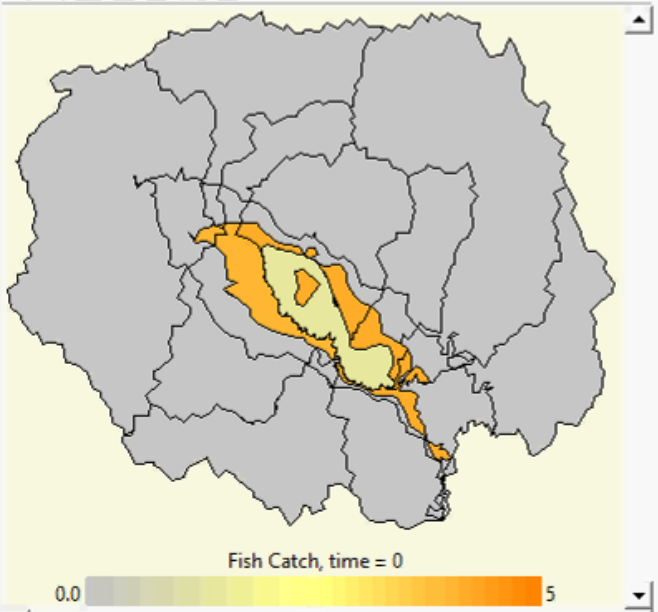
Spatial Distributions | Fish Catch | Page 3 | Page 4

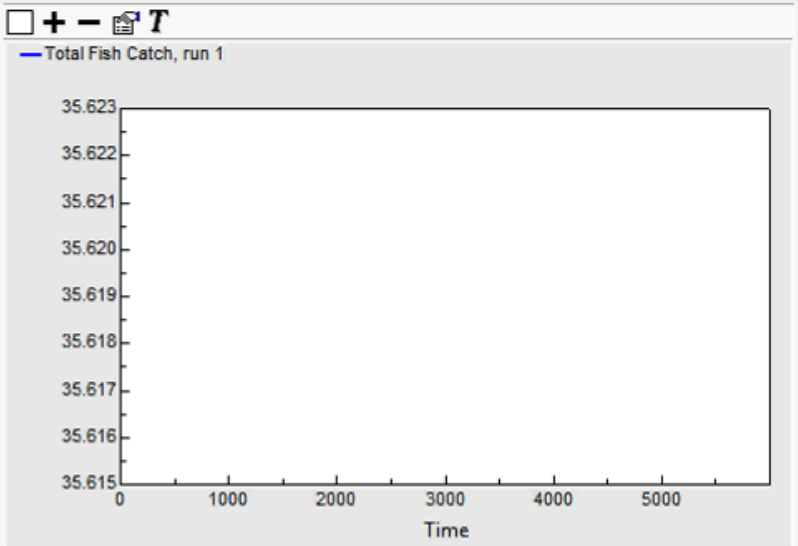
TOP LEVEL:

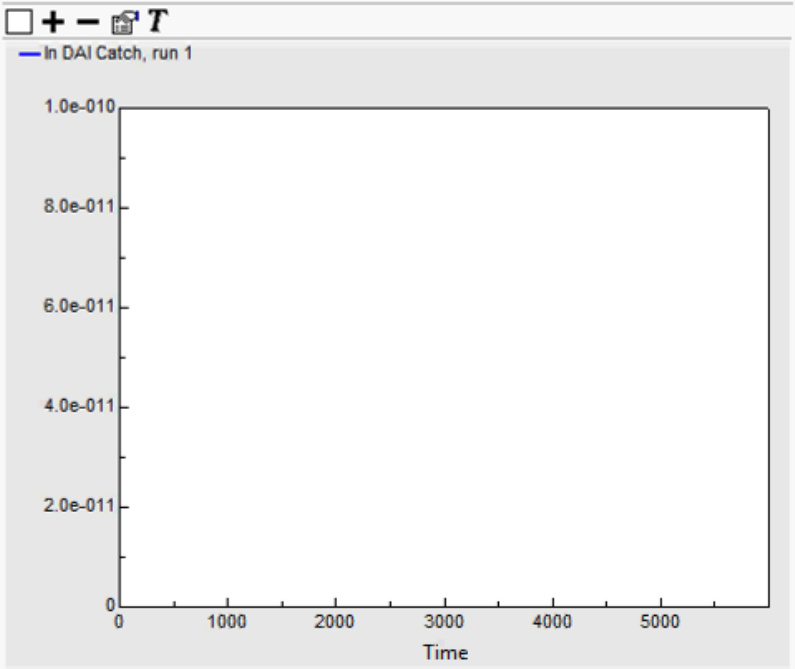
Choose fish 18 (0 10 20 30)

DAI fishing 0.01 (0.000 0.200 0.400 0.600 0.800 1.000)

Name	Species
	Pangasius elongatus







Spatial Distributions | Fish Catch | Page 3 | Page 4

TOP LEVEL:

Choose fish
18
0 10 20 30

DAI fishing
0.01
0.000 0.200 0.400 0.600 0.800 1.000

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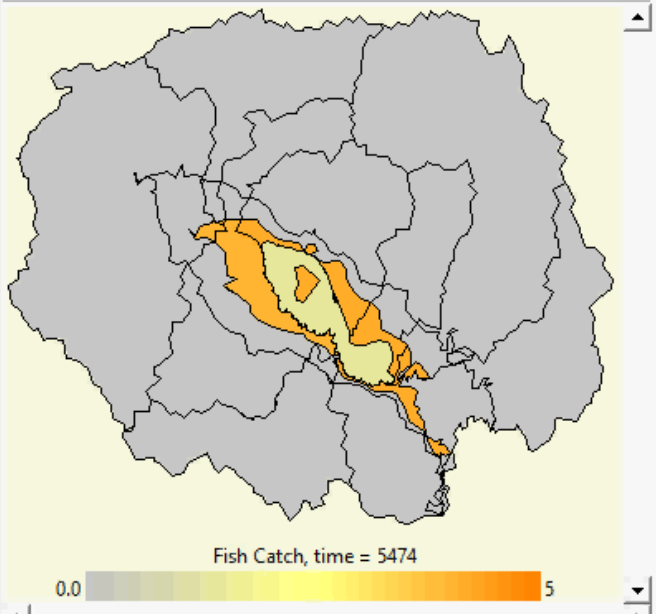
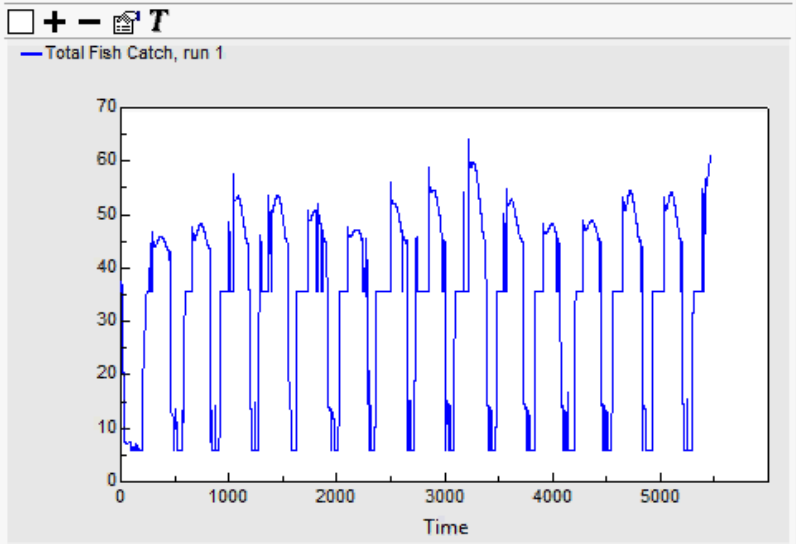
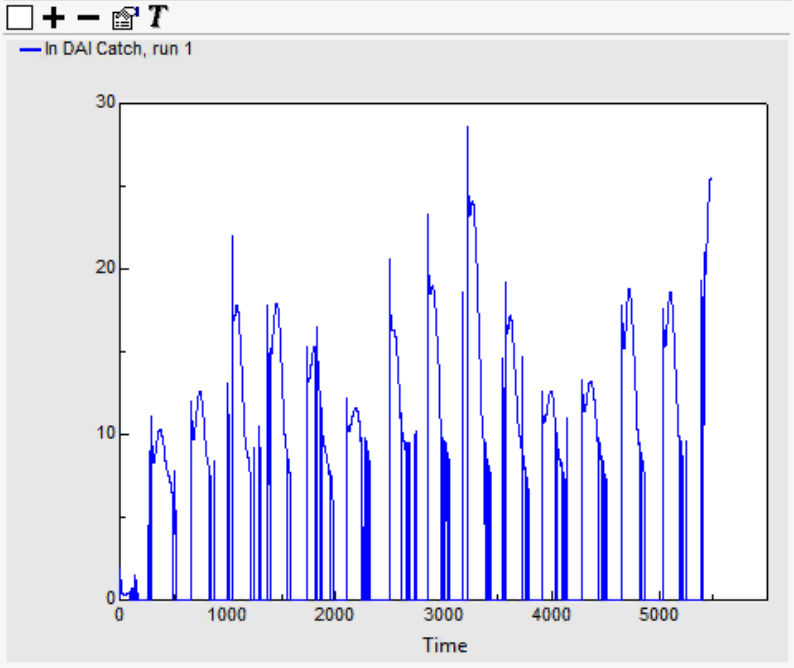
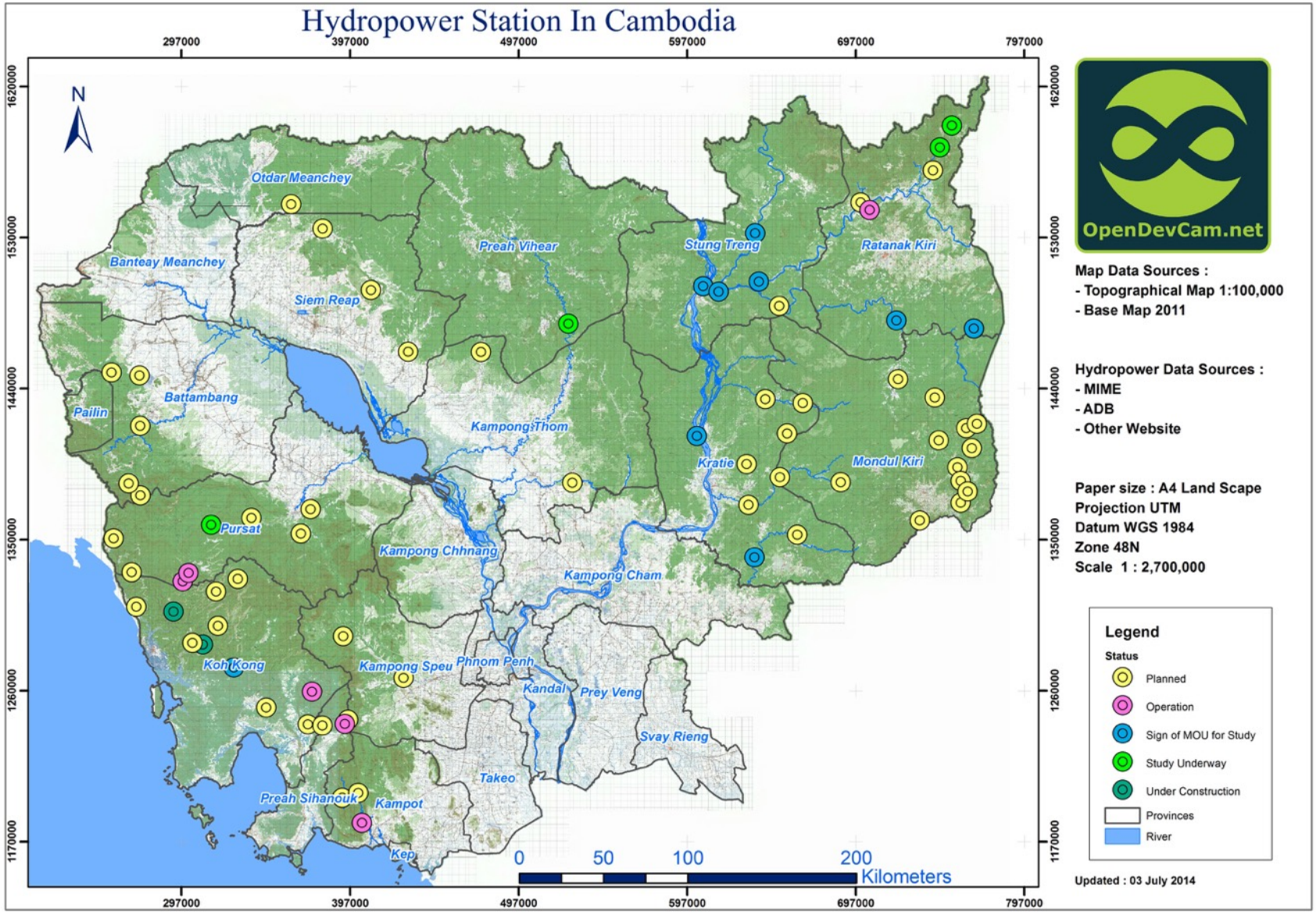






Hydropower Station In Cambodia



OpenDevCam.net

Map Data Sources :
- Topographical Map 1:100,000
- Base Map 2011

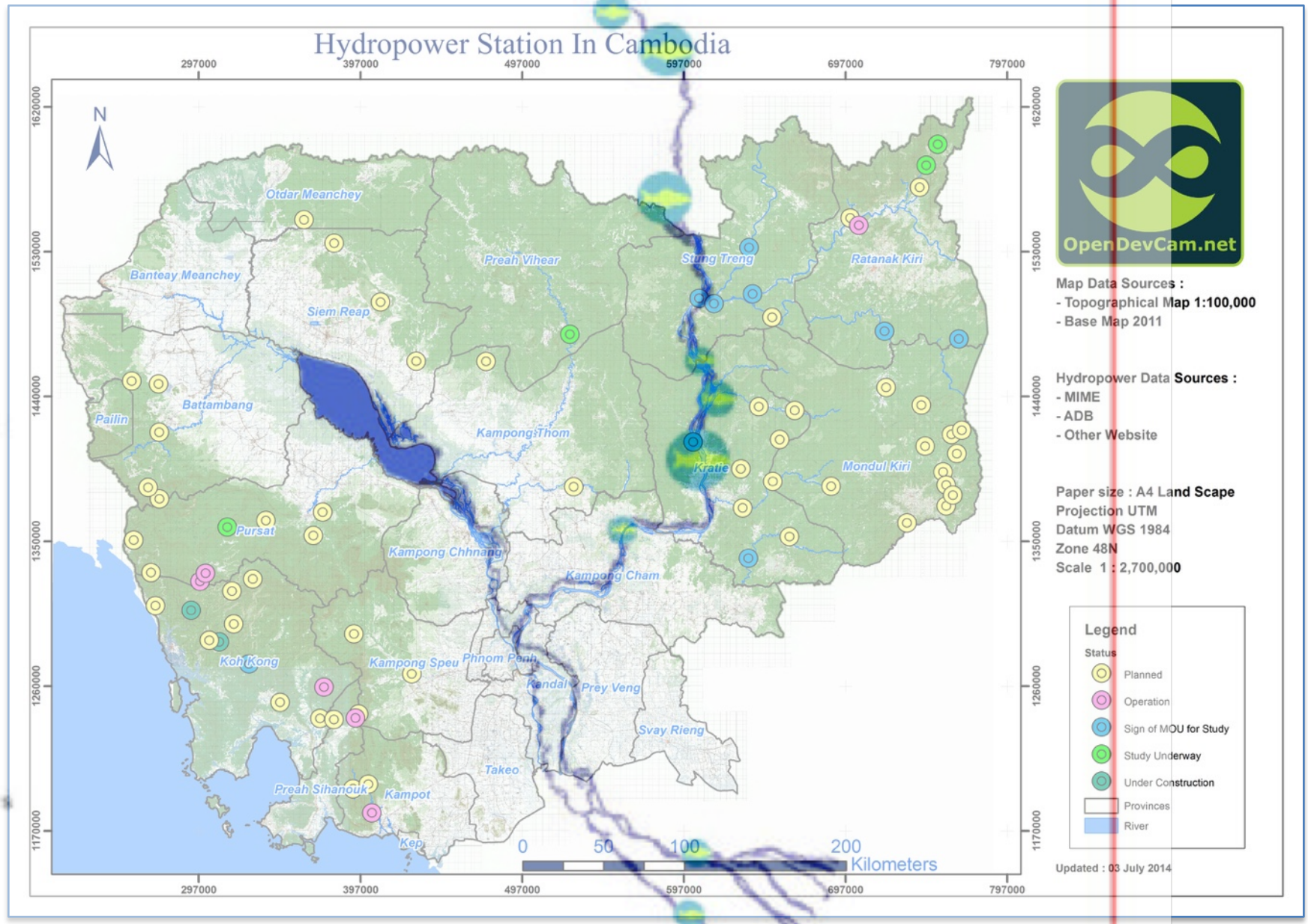
Hydropower Data Sources :
- MIME
- ADB
- Other Website

Paper size : A4 Land Scape
Projection UTM
Datum WGS 1984
Zone 48N
Scale 1 : 2,700,000

Legend

Status
- Planned
- Operation
- Sign of MOU for Study
- Study Underway
- Under Construction
- Provinces
- River

Updated : 03 July 2014


Hydropower Station In Cambodia
297000
397000
497000
597000
697000
797000
1620000
1530000
1440000
1350000
1260000
1170000
N
Otdar Meanchey
Banteay Meanchey
Siem Reap
Preah Vihear
Stung Treng
Ratanak Kiri
Pailin
Battambang
Kampong Thom
Kratie
Mondul Kiri
Pursat
Kampong Chhnang
Kampong Cham
Koh Kong
Kampong Speu
Phnom Penh
Kandal
Prey Veng
Svay Rieng
Takeo
Preah Sihanouk
Kampot
Kep
0
50
100
200
Kilometers
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Map Data Sources :
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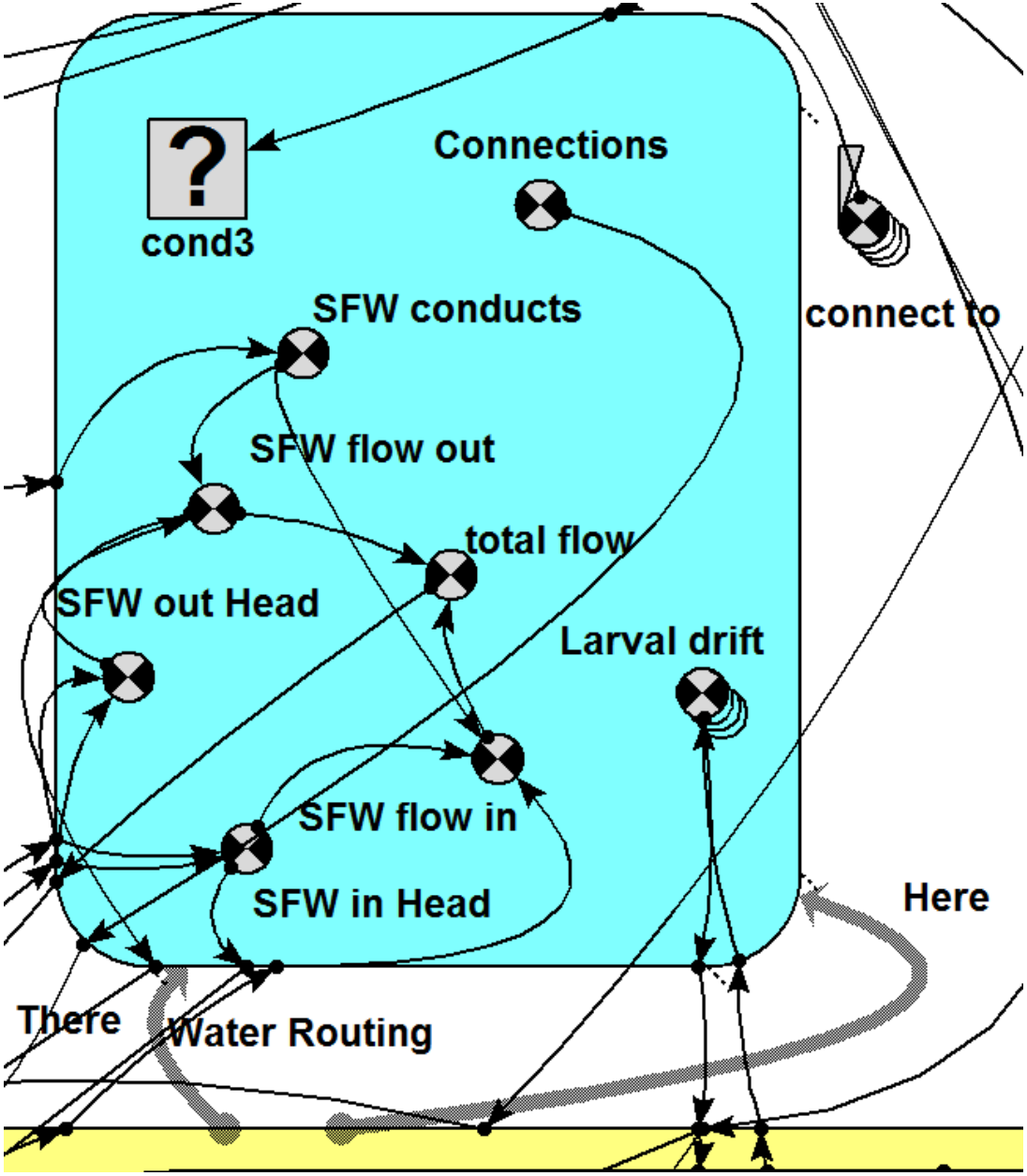
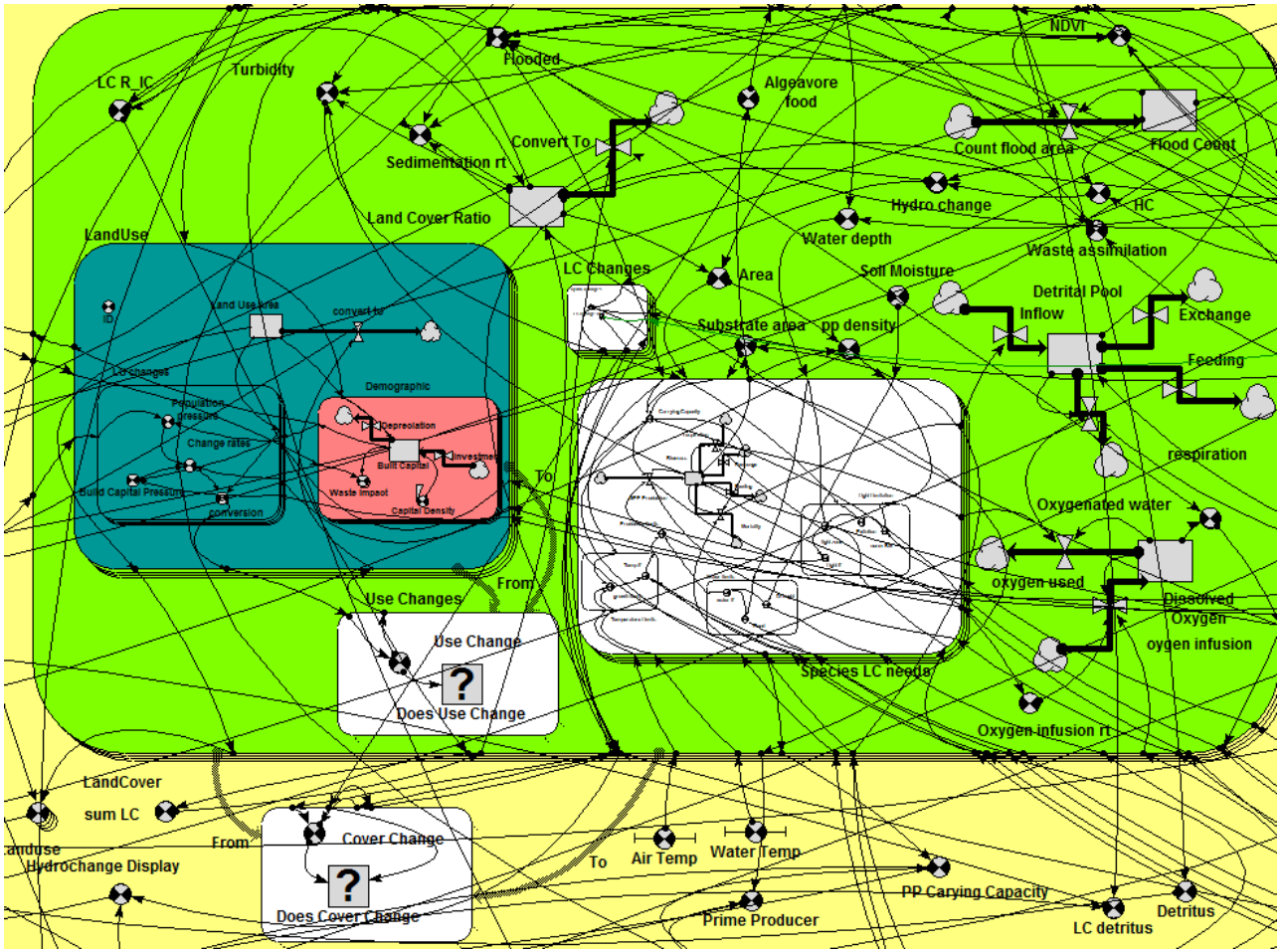
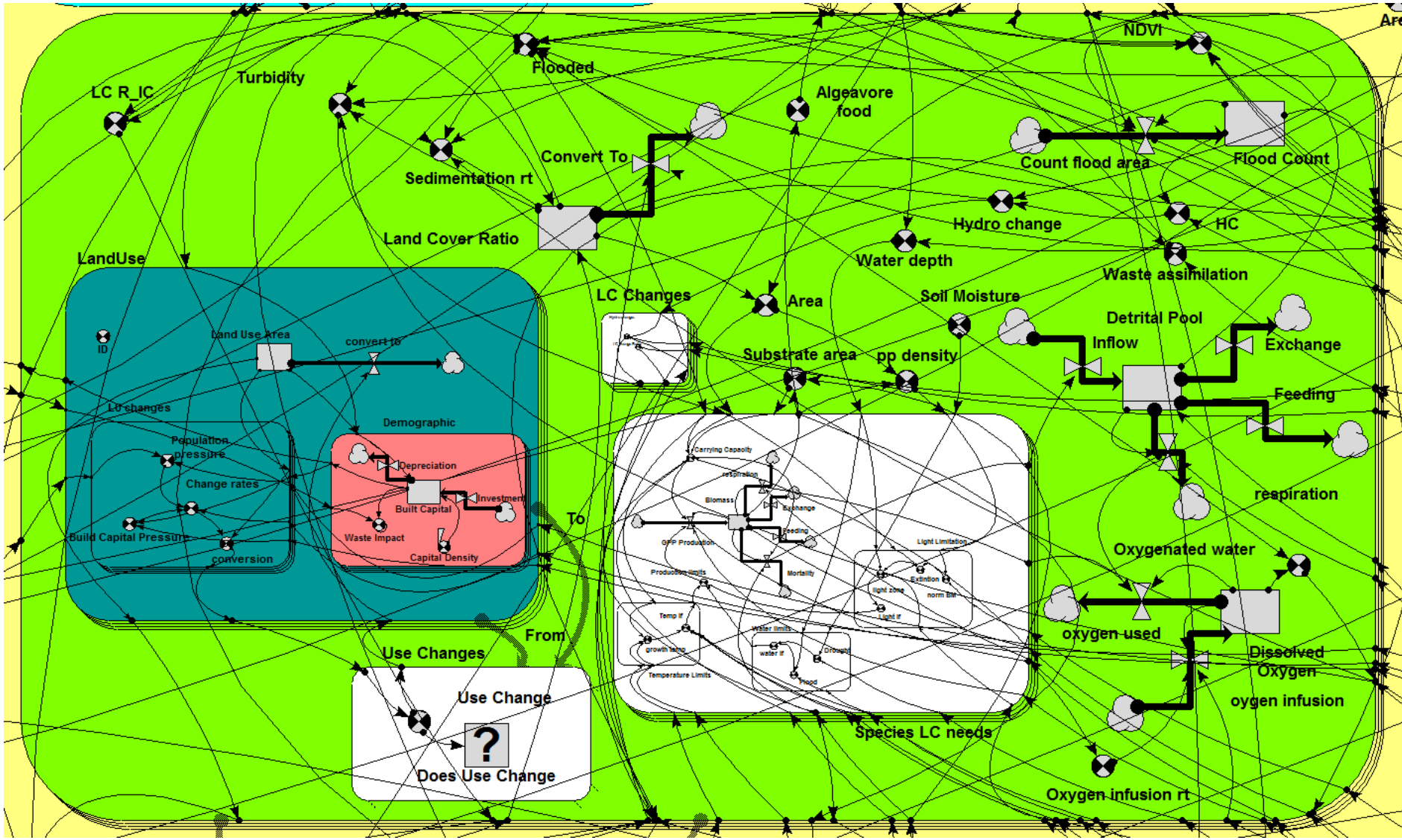


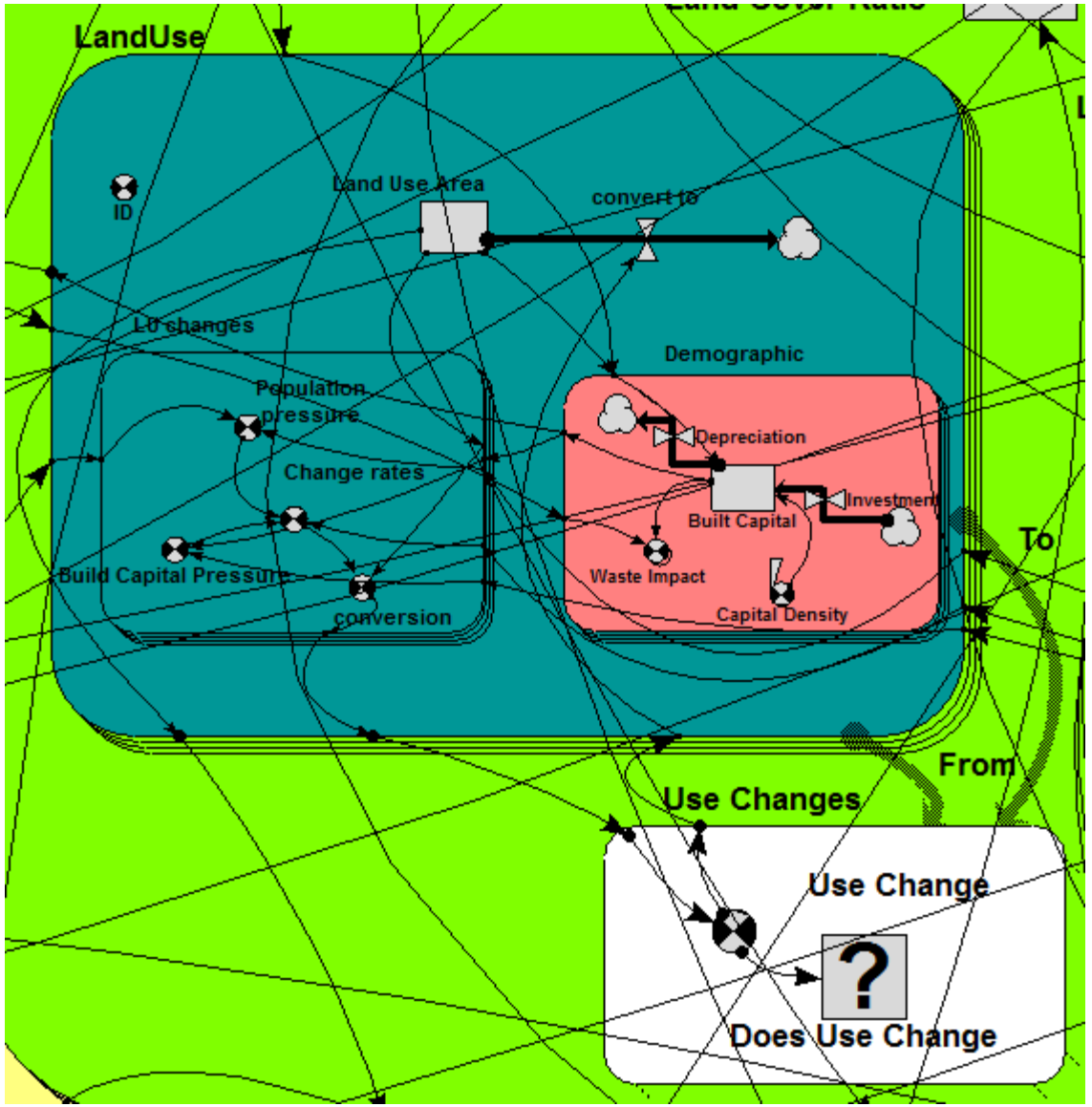
Hydrological Routing and Exchanges

Landcover and Landcover Change

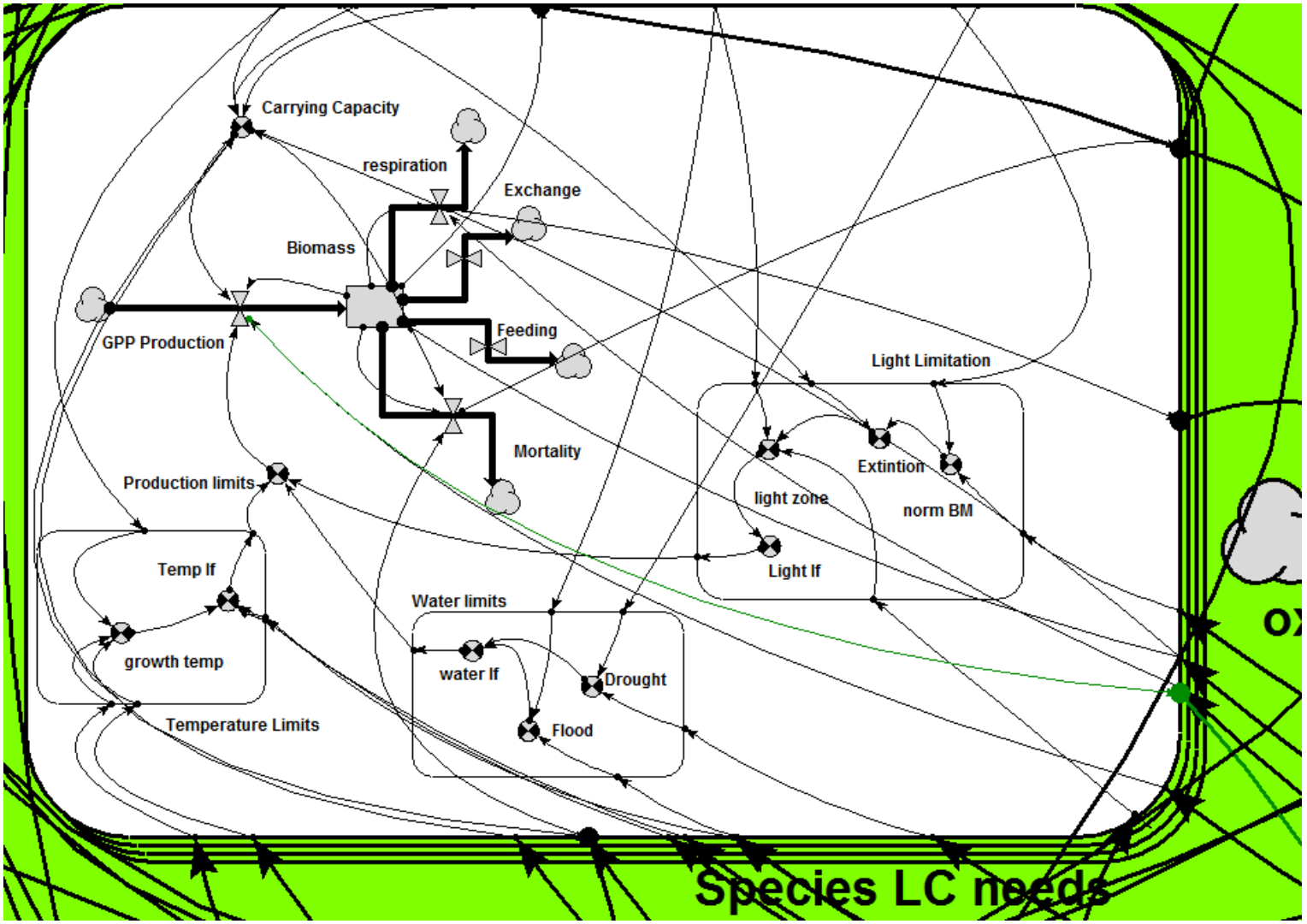



LC R_IC
Turbidity
Flooded
NDVI
Sedimentation rt
Convert To
Algeavore food
Count flood area
Flood Count
Hydro change
HC
Land Cover Ratio
Water depth
Waste assimilation
LandUse
LC Changes
Area
Soil Moisture
Detrital Pool
Inflow
Exchange
Substrate area
pp density
Feeding
ID
Land Use Area
convert to
LU changes
Demographic
Population pressure
Depreciation
Change rates
Built Capital
Investment
Build Capital Pressure
Waste Impact
Capital Density
conversion
To
From
respiration
Oxygenated water
oxygen used
Dissolved Oxygen
oygen infusion
Use Changes
Use Change
Does Use Change
Species LC needs
Oxygen infusion rt

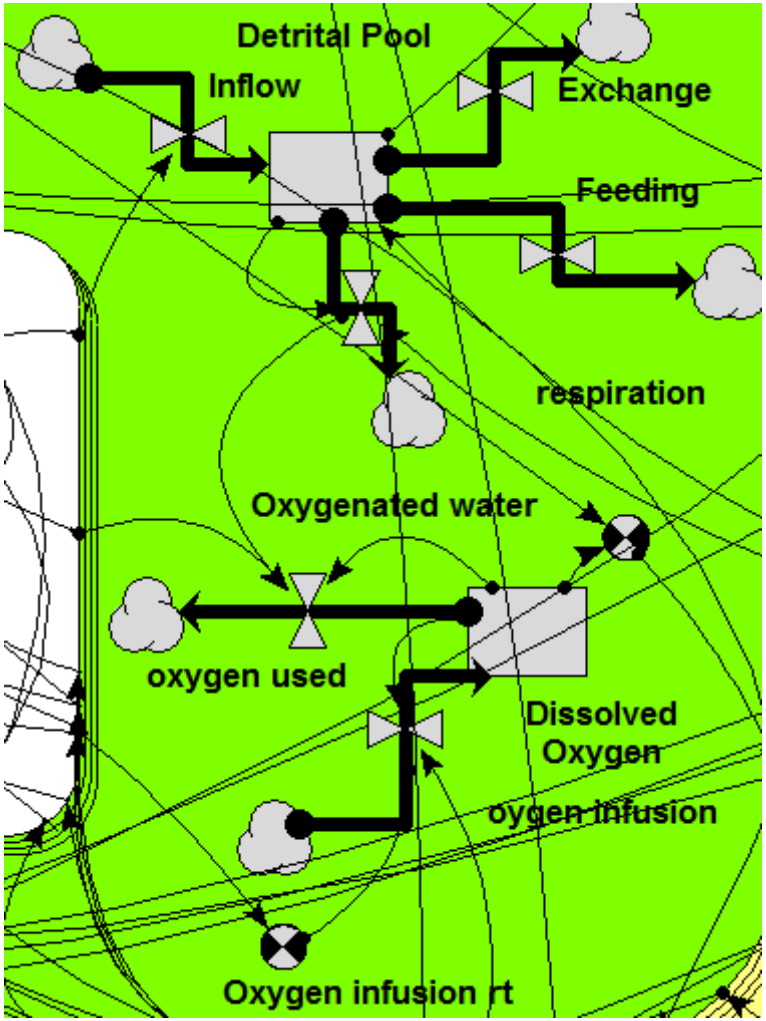
Landuse and Landuse Change



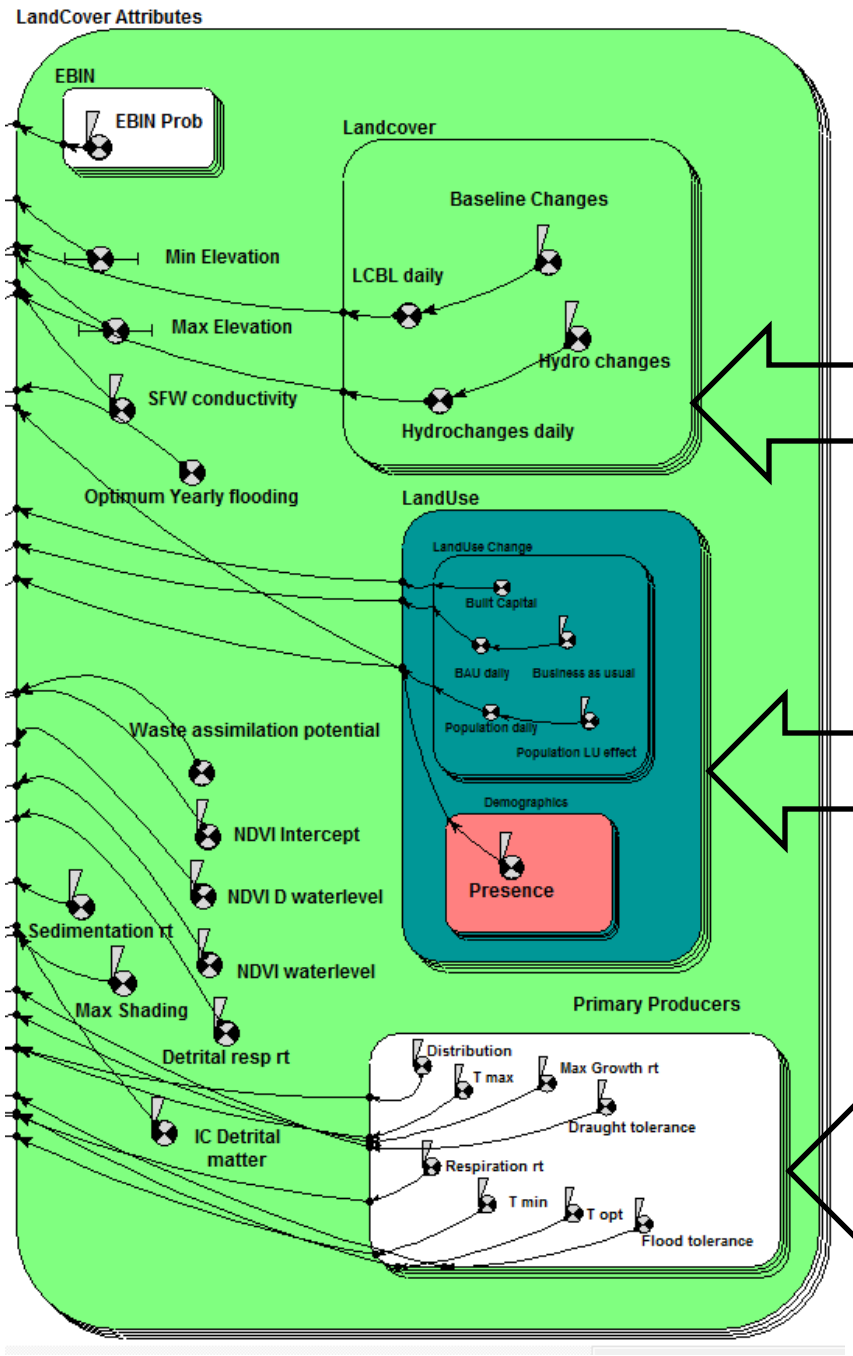
Primary producers



Aerobic Anaerobic Dynamics



Land Cover Attributes

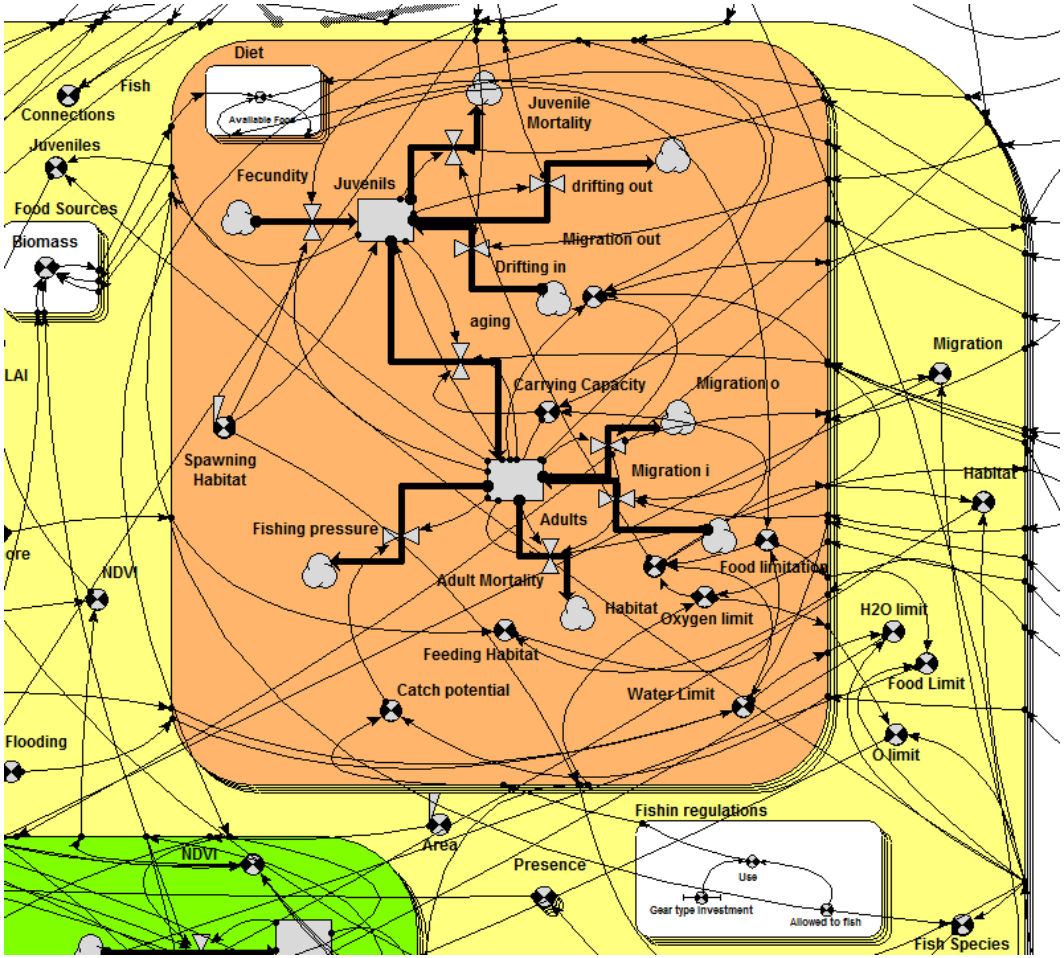


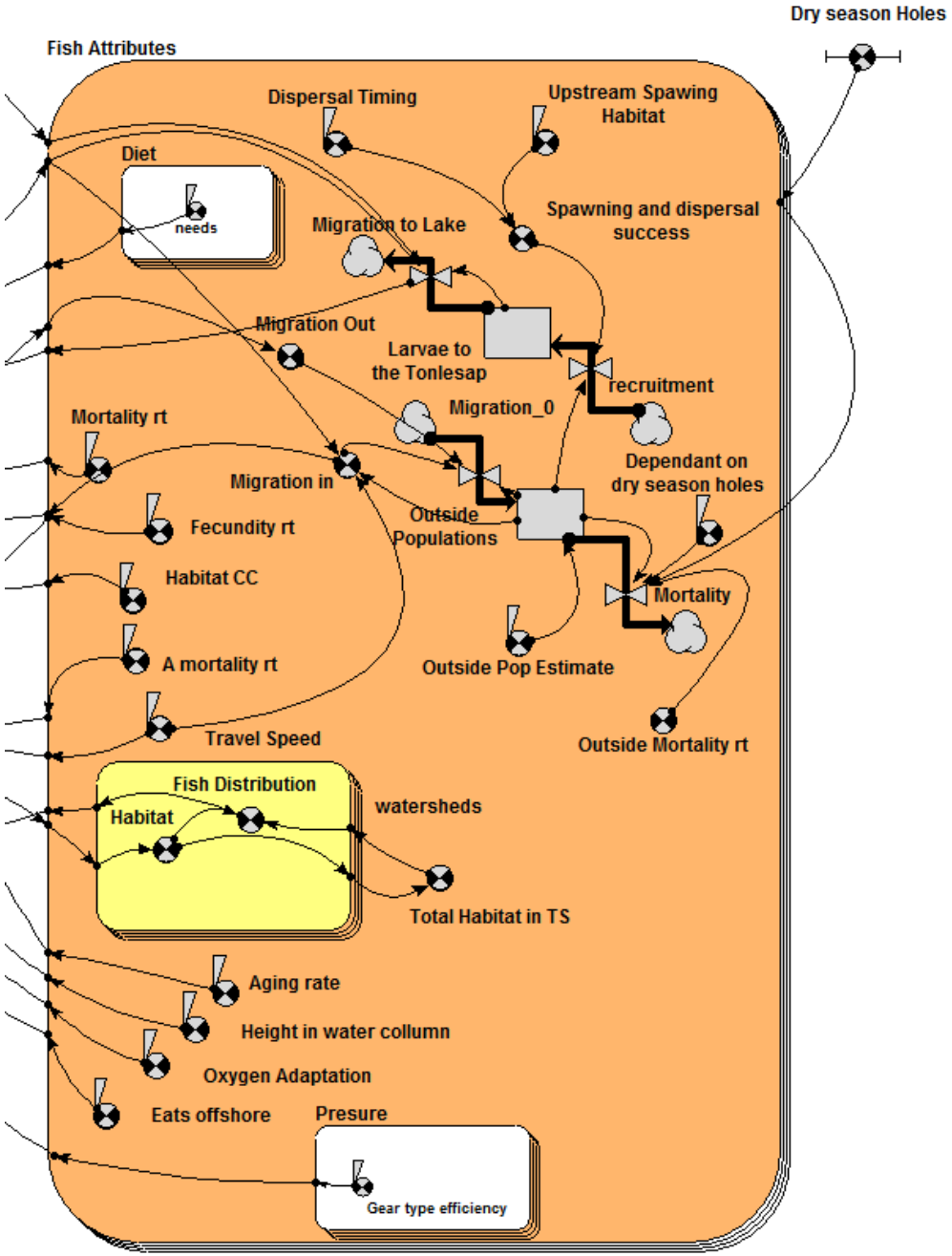
Drivers of Land Cover change

Drivers of Land Use change

Primary Producers Attributes

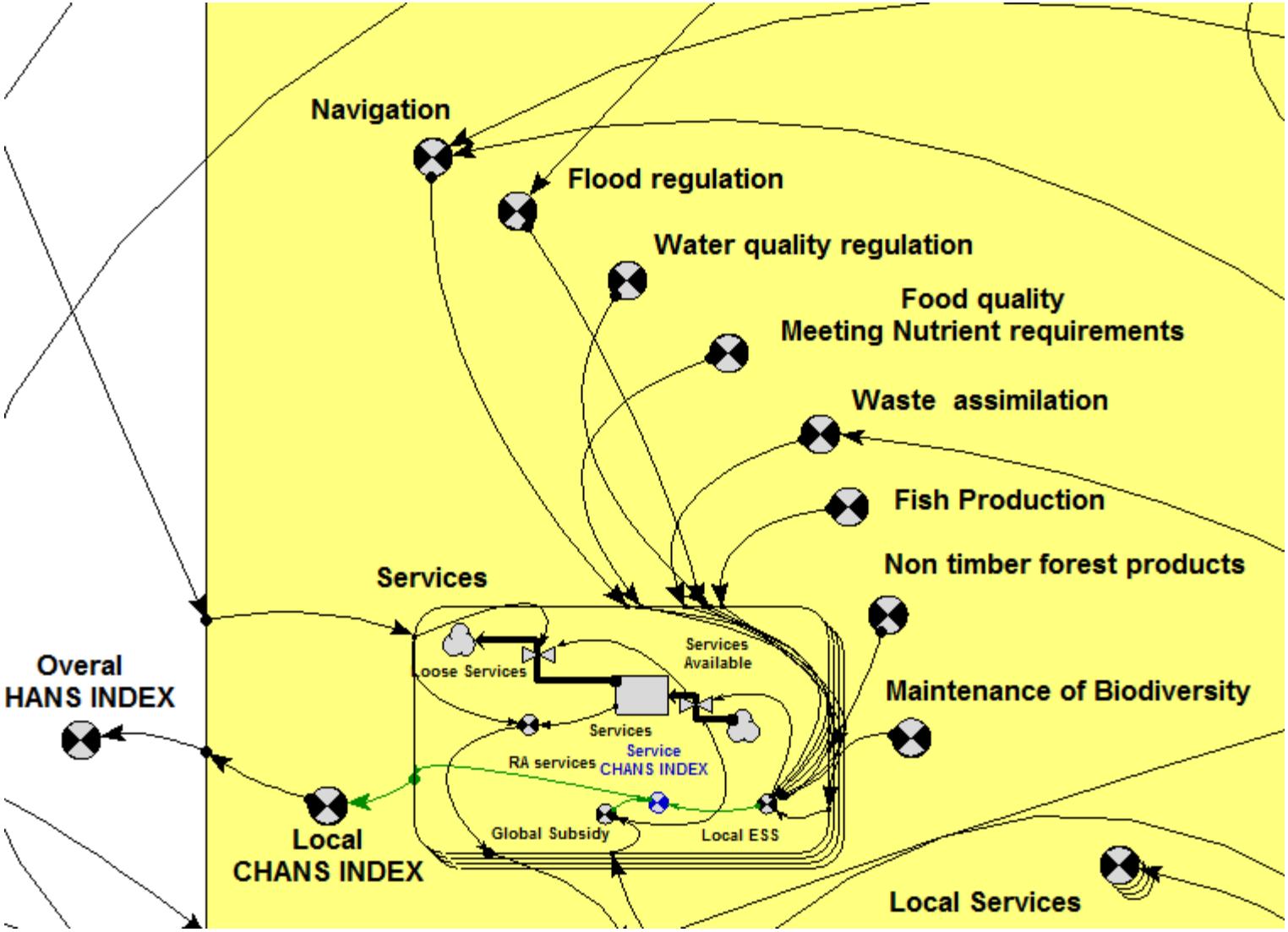
Fish Dynamics and Fishing Regulations



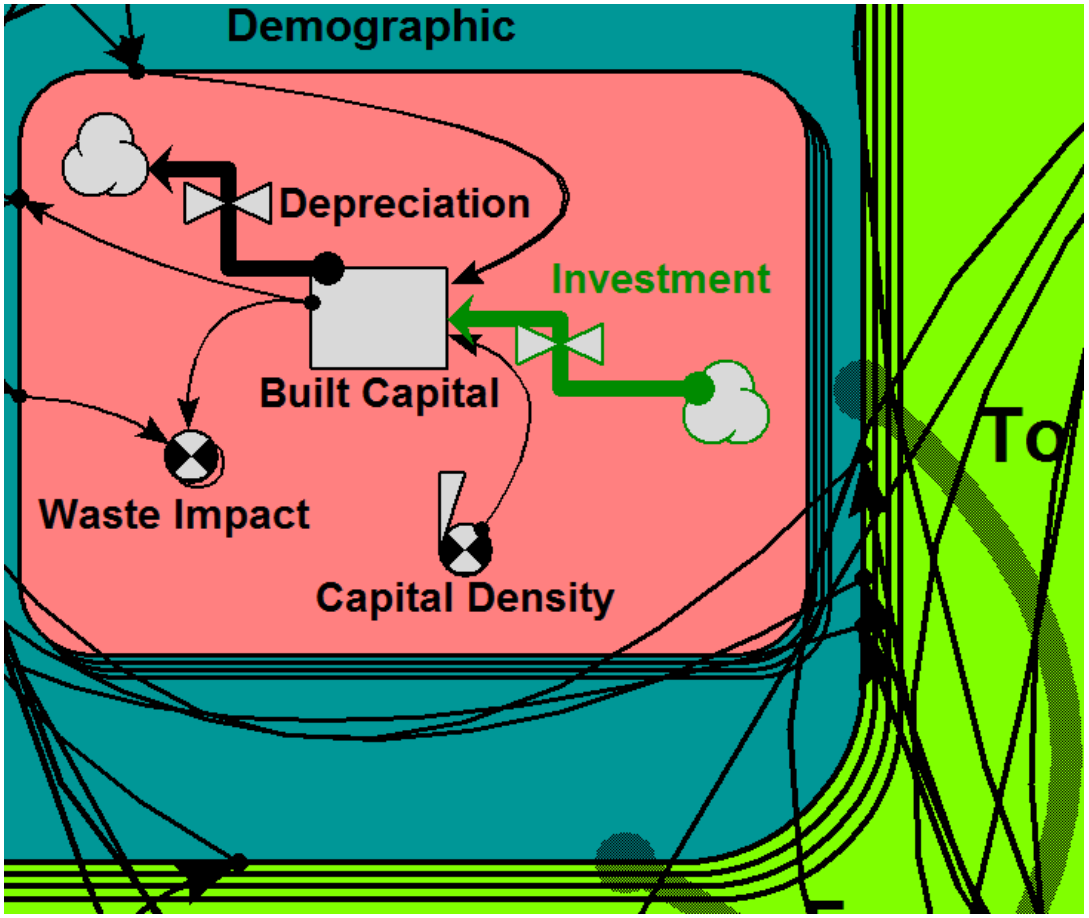


Fish Life History and Migration Dynamics

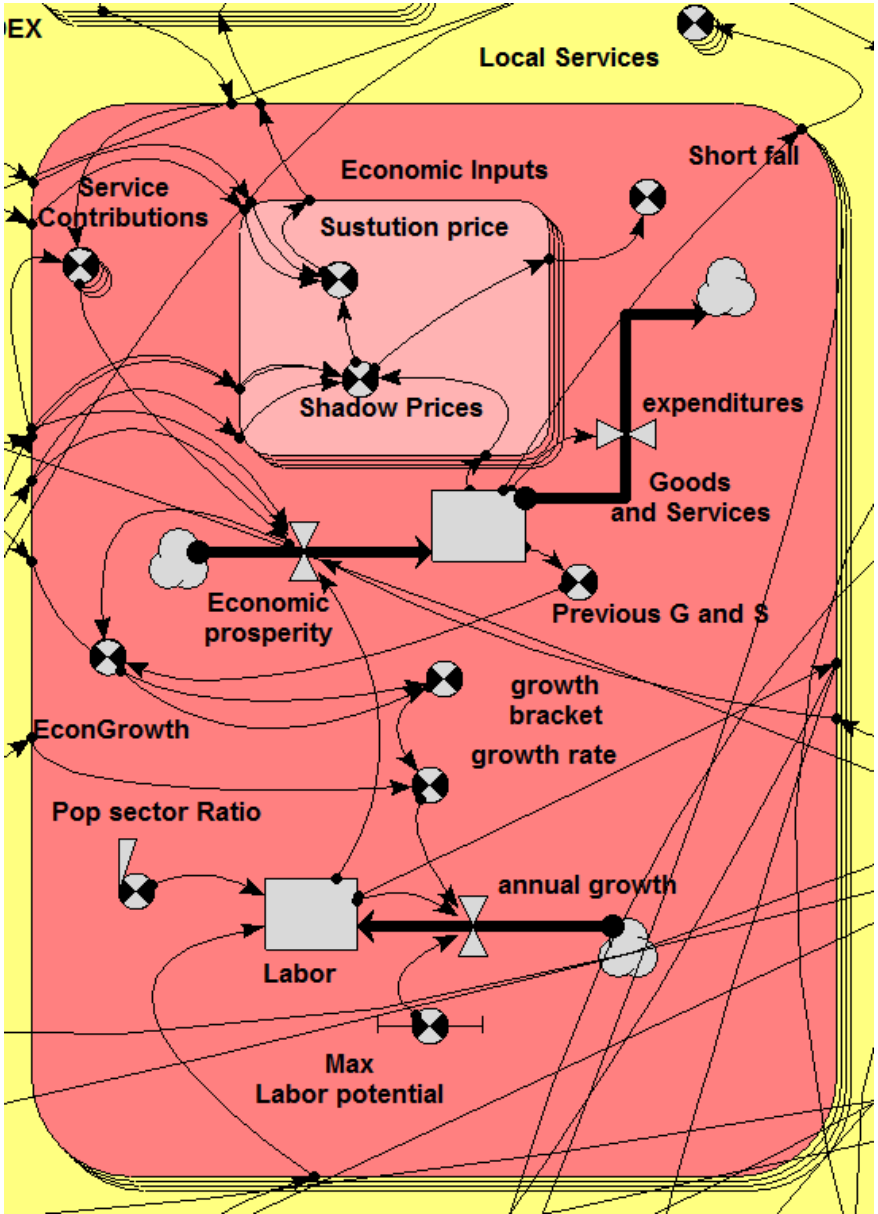
ESS and Subsidies

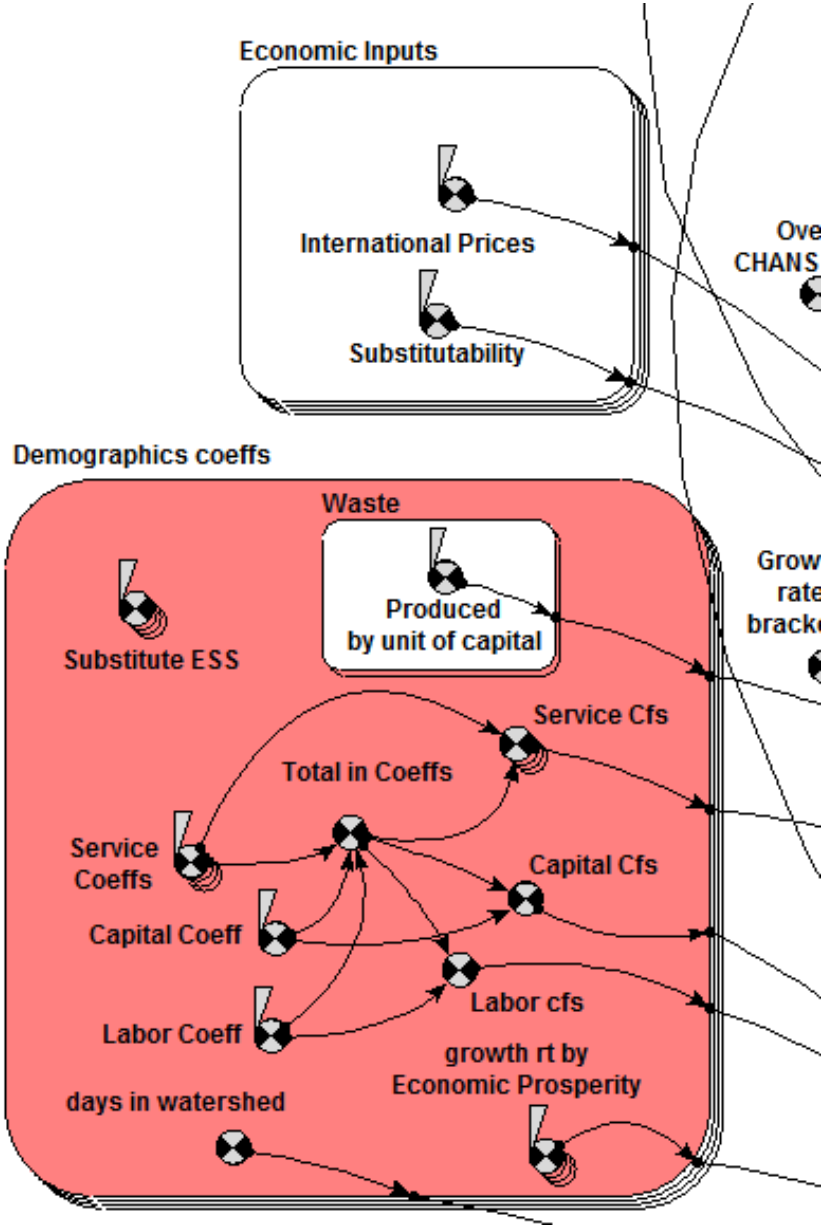


Capital within LandUse



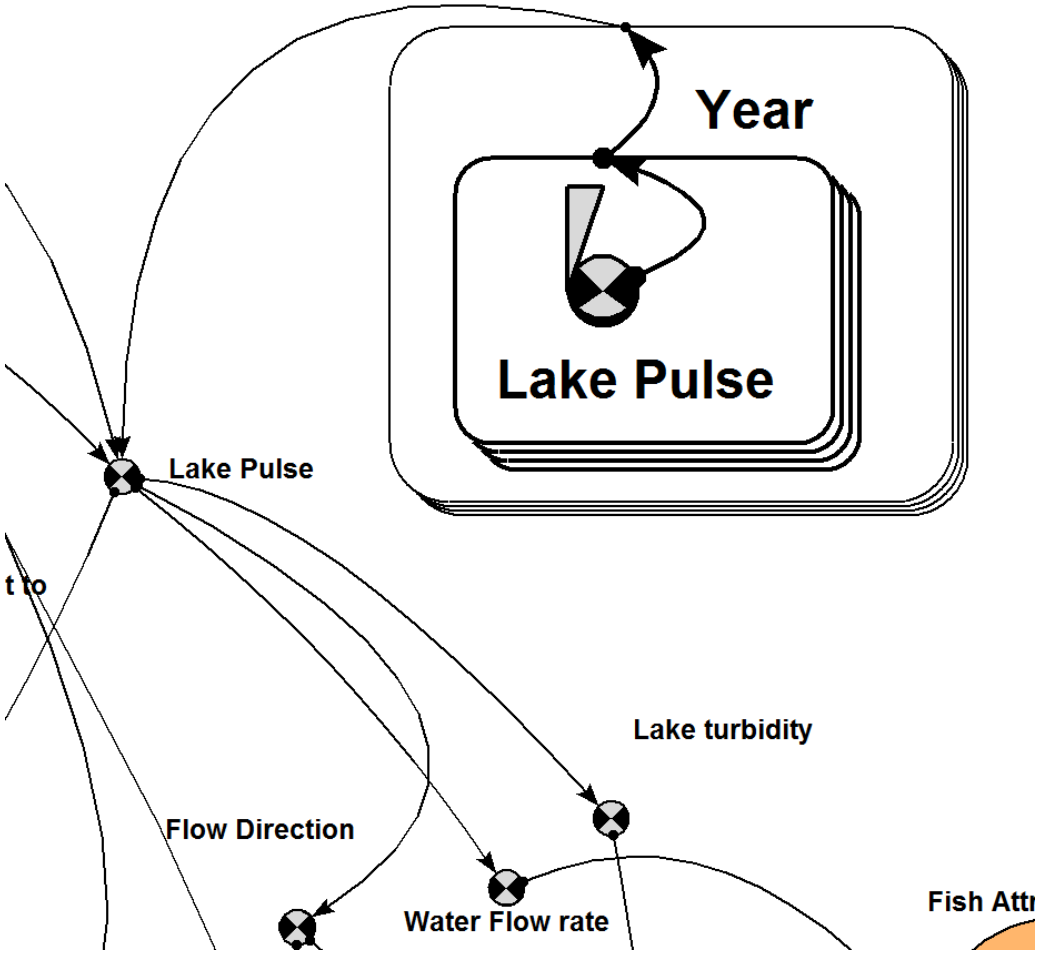
Economics


EX
Local Services
Short fall
Economic Inputs
Service
Contributions
Sustution price
Shadow Prices
expenditures
Goods
and Services
Economic
prosperity
Previous G and S
growth
bracket
EconGrowth
growth rate
Pop sector Ratio
annual growth
Labor
Max
Labor potential

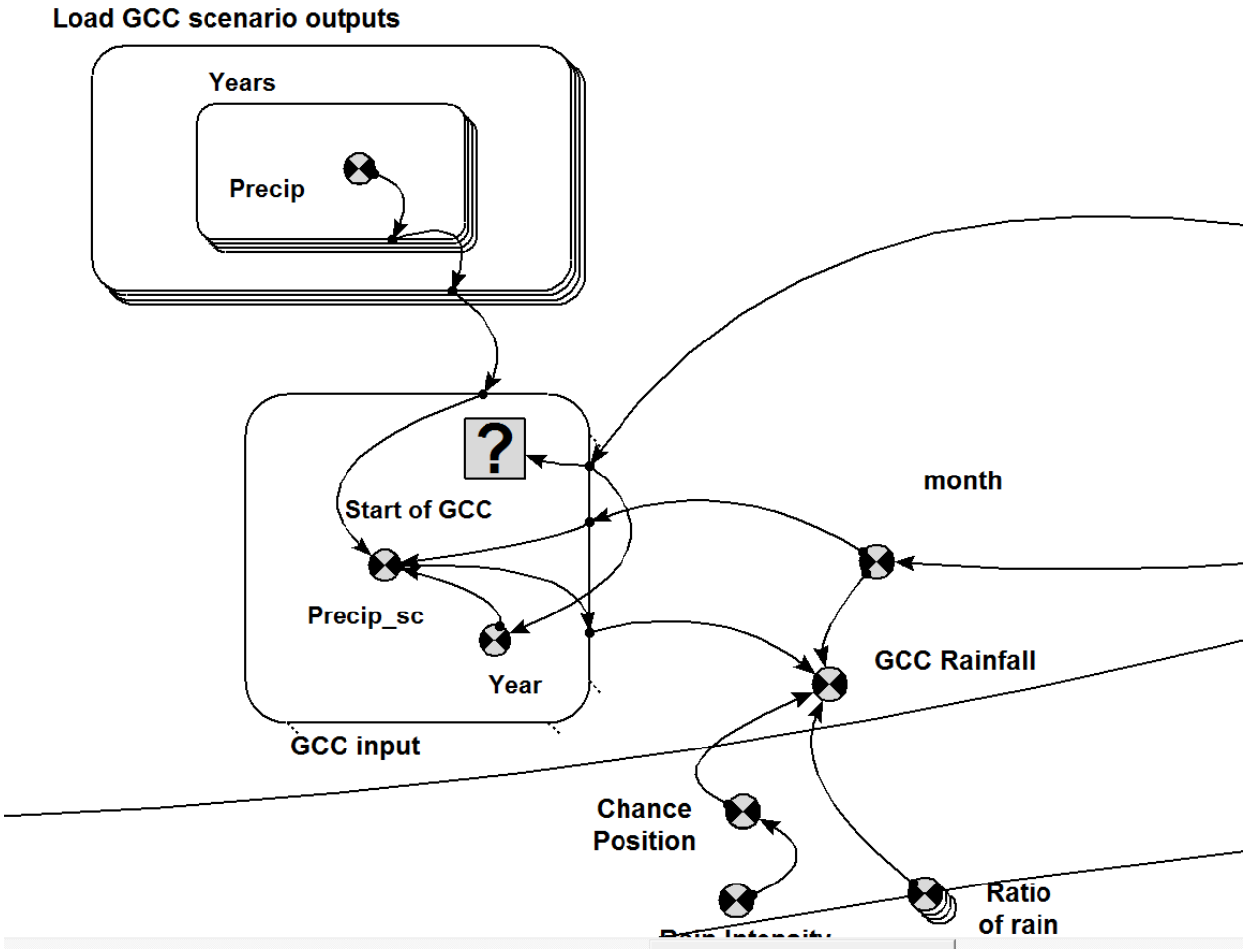


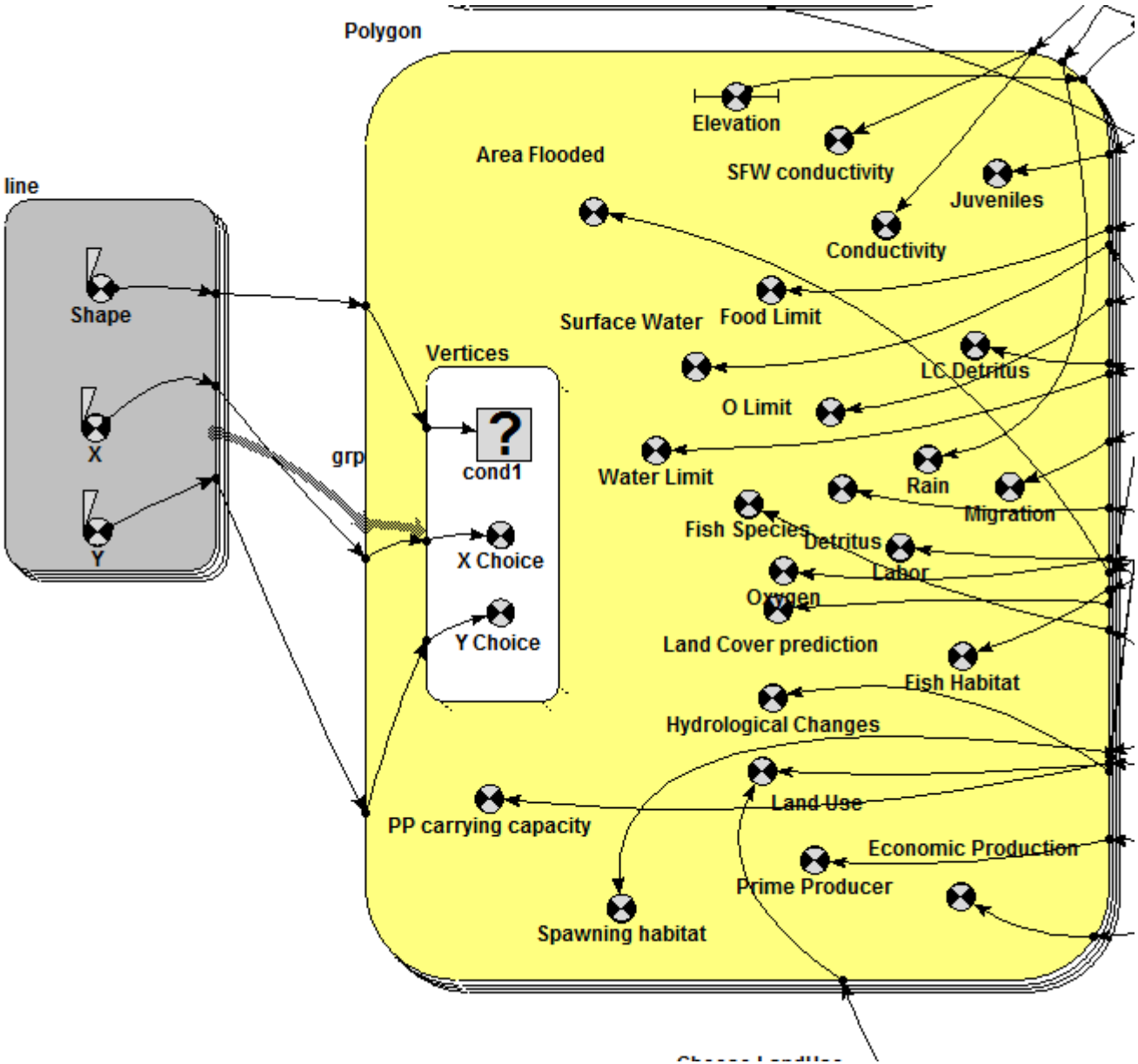
Economic Attributes and the Avail bility of Services for Substituting Shortfall in Local Services

Hydrology from Dam Scenarios



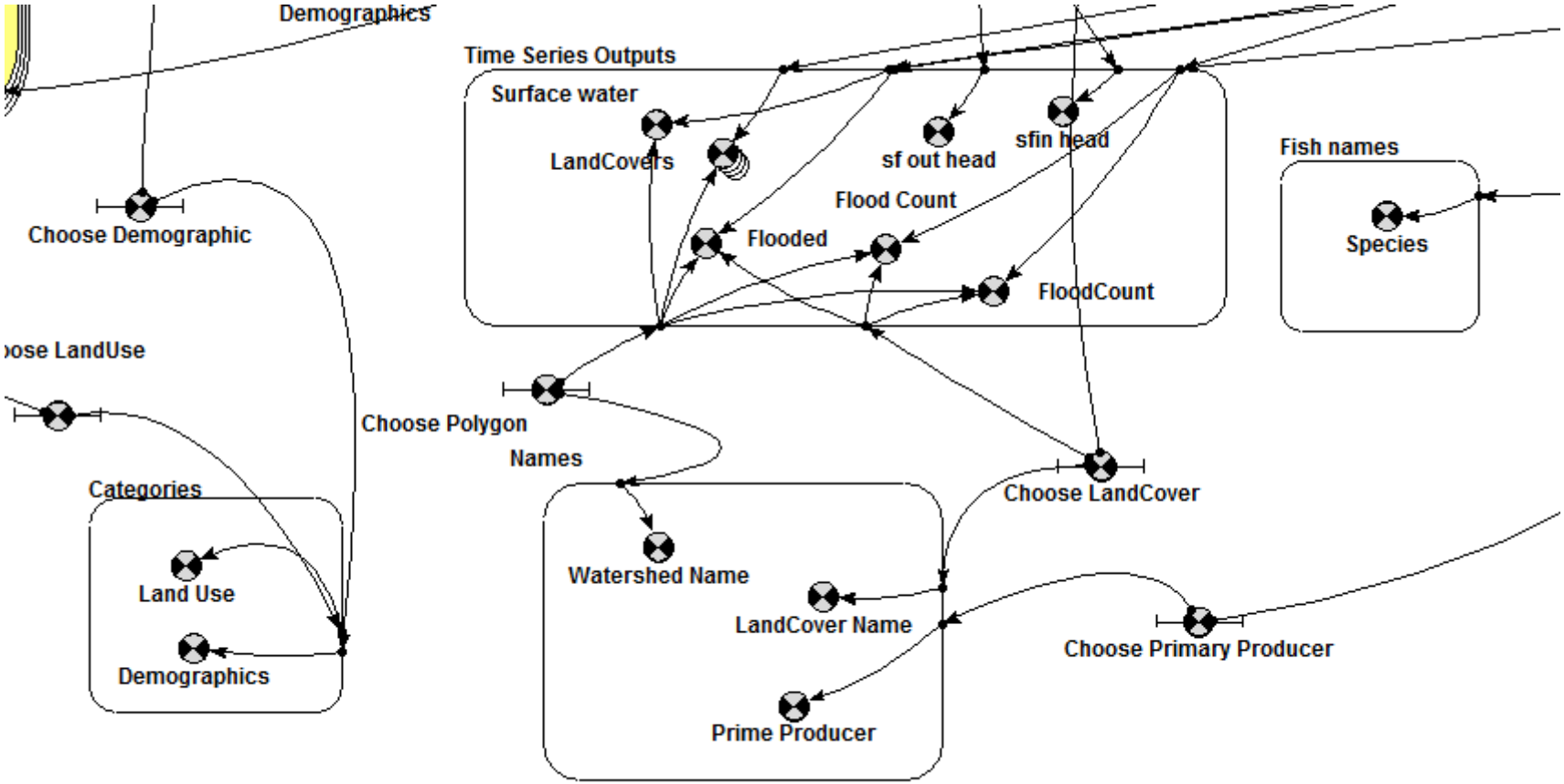
Input of Global Climate Change Scenarios

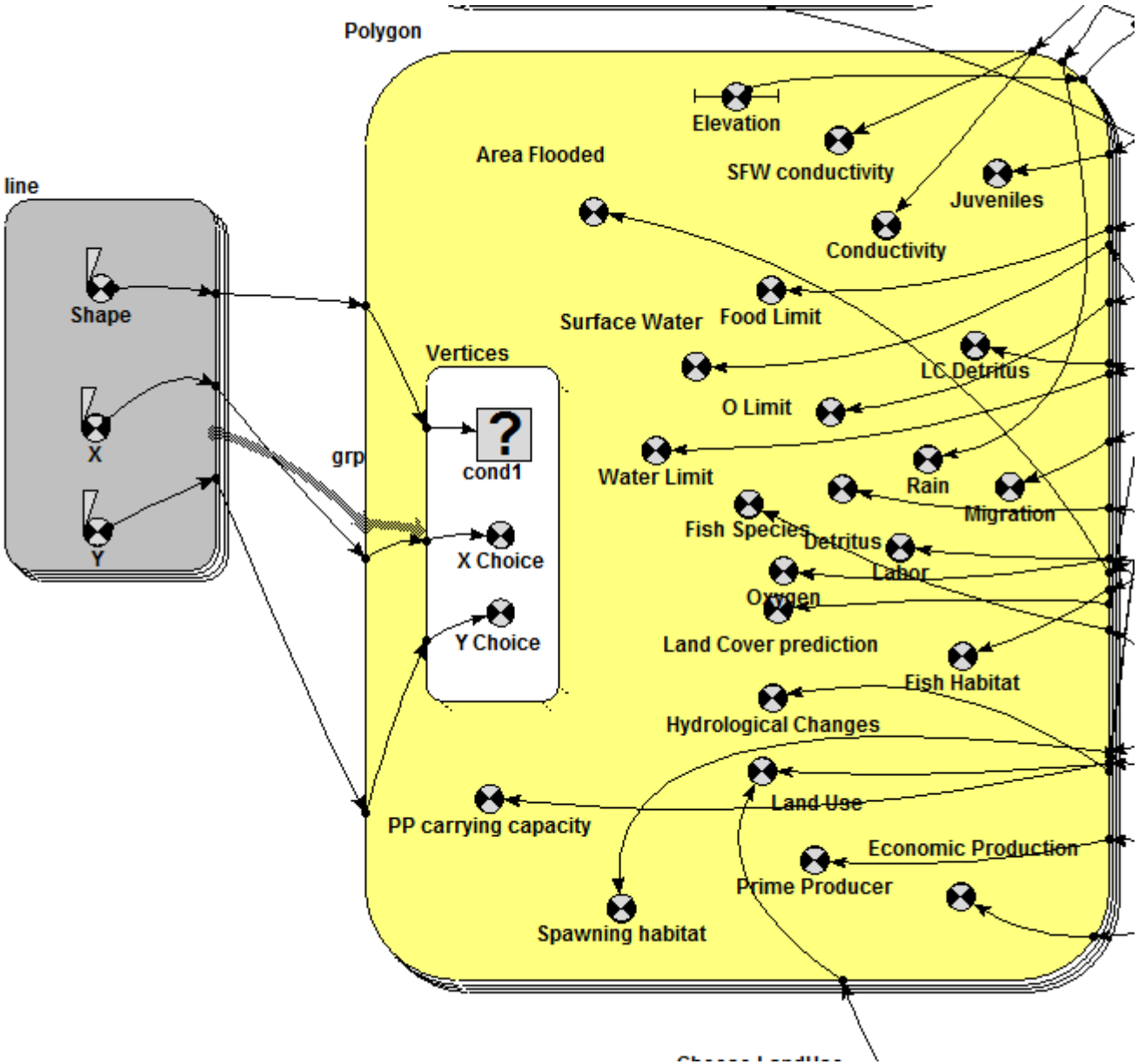




Spatial Outputs

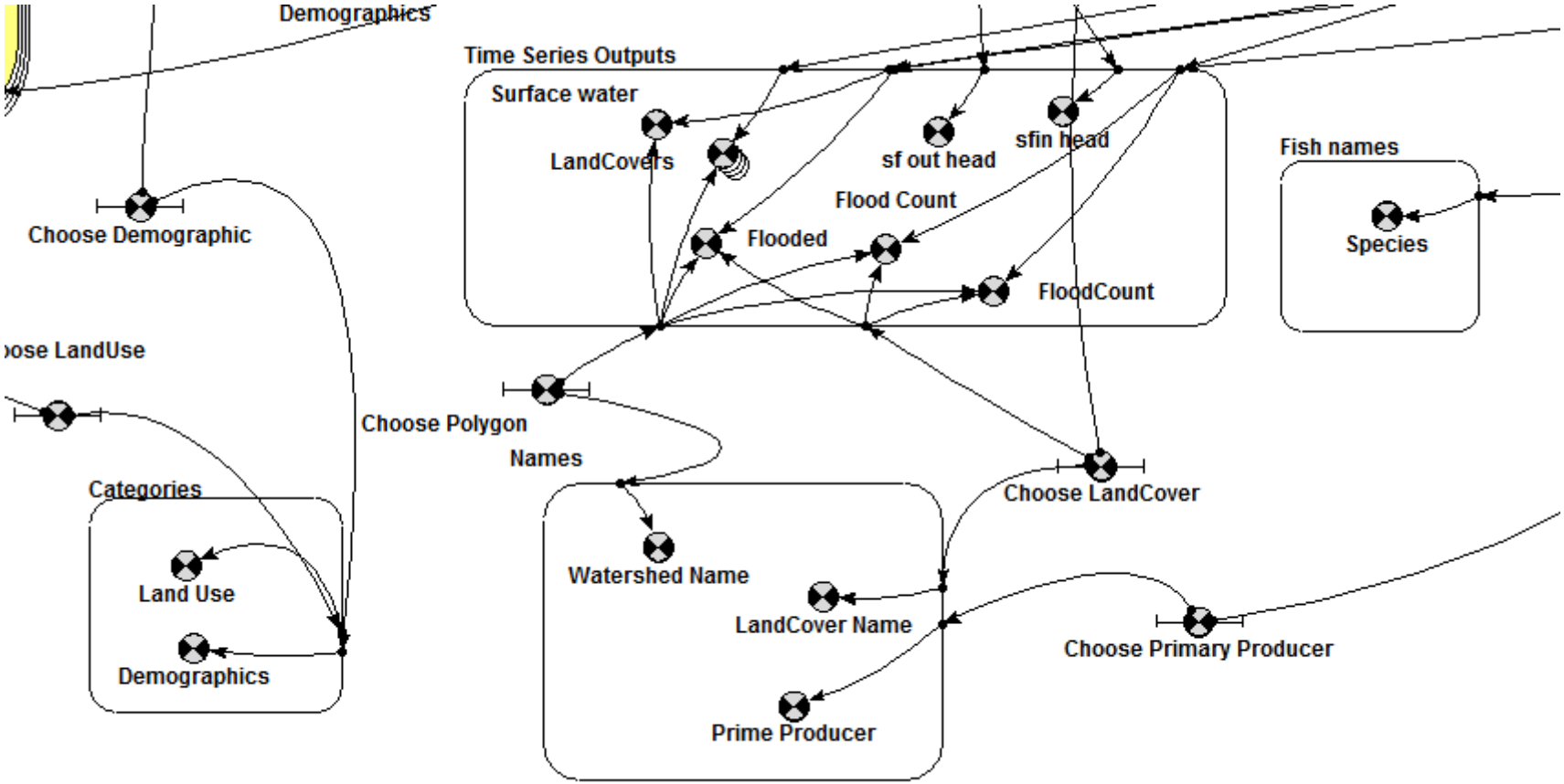
Time Series Outputs



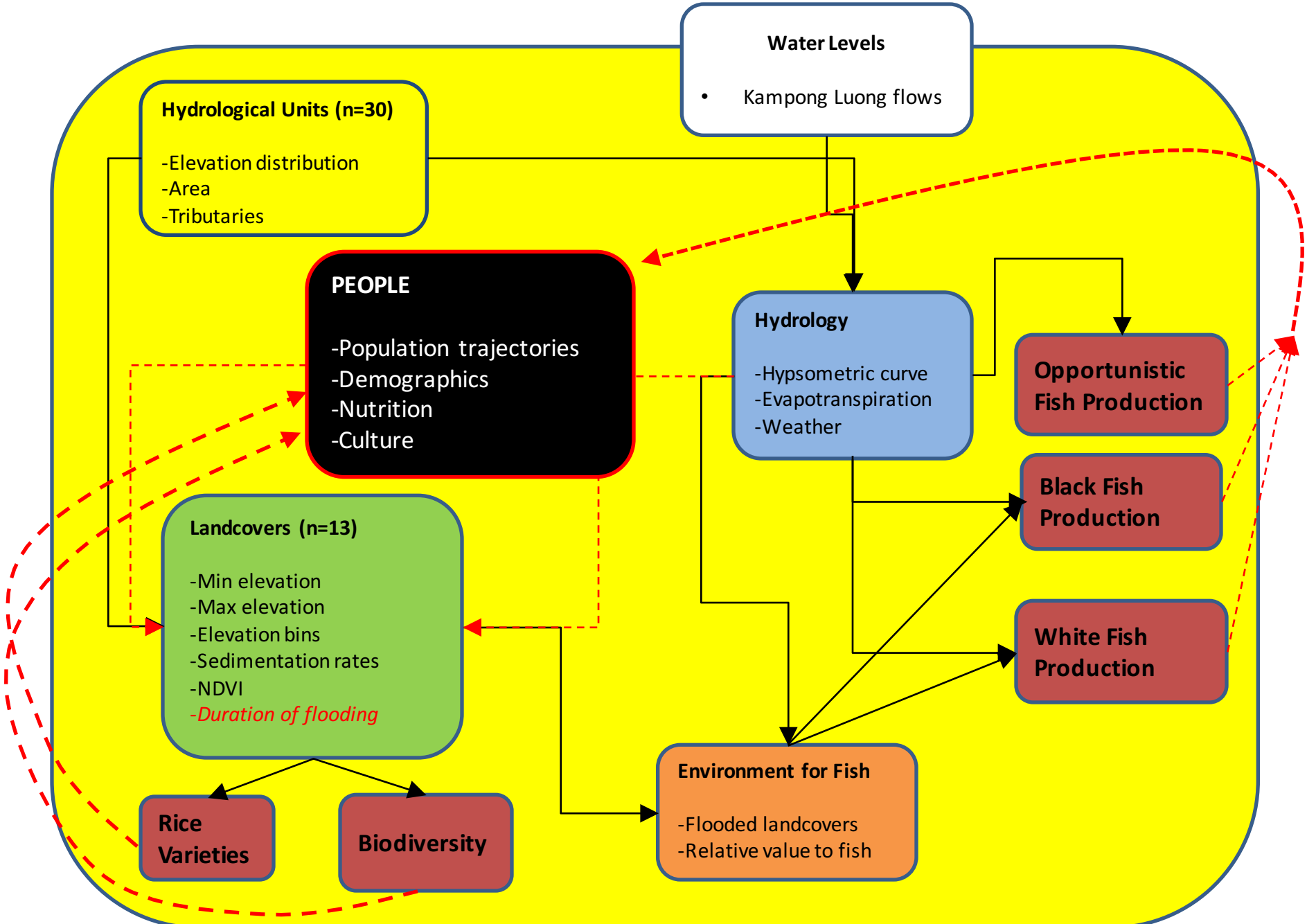


Spatial Outputs

Time Series Outputs

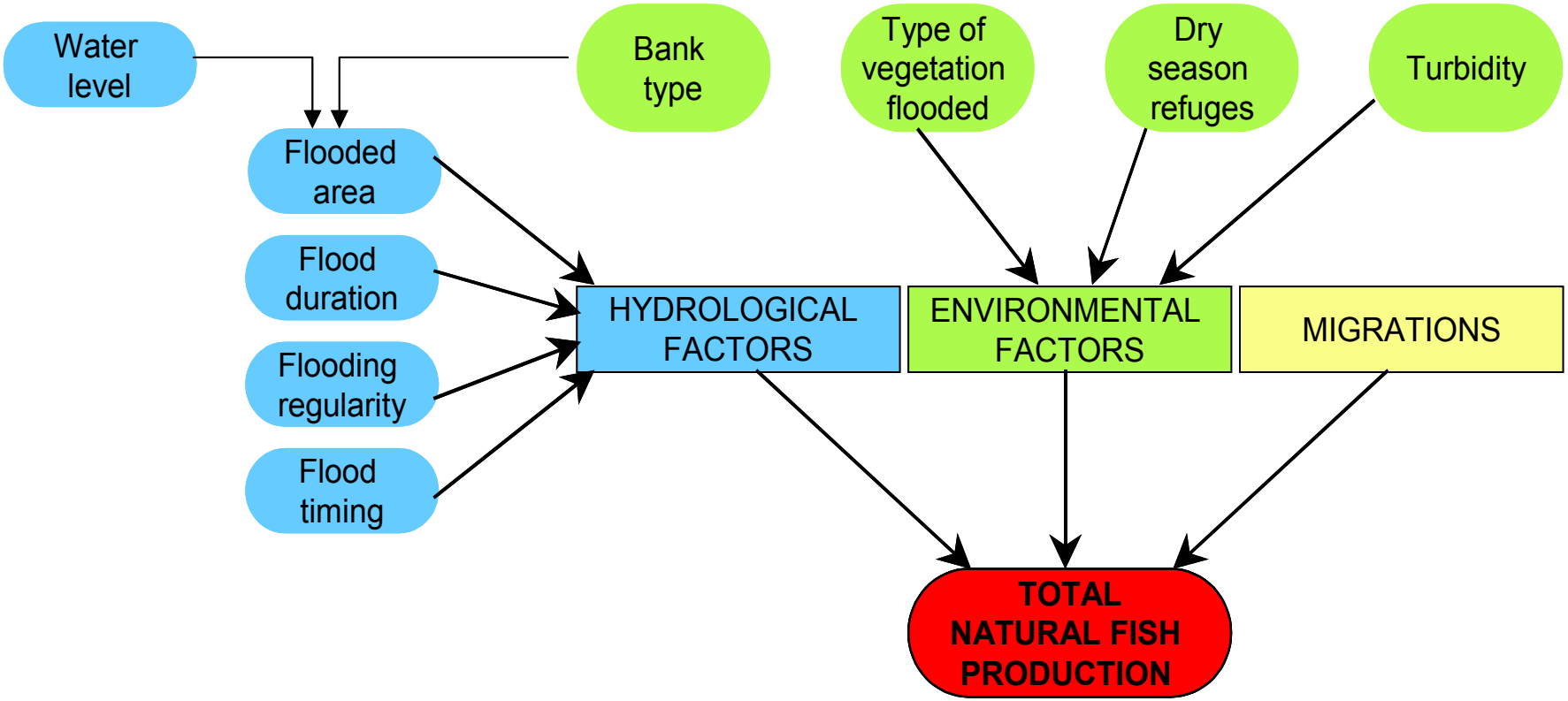


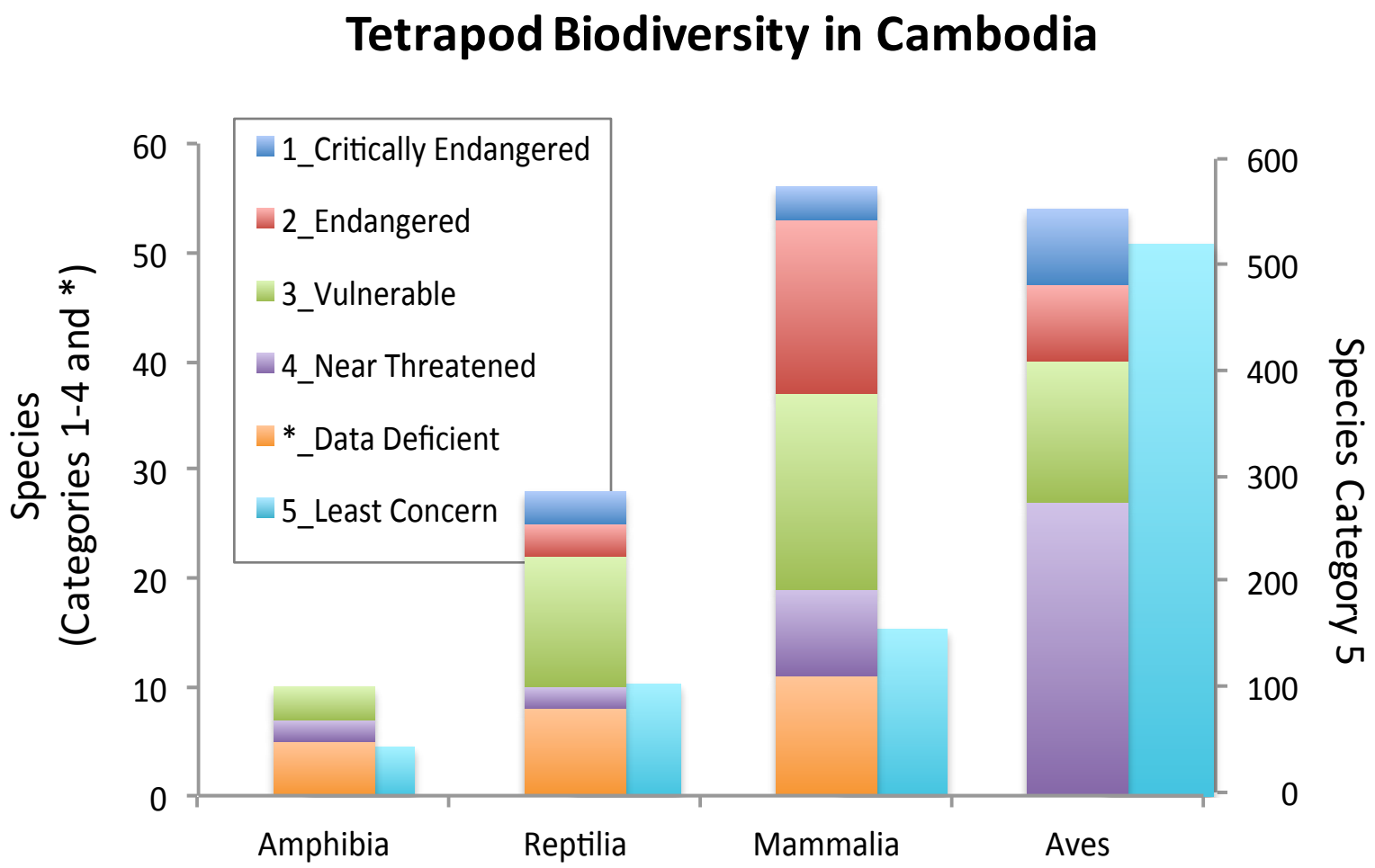
Tonle Sap Integrated Modeling: Design and Methods



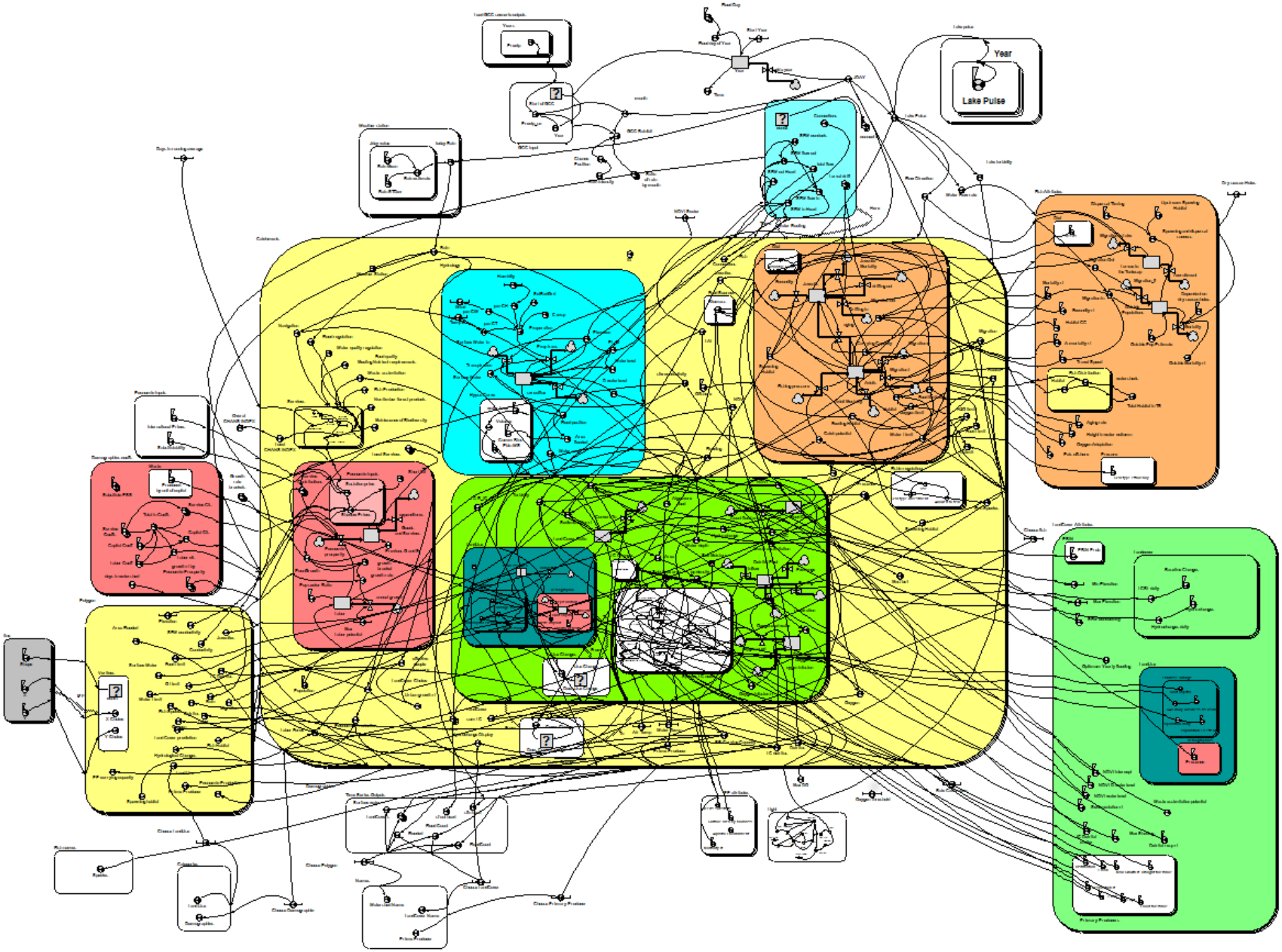
Tonle Sap Integrated Modeling: Design and Methods

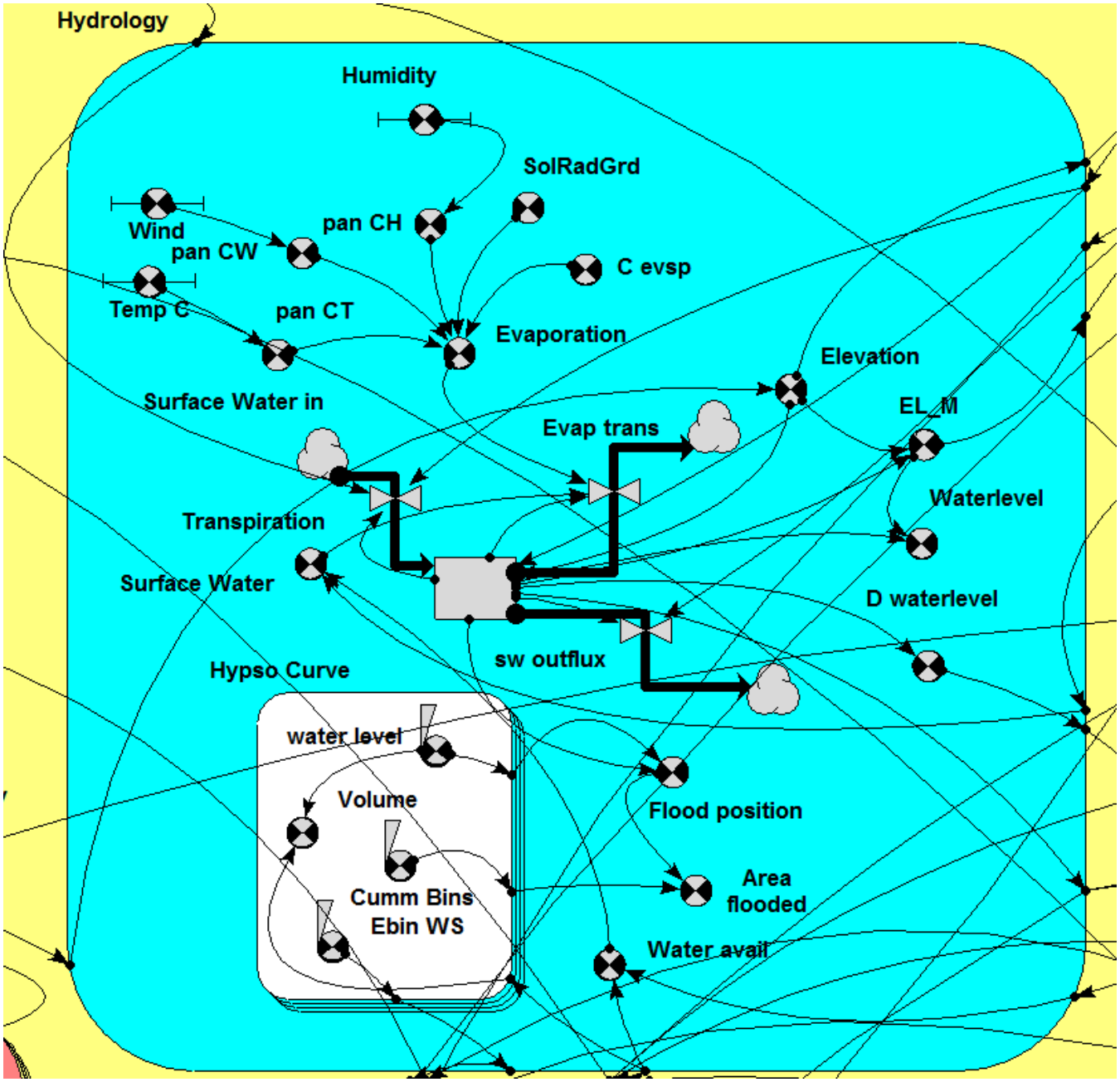
Baran E., Makin I., Baird I.G. 2003 BayFish: a model of environmental factors driving fish production in the Lower Mekong Basin. Contribution to the Second International Symposium on Large Rivers for Fisheries. Phnom Penh, Cambodia, 11-14 February 2003.

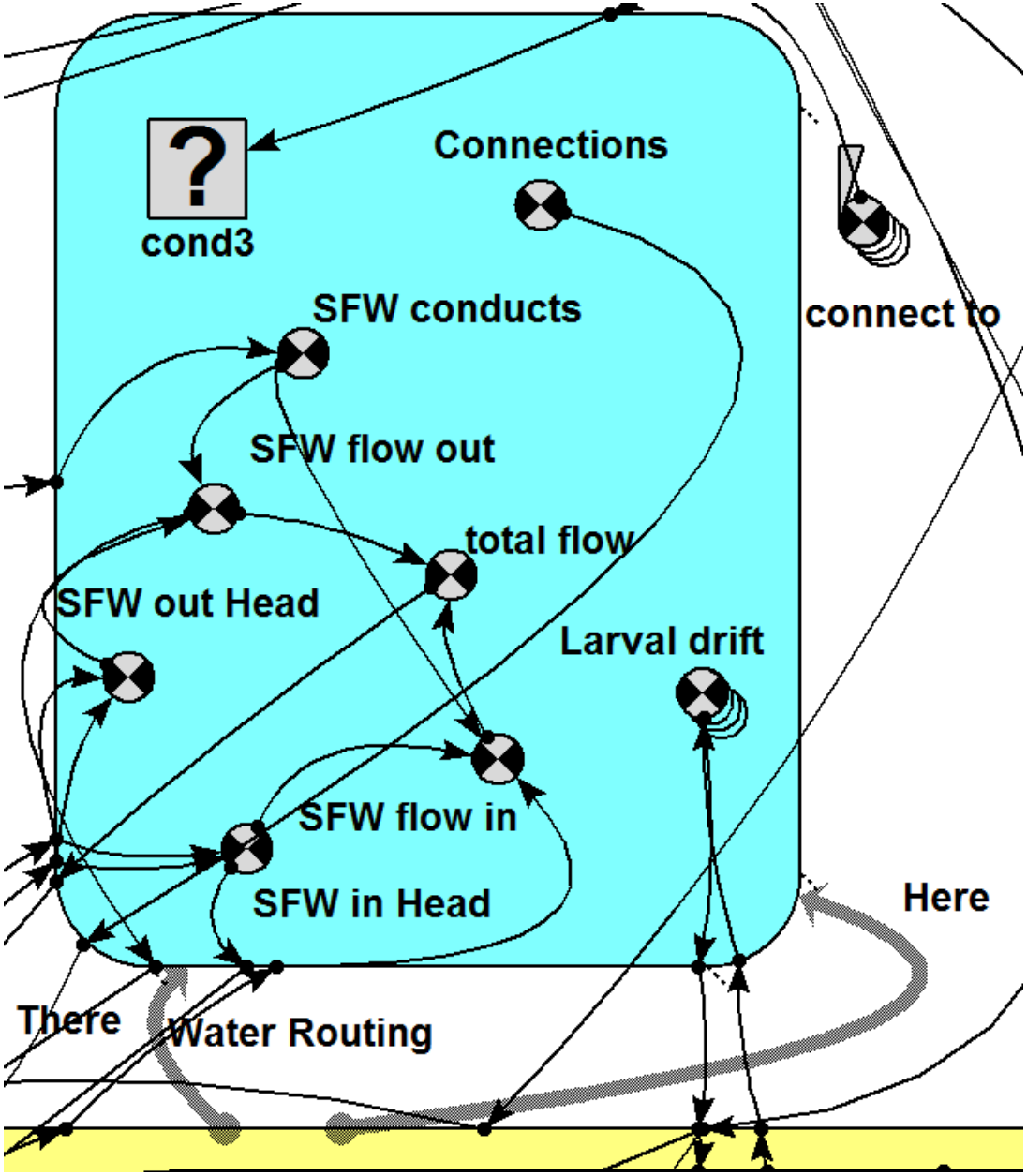




Source Data: International Union for The Conservation of Nature (IUCN)

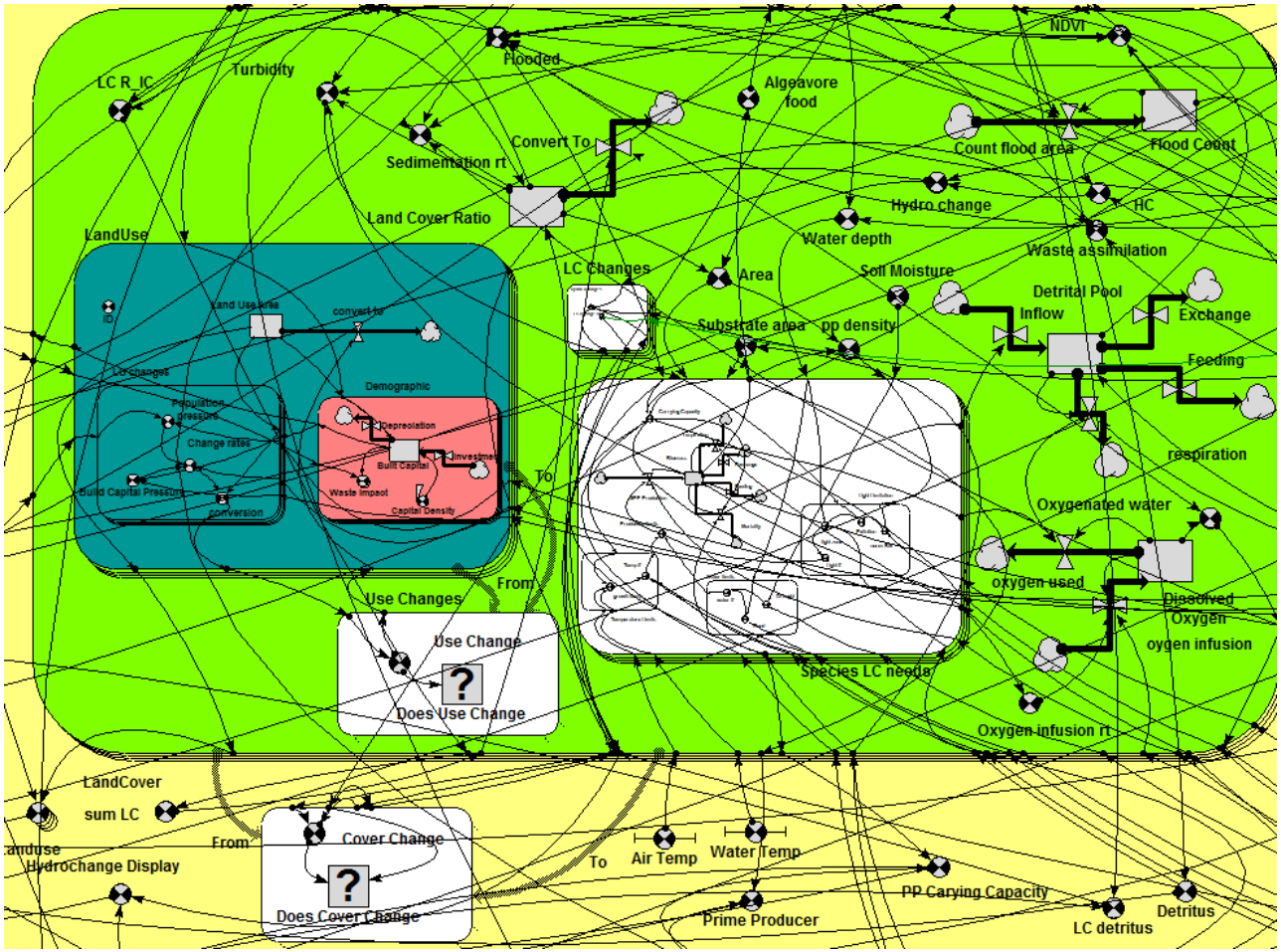

Year
Lake Pulse

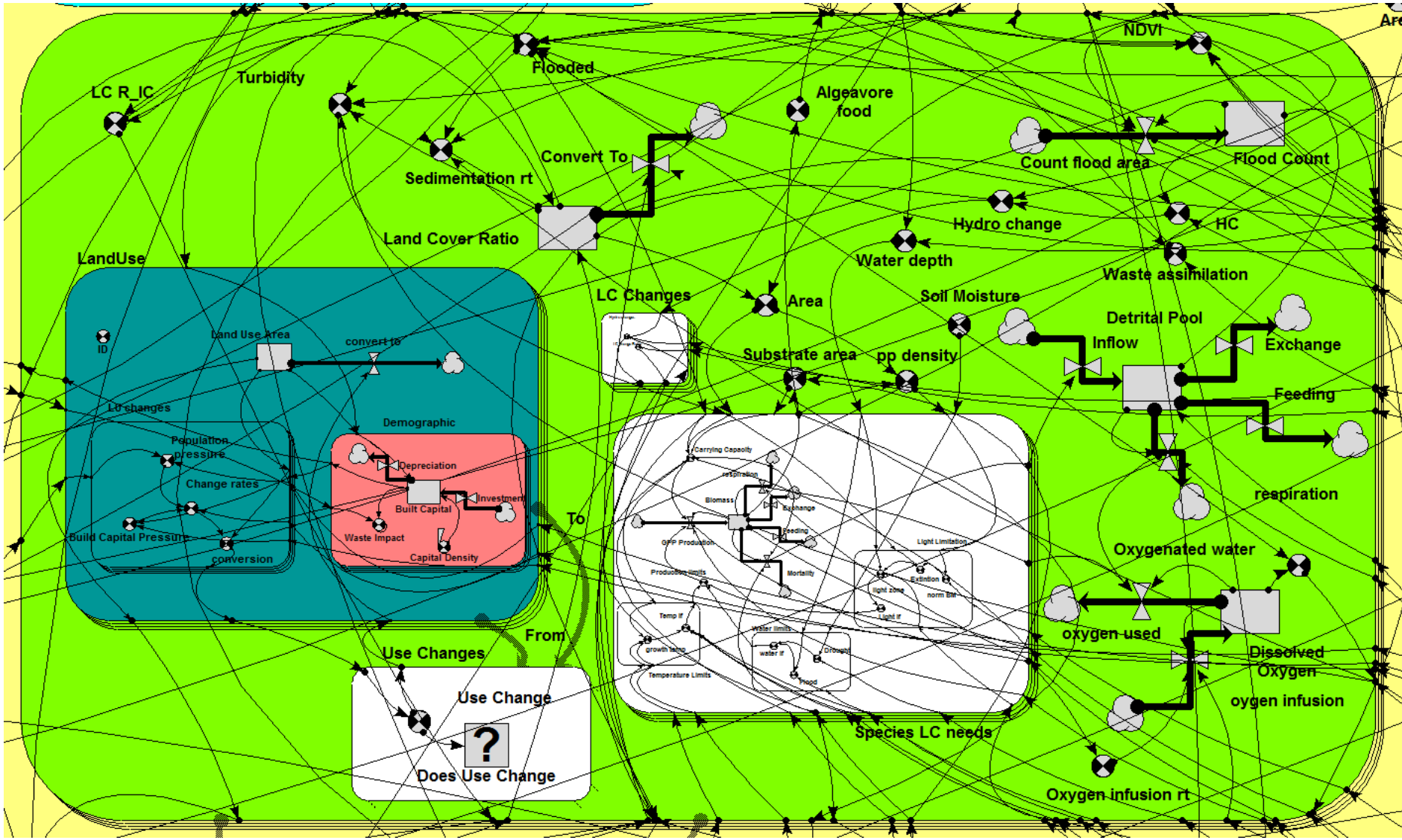

Hydrology
Humidity
SolRadGrd
Wind
pan CH
pan CW
C evsp
Temp C
pan CT
Evaporation
Elevation
Surface Water in
EL_M
Evap trans
Waterlevel
Transpiration
Surface Water
D waterlevel
sw outflux
Hypso Curve
water level
Volume
Flood position
Area
flooded
Cumm Bins
Ebin WS
Water avail



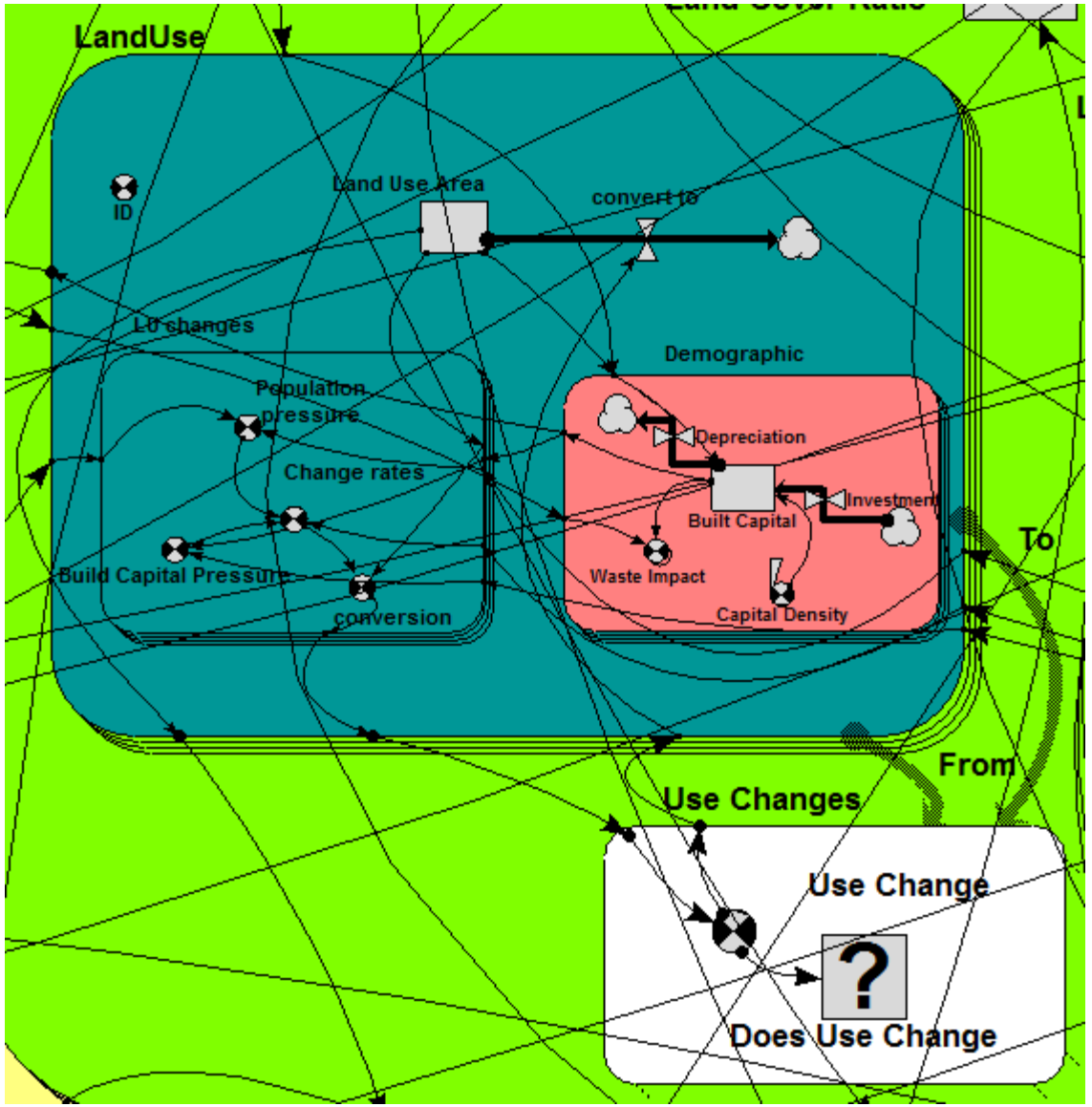
Hydrological Routing and Exchanges

Landcover and Landcover Change

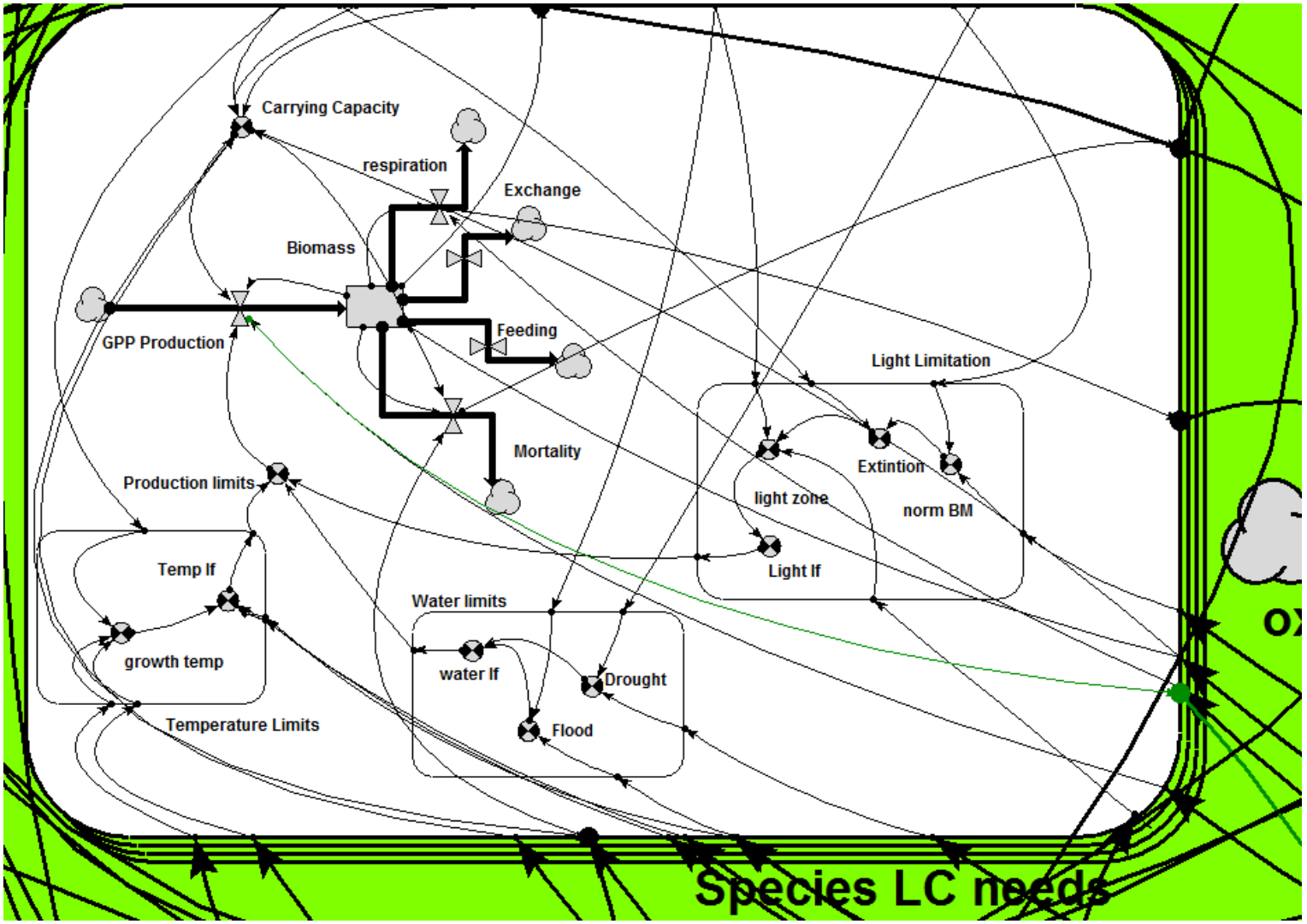



LC R_IC
Turbidity
Flooded
NDVI
Sedimentation rt
Convert To
Algeavore food
Count flood area
Flood Count
Hydro change
HC
Land Cover Ratio
Water depth
Waste assimilation
LandUse
LC Changes
Area
Soil Moisture
Detrital Pool
Inflow
Exchange
Substrate area
pp density
Feeding
ID
Land Use Area
convert to
LU changes
Demographic
Population pressure
Depreciation
Change rates
Built Capital
Investment
Build Capital Pressure
Waste Impact
Capital Density
conversion
To
From
respiration
Oxygenated water
oxygen used
Dissolved Oxygen
oygen infusion
Use Changes
Use Change
Does Use Change
Species LC needs
Oxygen infusion rt

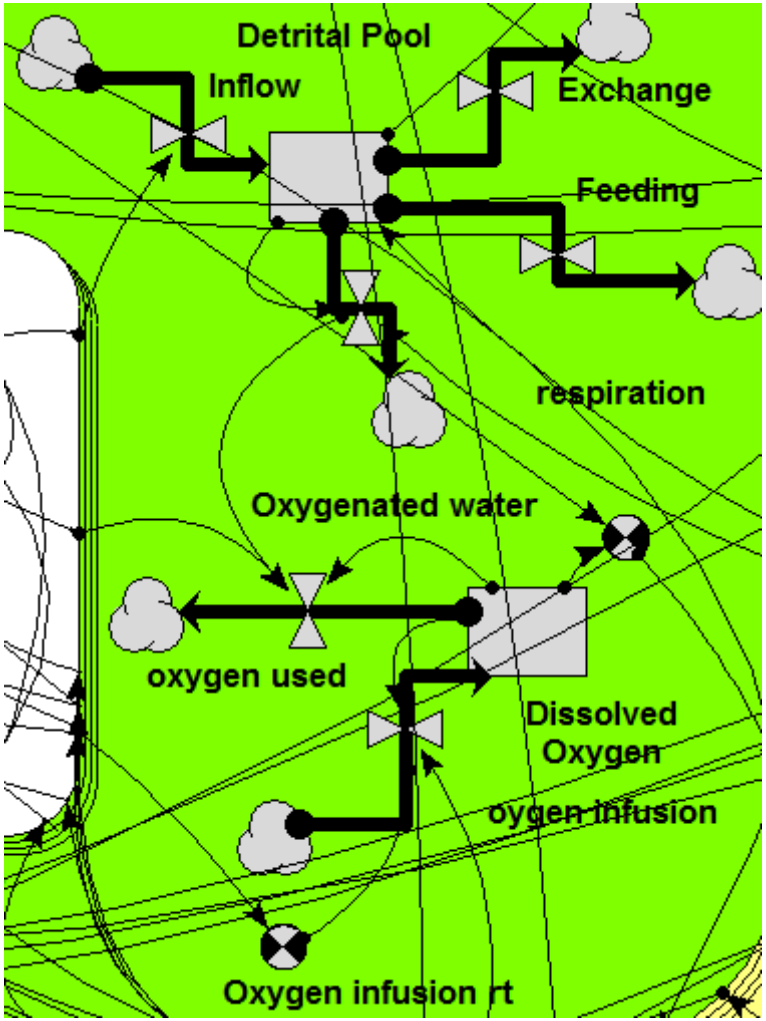
Landuse and Landuse Change



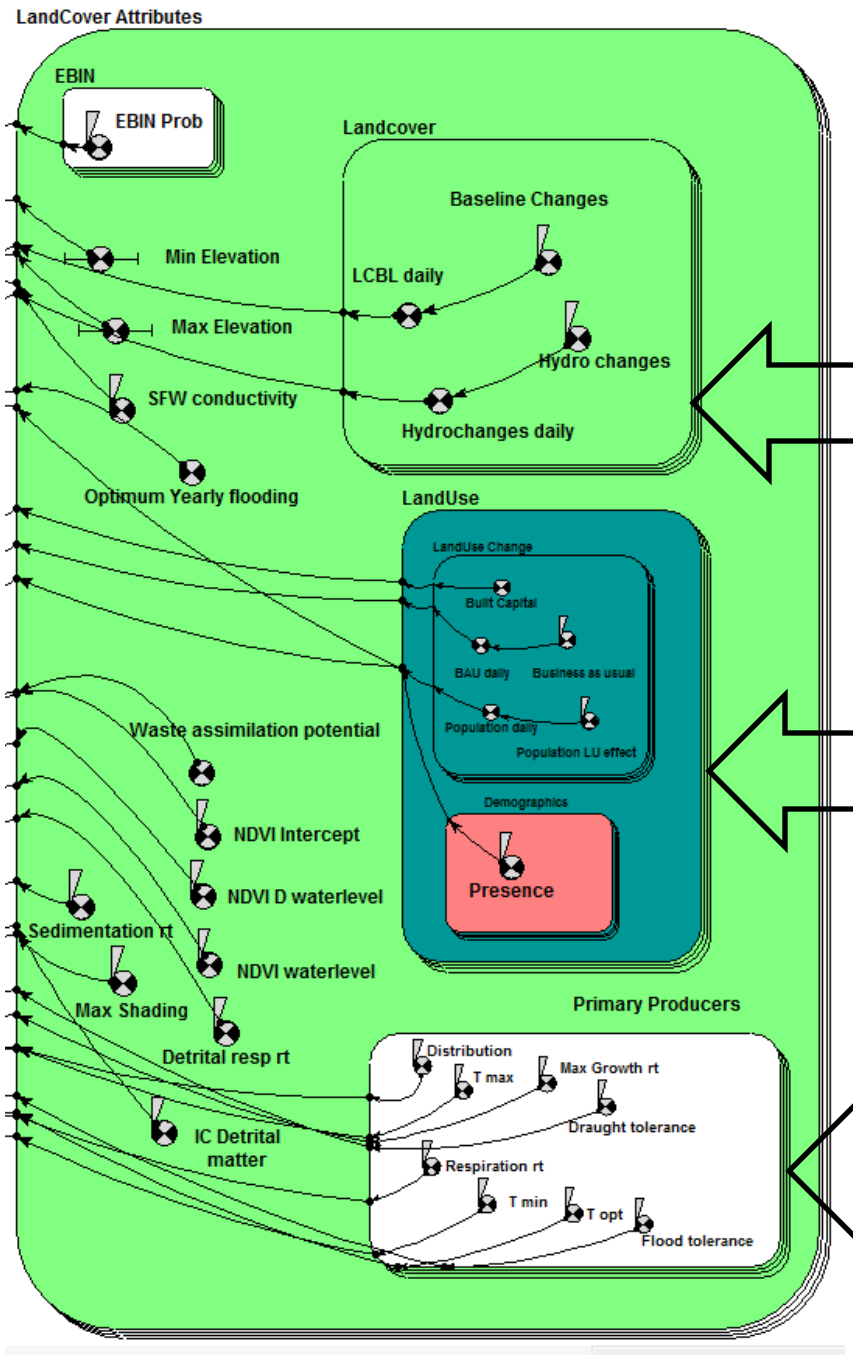
Primary producers



Aerobic Anaerobic Dynamics



Land Cover Attributes

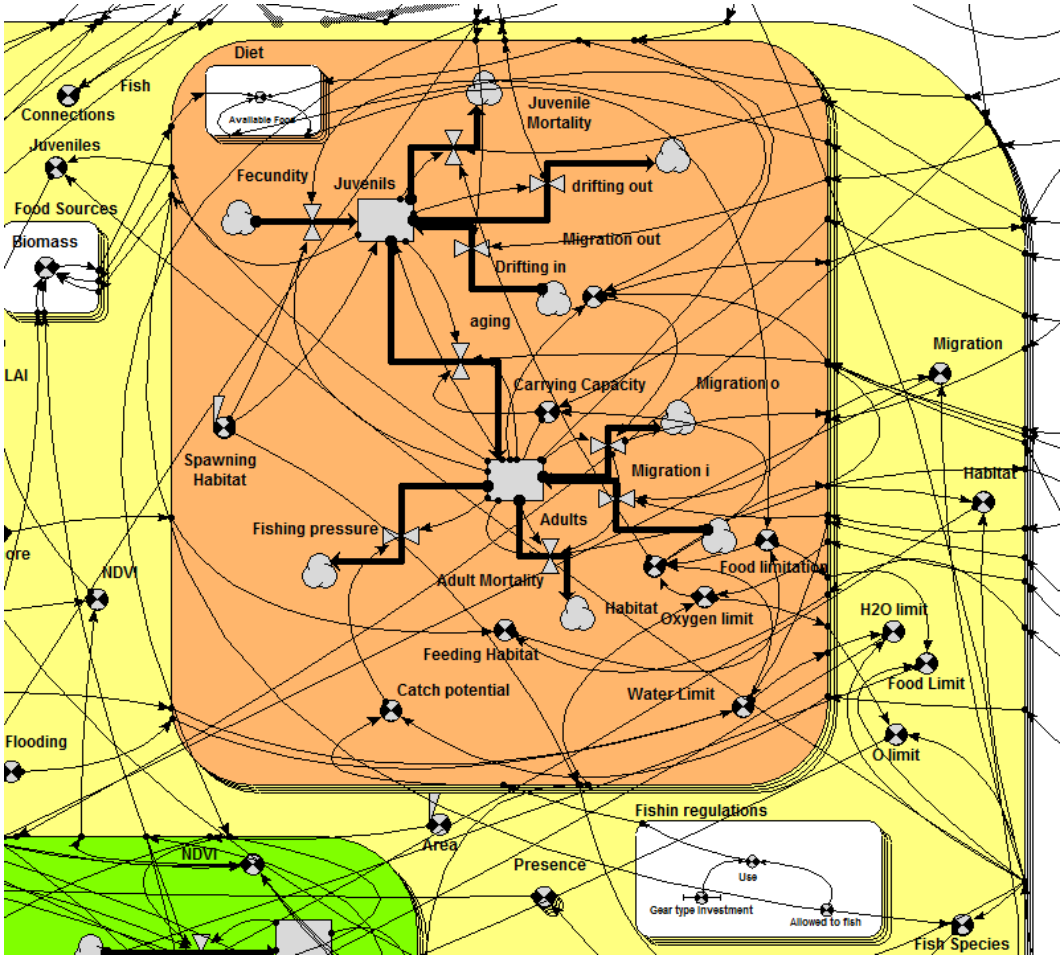


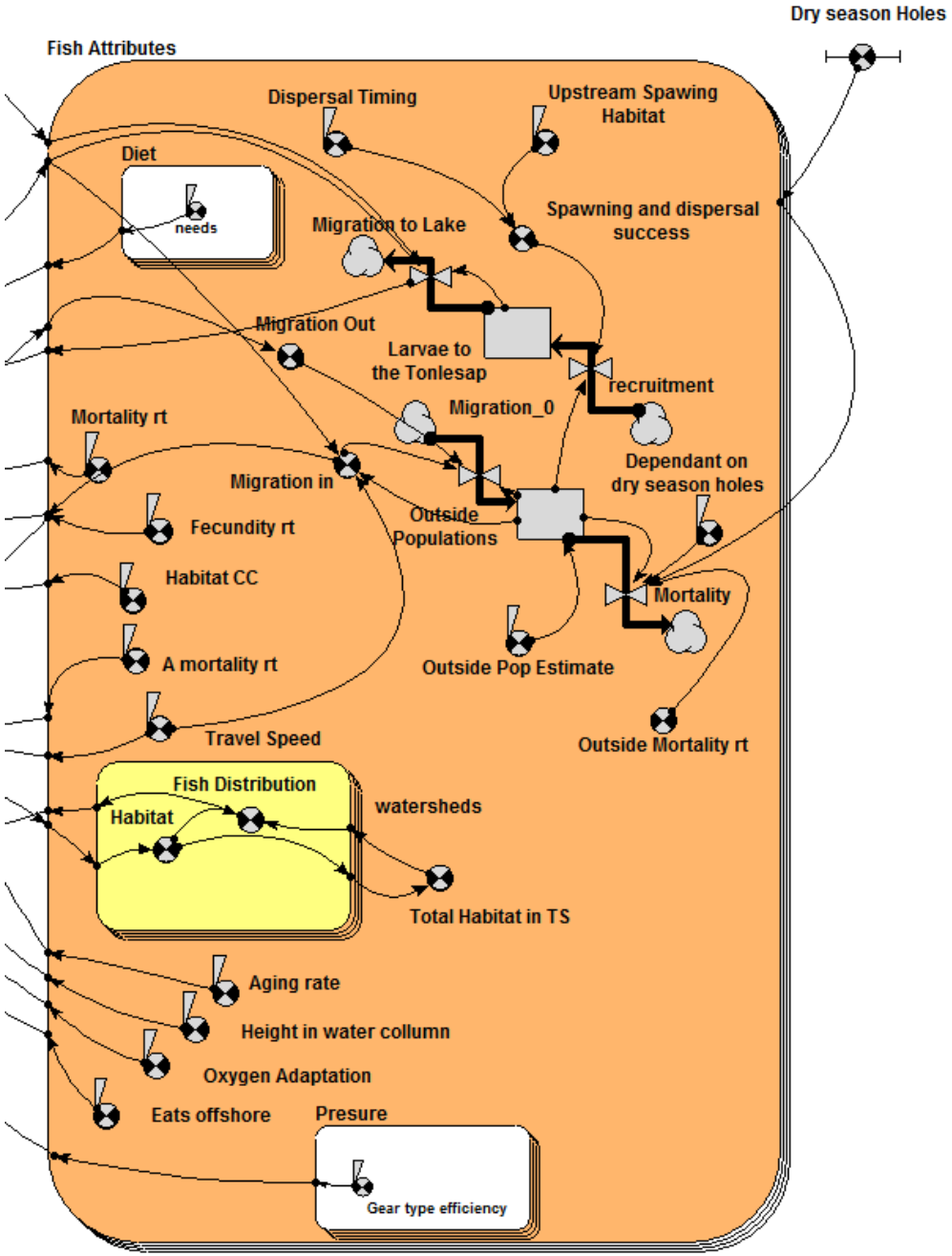
Drivers of Land Cover change

Drivers of Land Use change

Primary Producers Attributes

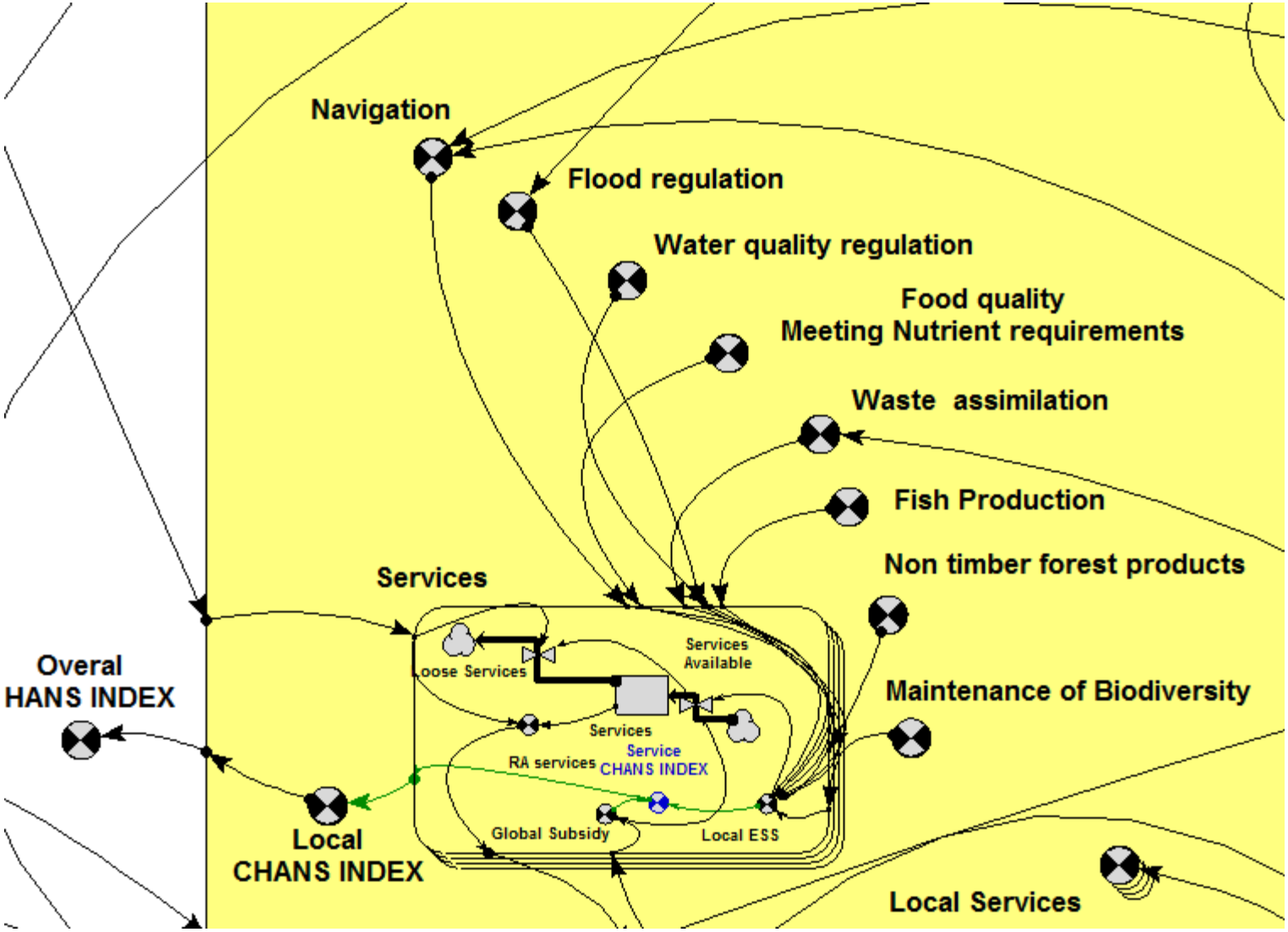
Fish Dynamics and Fishing Regulations



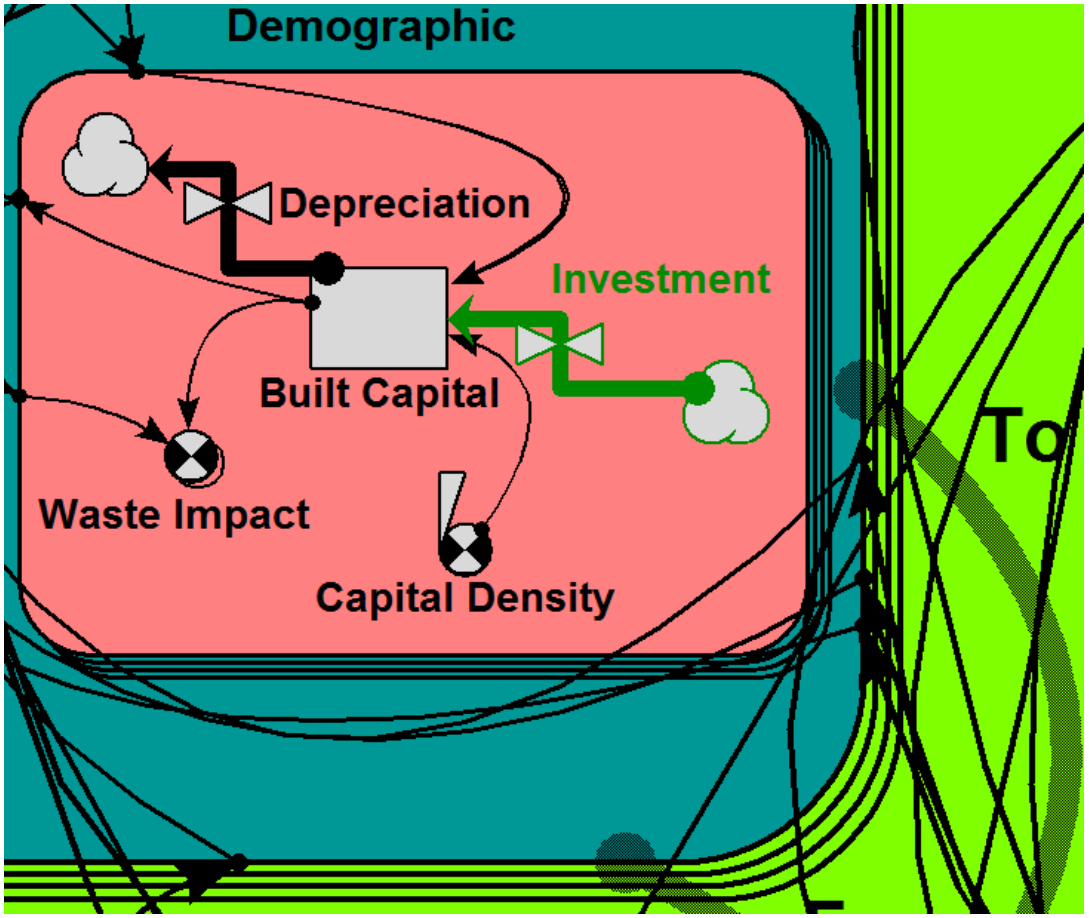


Fish Life History and Migration Dynamics

ESS and Subsidies



Capital within LandUse



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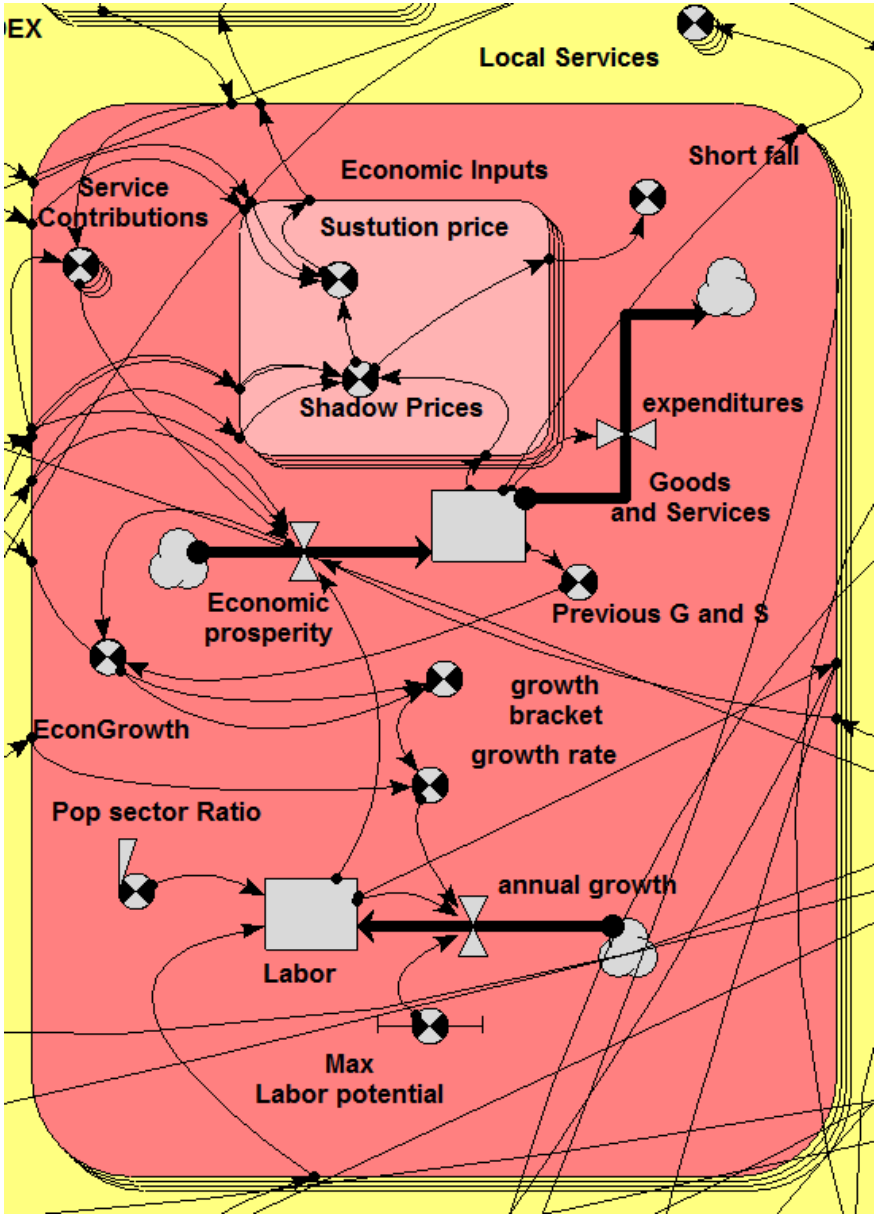
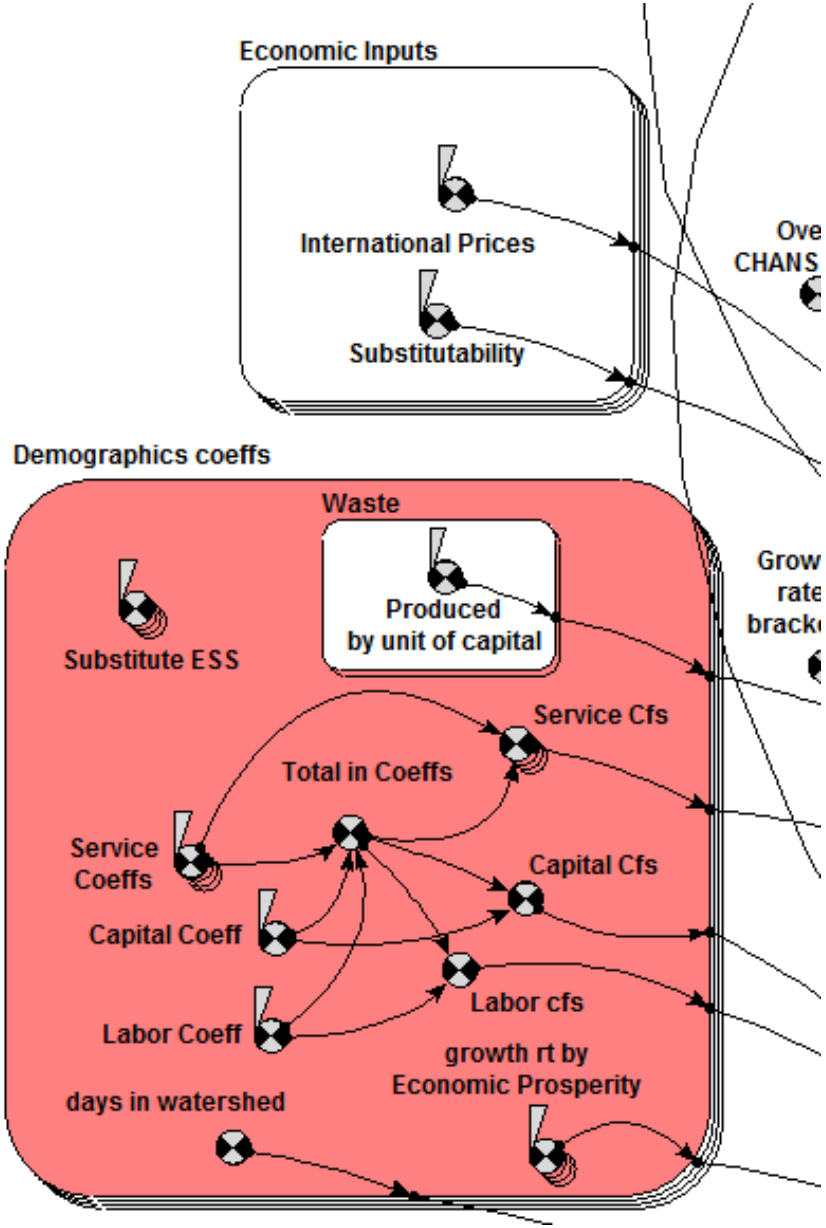
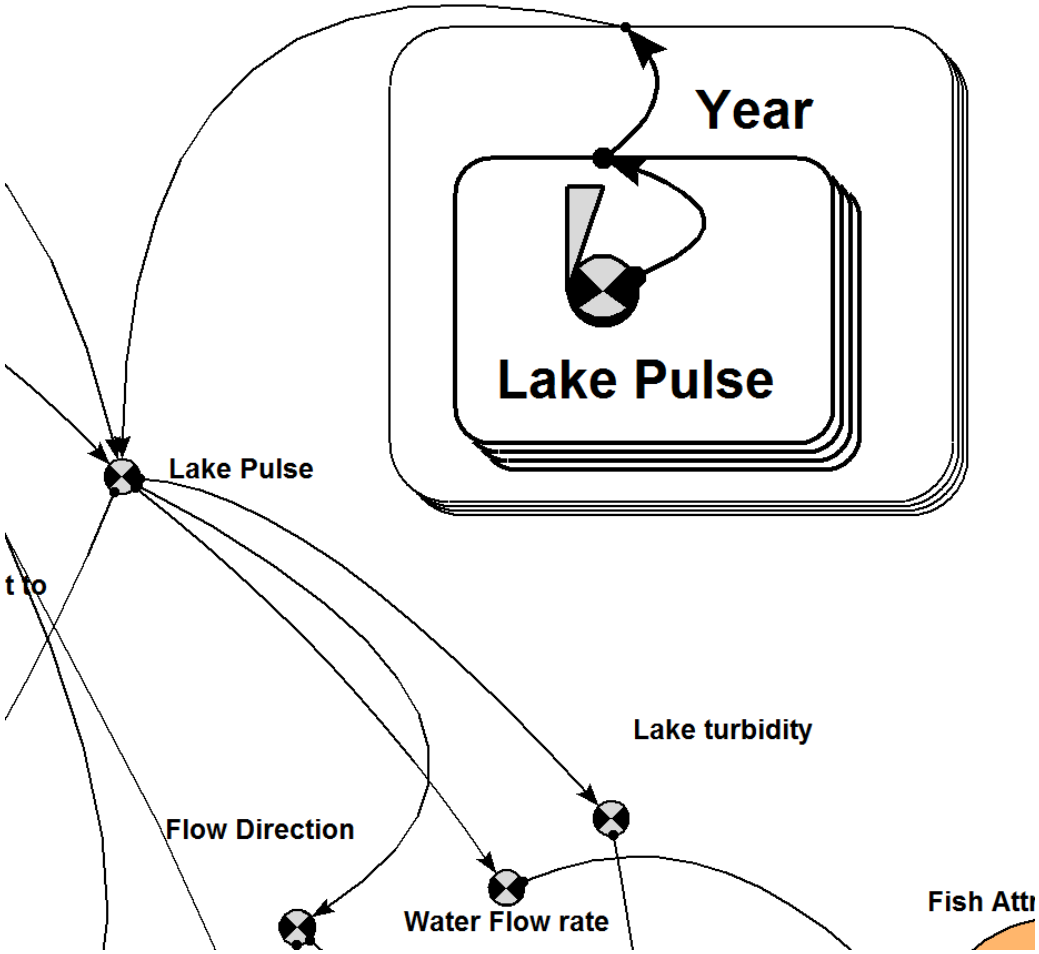

EX
Local Services
Short fall
Economic Inputs
Service
Contributions
Sustution price
Shadow Prices
expenditures
Goods
and Services
Economic
prosperity
Previous G and S
growth
bracket
EconGrowth
growth rate
Pop sector Ratio
annual growth
Labor
Max
Labor potential



Economic Attributes and the Avail bility of Services for Substituting Shortfall in Local Services

Hydrology from Dam Scenarios



Input of Global Climate Change Scenarios