

# Coupling energy-models for better representation of cross-sectoral dynamics

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IIASA and Technical University Graz,  
Austria

*Snowmass: Assessing Transformation Pathways Post-Paris and Implications for IA Research - 20 July 2016*

# Key energy challenges



**Energy Access**



**Energy Security**



**Land & Food**



**Climate Change**



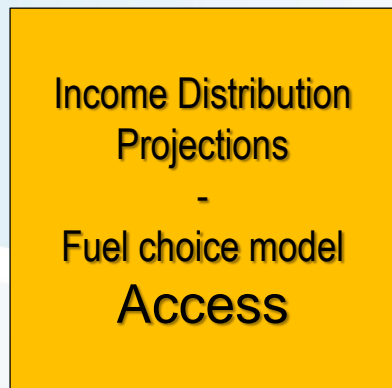
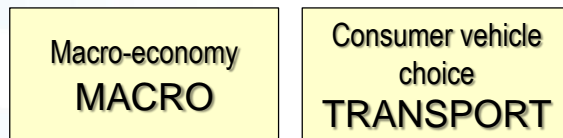
**Water Scarcity**



**Local Air Pollution**

Image sources: NASA, <http://www.powernetwork.com/white-house-releases-plan-to-cut-oil-imports-by-13-by-2025/1798/>, <http://wheresmyamerica.wordpress.com/2007/08/26/i-cant-see-my-america/>, <http://www.americanprogress.org/issues/green/report/2009/05/14/6142/energy-poverty-101/>, <http://today.uconn.edu/blog/2010/12/reclaiming-water-a-green-leap-forward/>, [http://te.wikipedia.org/wiki/%E0%B0%A6%E0%B0%B8%E0%B1%8D%E0%B0%A4%E0%B1%8D%E0%B0%B0%E0%B0%82:Forest\\_Osaka\\_Japan.jpg](http://te.wikipedia.org/wiki/%E0%B0%A6%E0%B0%B8%E0%B1%8D%E0%B0%A4%E0%B1%8D%E0%B0%B0%E0%B0%82:Forest_Osaka_Japan.jpg)

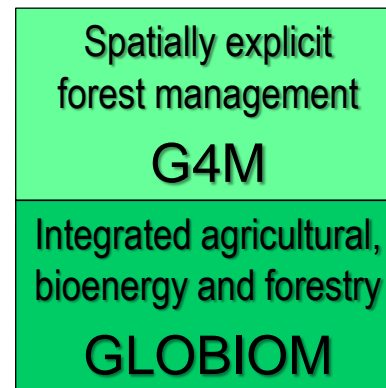
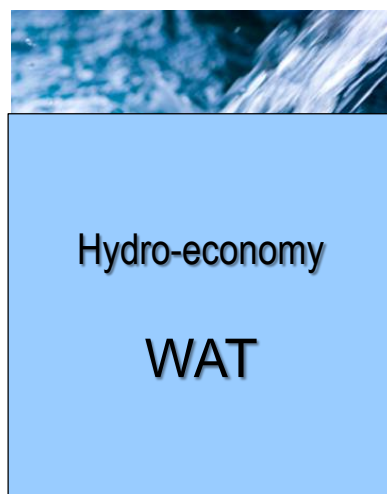
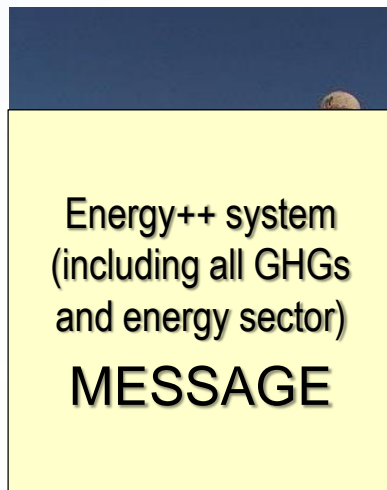
# IIASA Integrated Assessment Framework



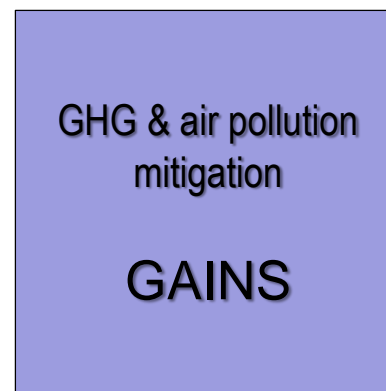
**Energy Access**



**Climate Change**



**Land & Food**



**Local Air Pollution**

# IIASA Integrated Assessment Framework

Macro-economy  
**MACRO**

Consumer vehicle  
choice  
**TRANSPORT**

Income Distribution  
Projections  
-  
Fuel choice model  
**Access**

Energy++ system  
(including all GHGs  
and energy sector)  
**MESSAGE**

Spatially explicit  
forest management  
**G4M**

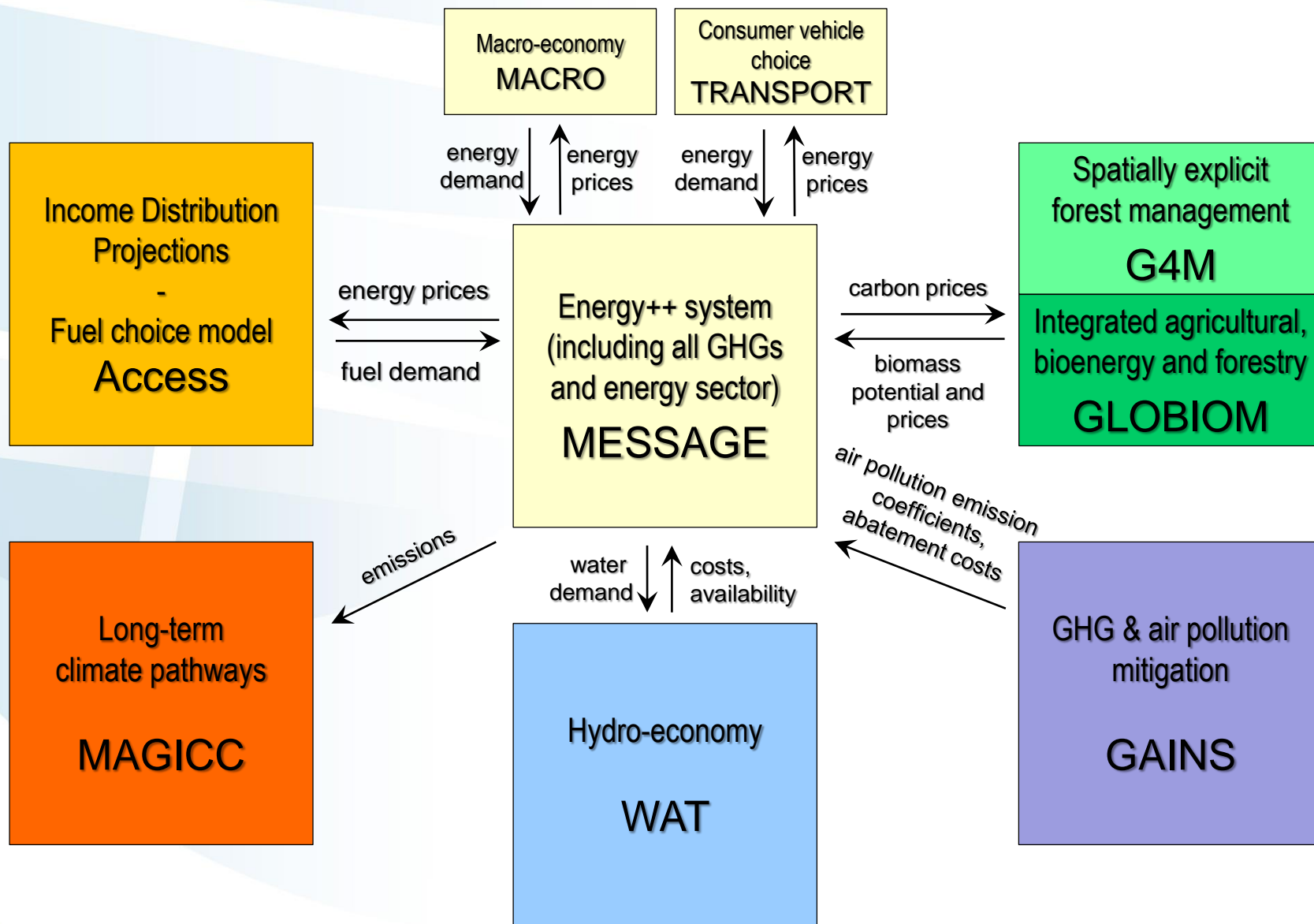
Integrated agricultural,  
bioenergy and forestry  
**GLOBIOM**

Long-term  
climate pathways  
**MAGICC**

Hydro-economy  
**WAT**

GHG & air pollution  
mitigation  
**GAINS**

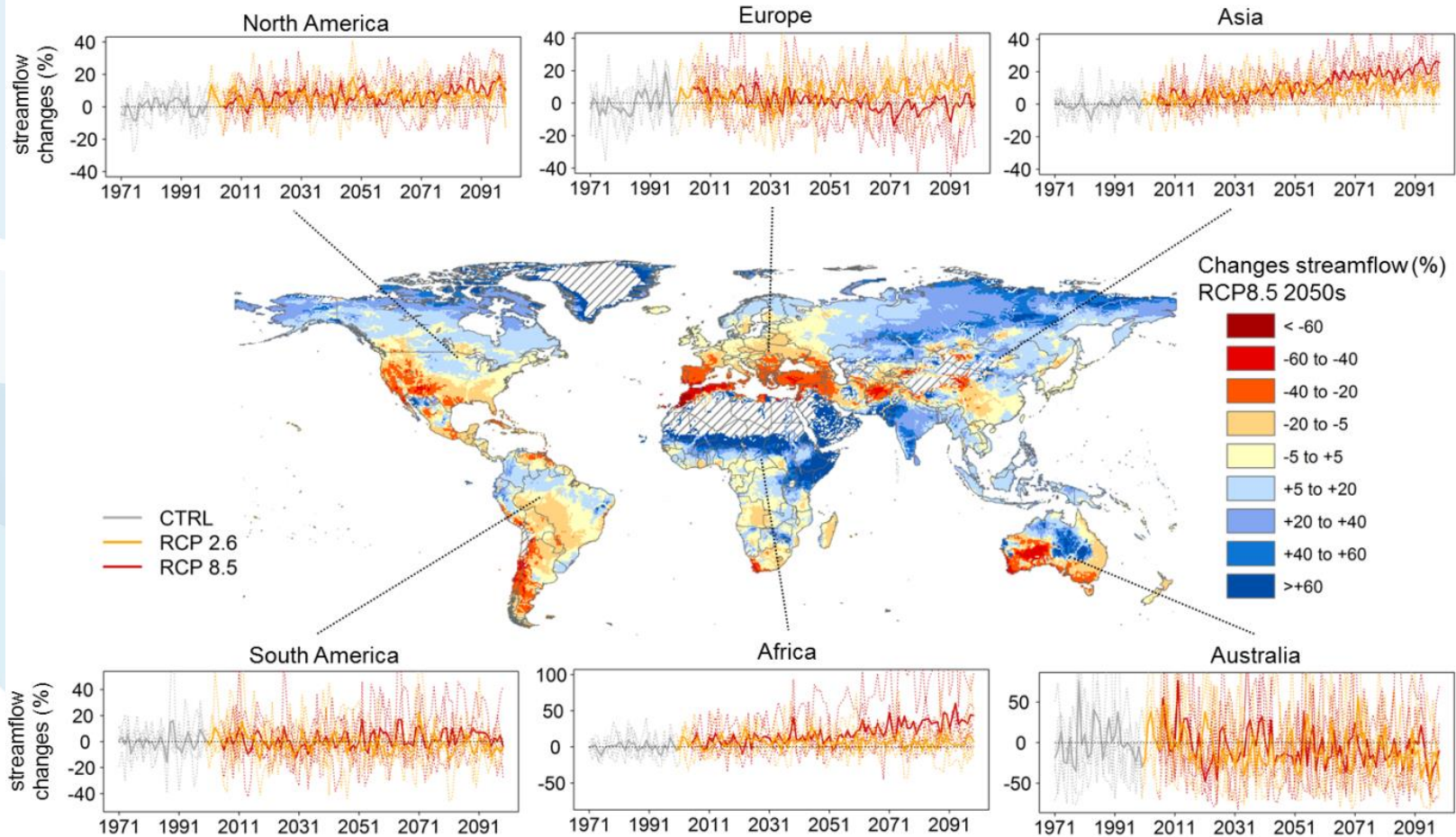
# IIASA Integrated Assessment Framework



# **Exogenous inputs from other models**

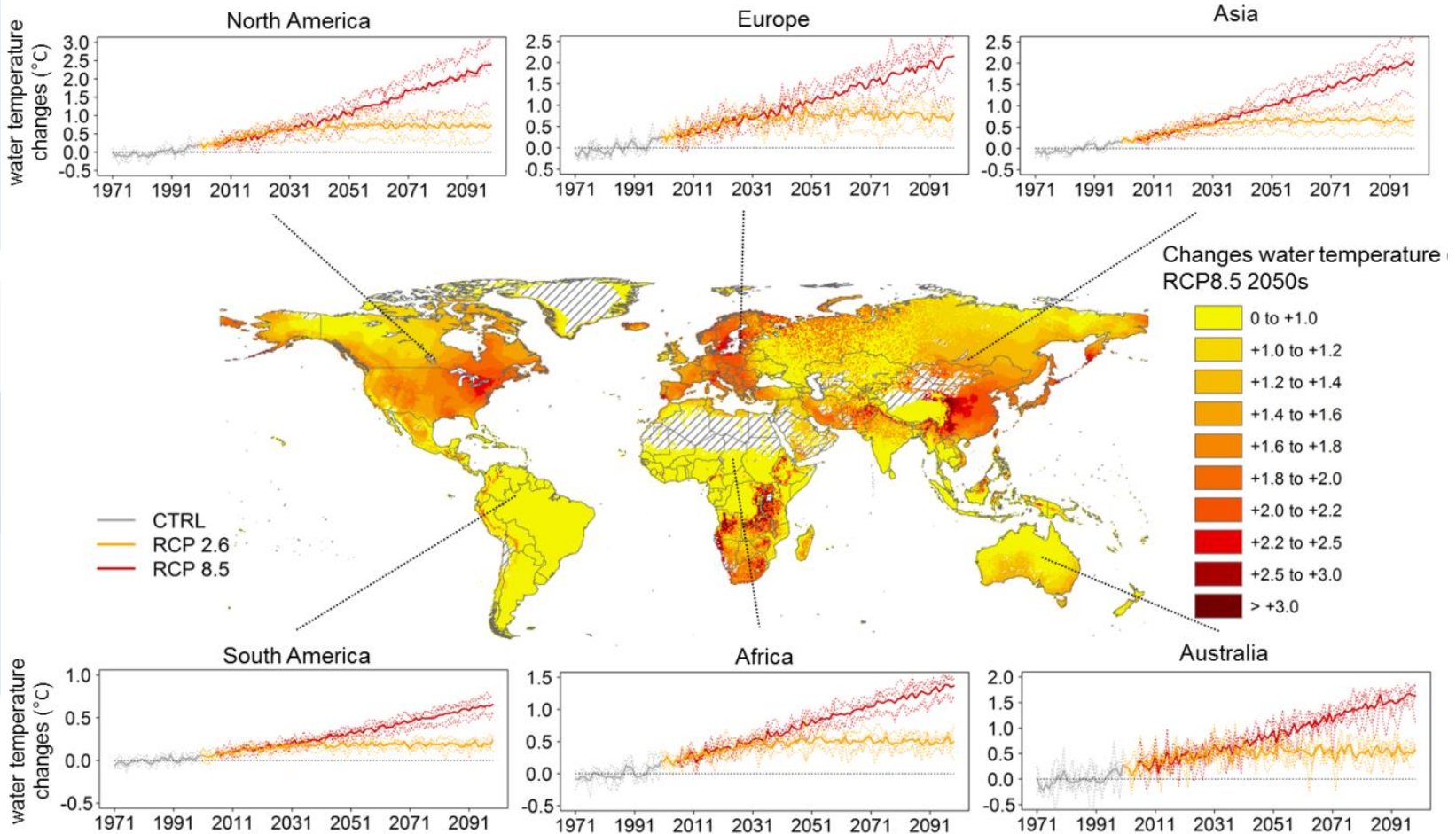
(example: GHM/ESM for water impacts on electricity)

# Streamflow



a

# Water temperature



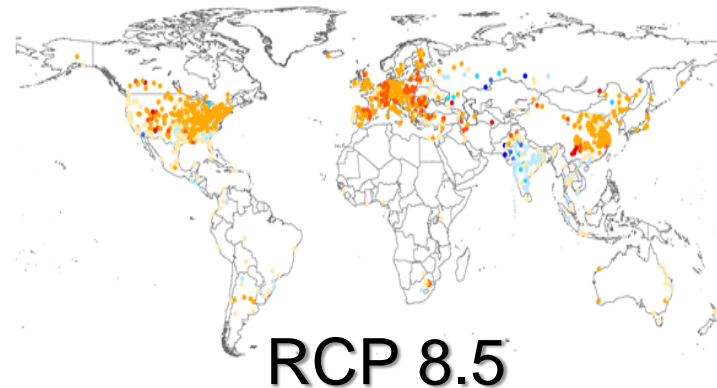
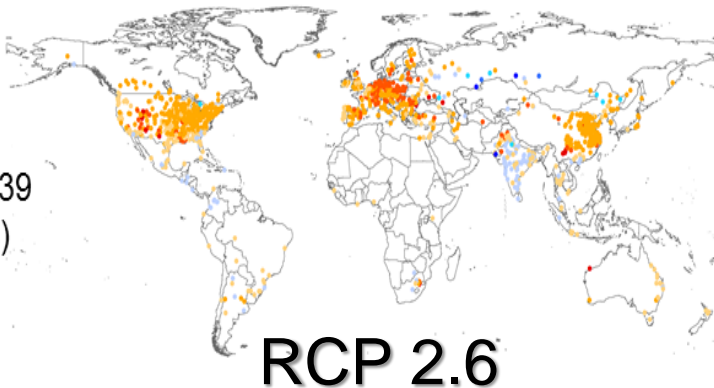
b



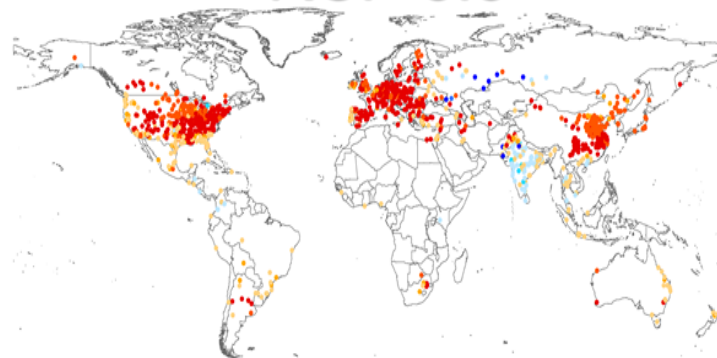
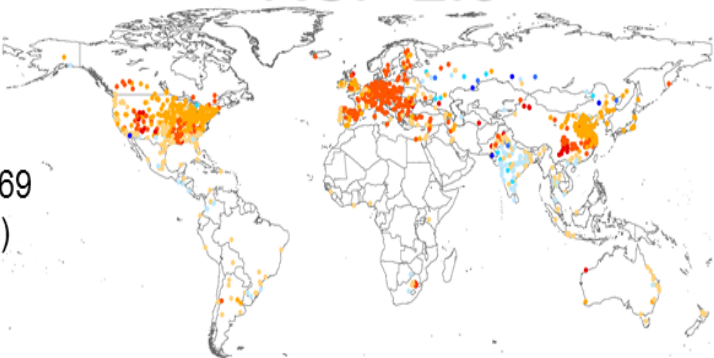
# Affected fossil power plants

Thermoelectric power

2010-2039  
(2020s)



2040-2069  
(2050s)



b

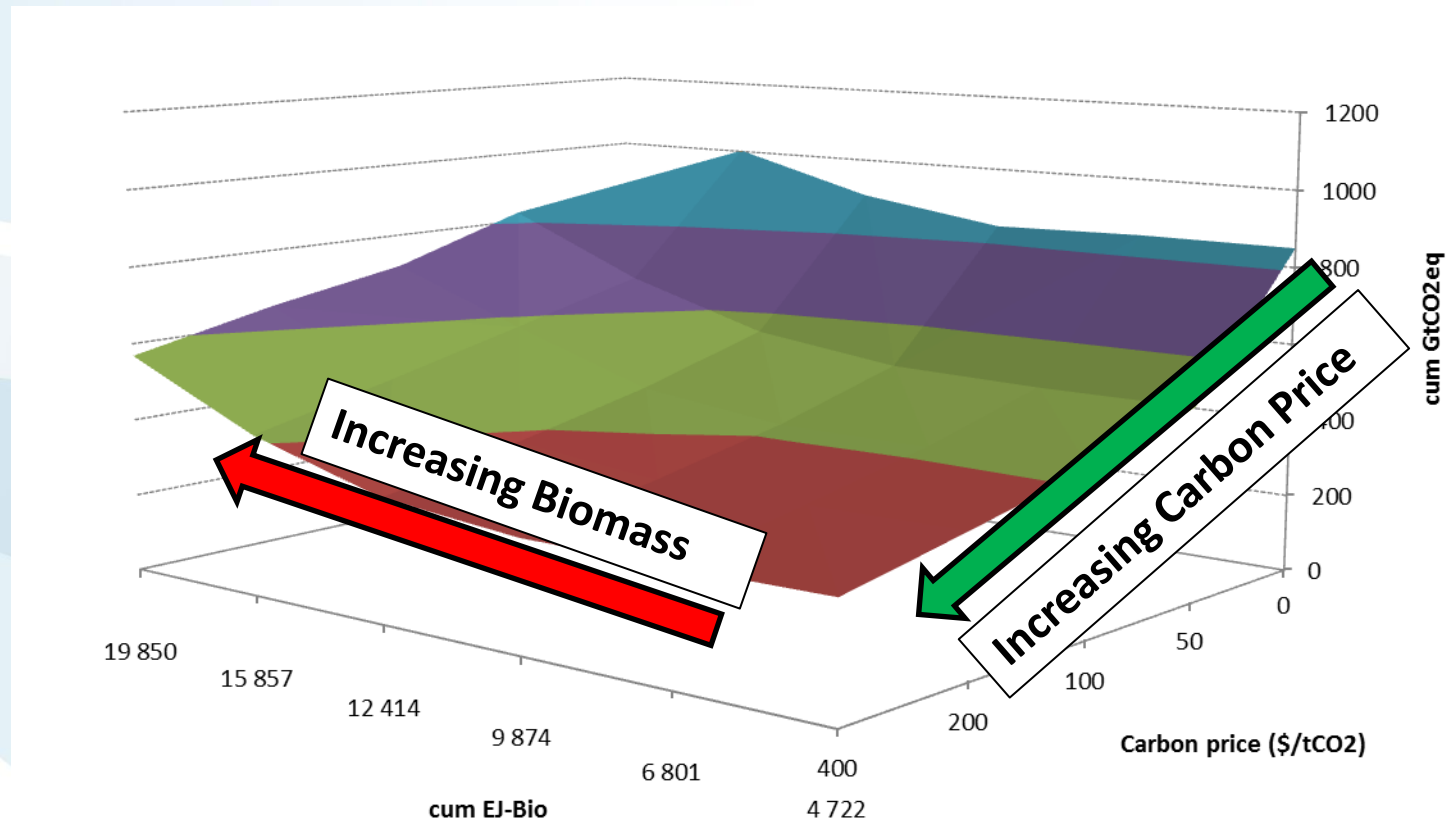
Changes usable power plant capacity (%)



# **Emulators for linking energy to other systems/impacts**

(examples: bioenergy & water adaptation)

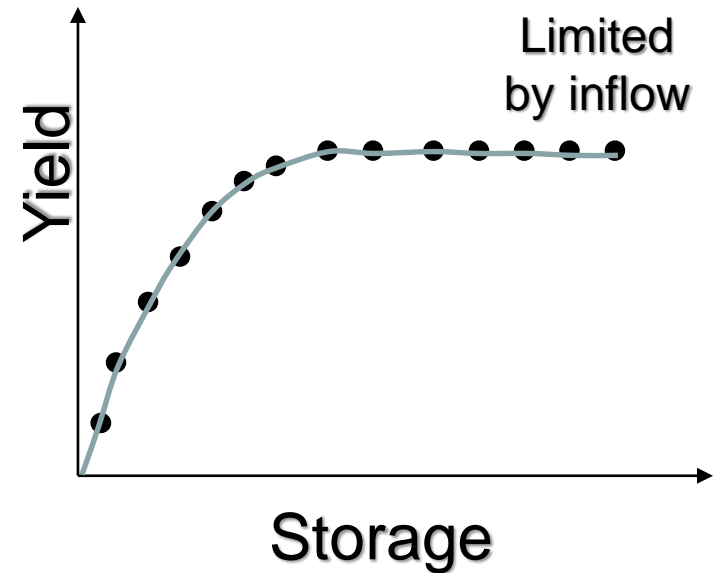
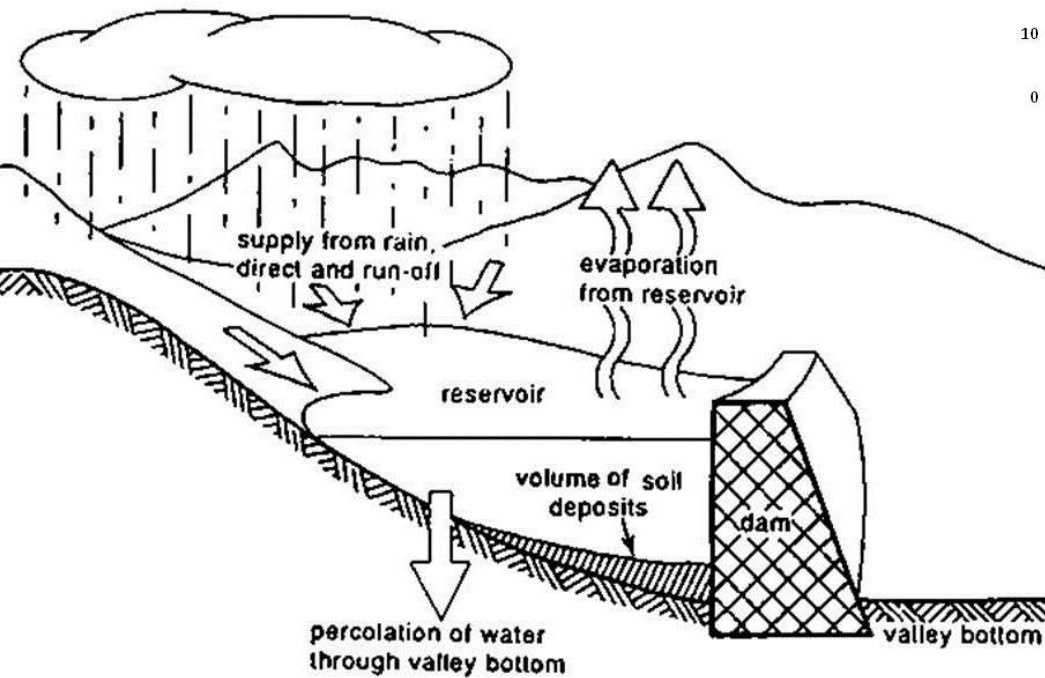
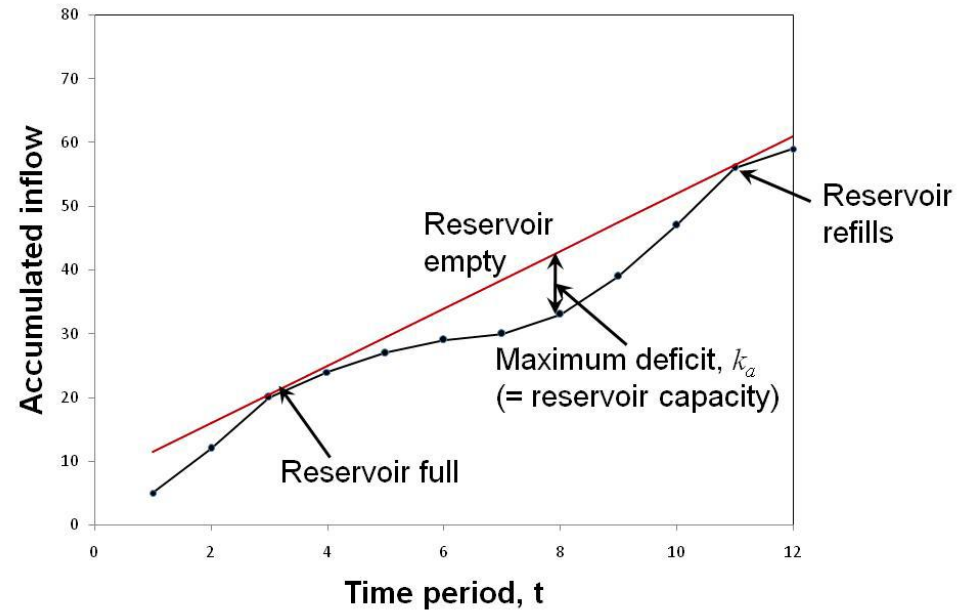
# Bio-GHG emulator for linking the energy and land-use model



*Fricko & Havlik et al  
(surface based on GLOBIOM)*

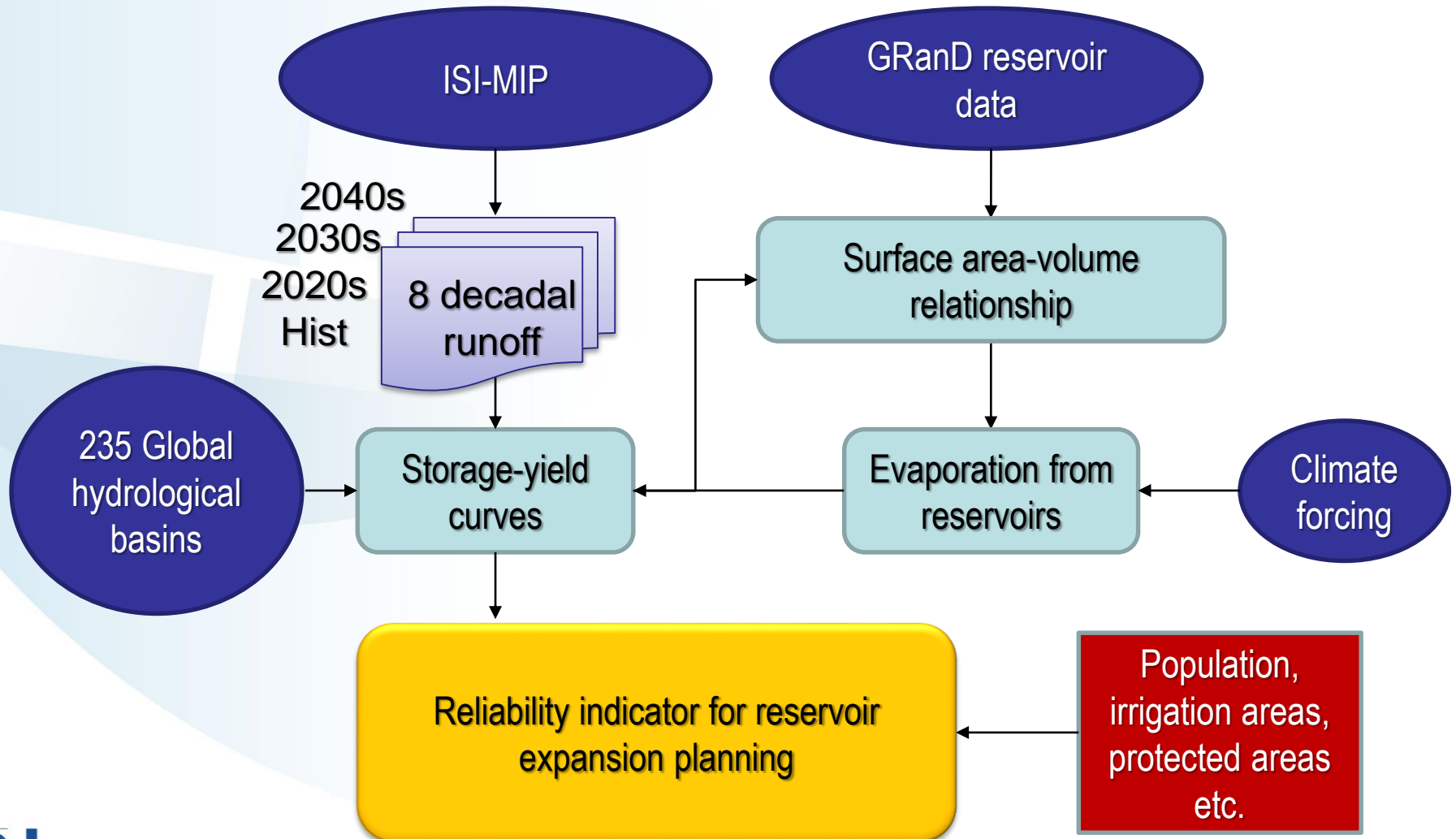
# Storage-Yield Curves

$$K_t = K_{t-1} + R_t - Q_t \dots \dots \dots \text{if positive} \\ = 0 \dots \dots \dots \text{otherwise}$$



# Overall diagram

4 GHM × 5 GCM × (1 hist + 4 RCP) = 100 combinations

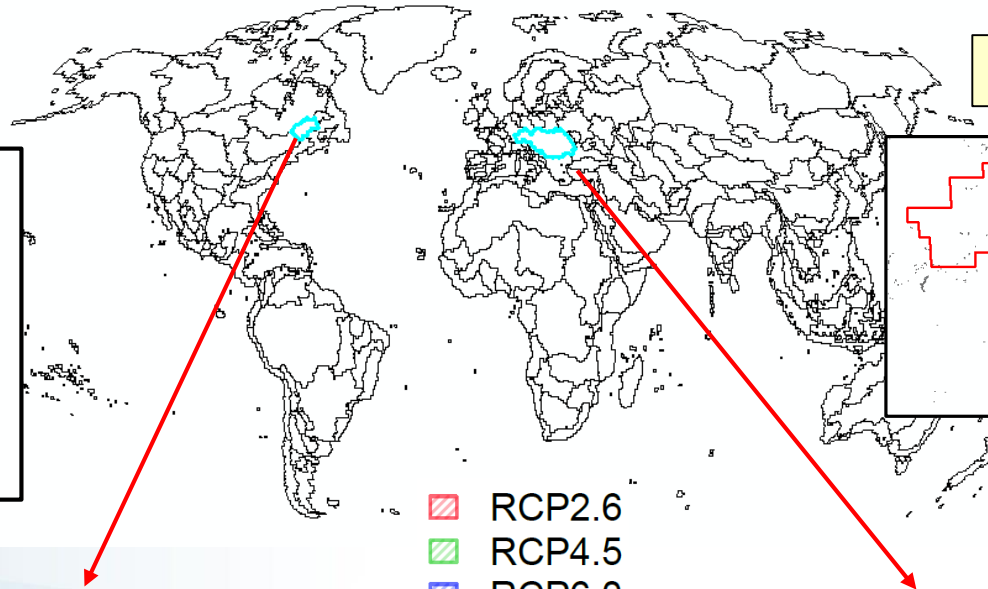


# Preliminary results

Lu Liu et al, forthcoming

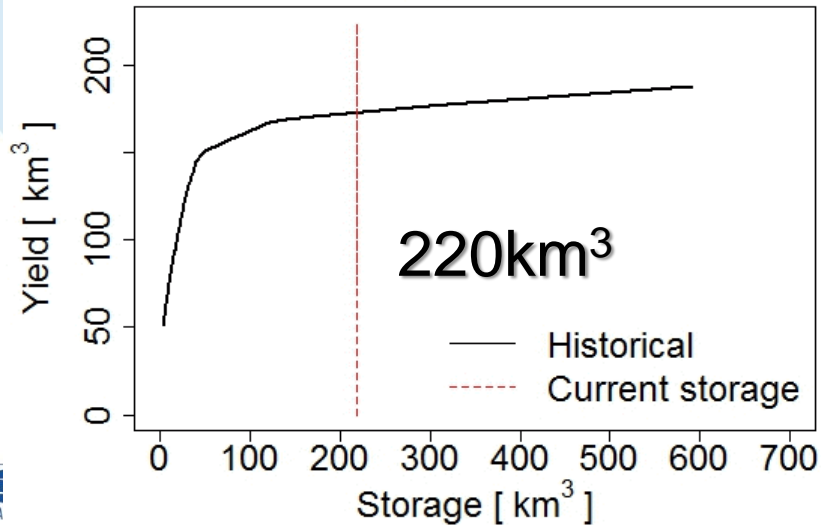
St. Lawrence basin

Danube basin

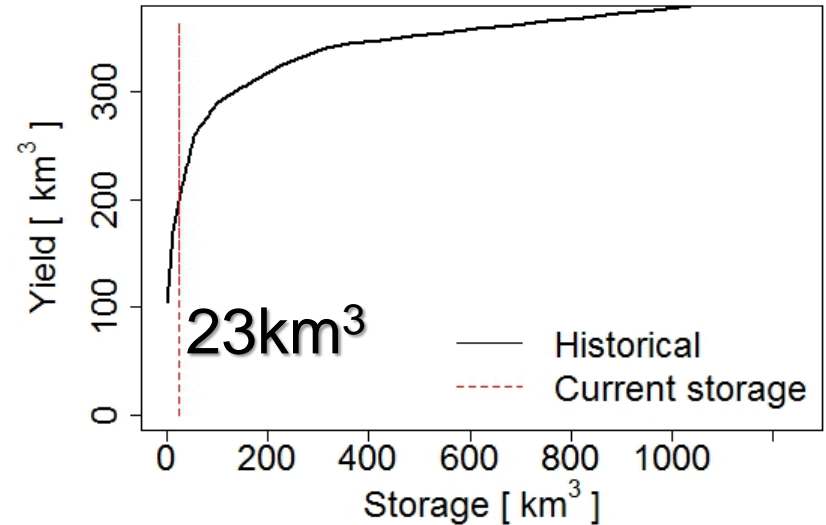


- RCP2.6
- RCP4.5
- RCP6.0
- RCP8.5

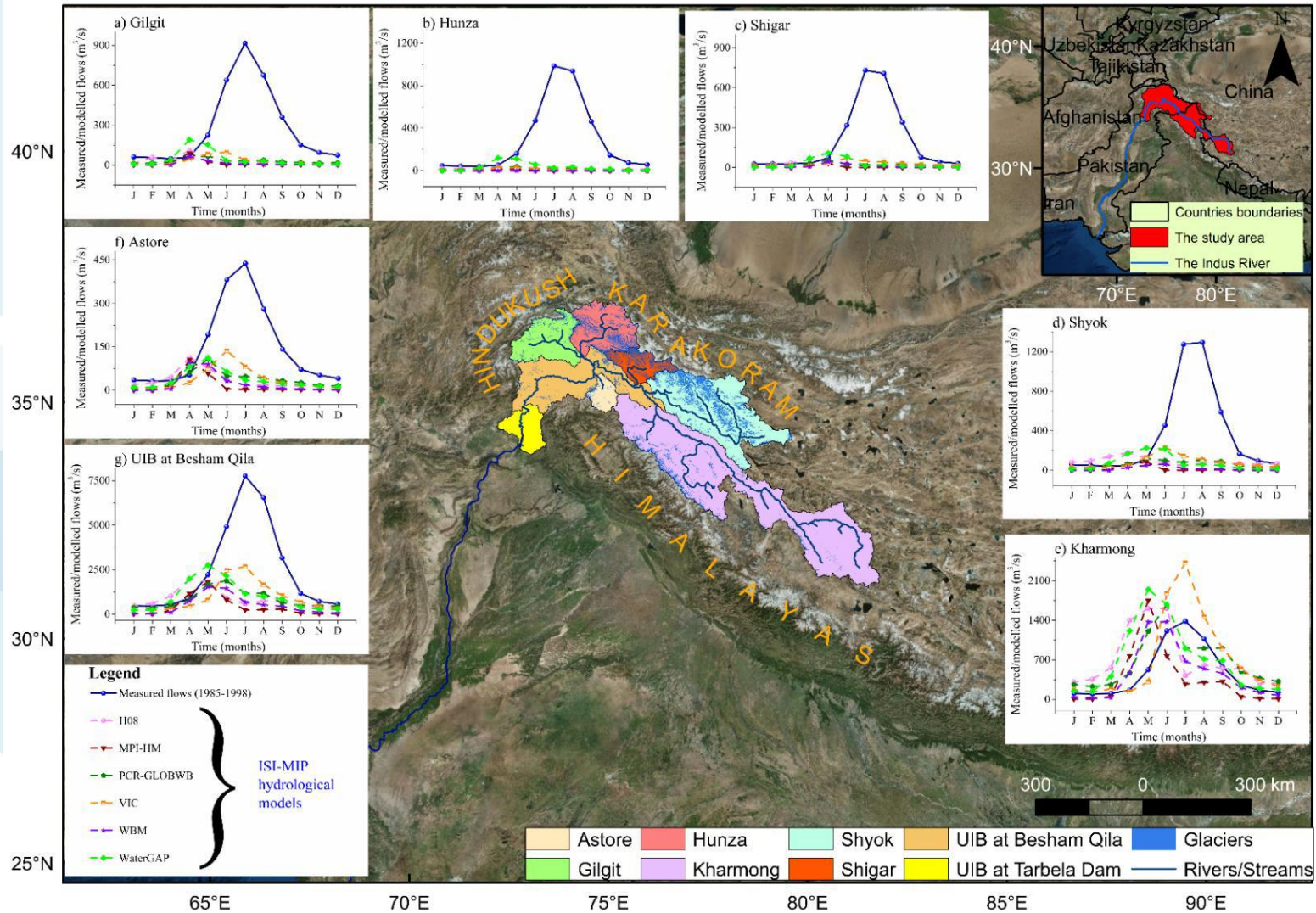
Storage-yield curves



Storage-yield curves

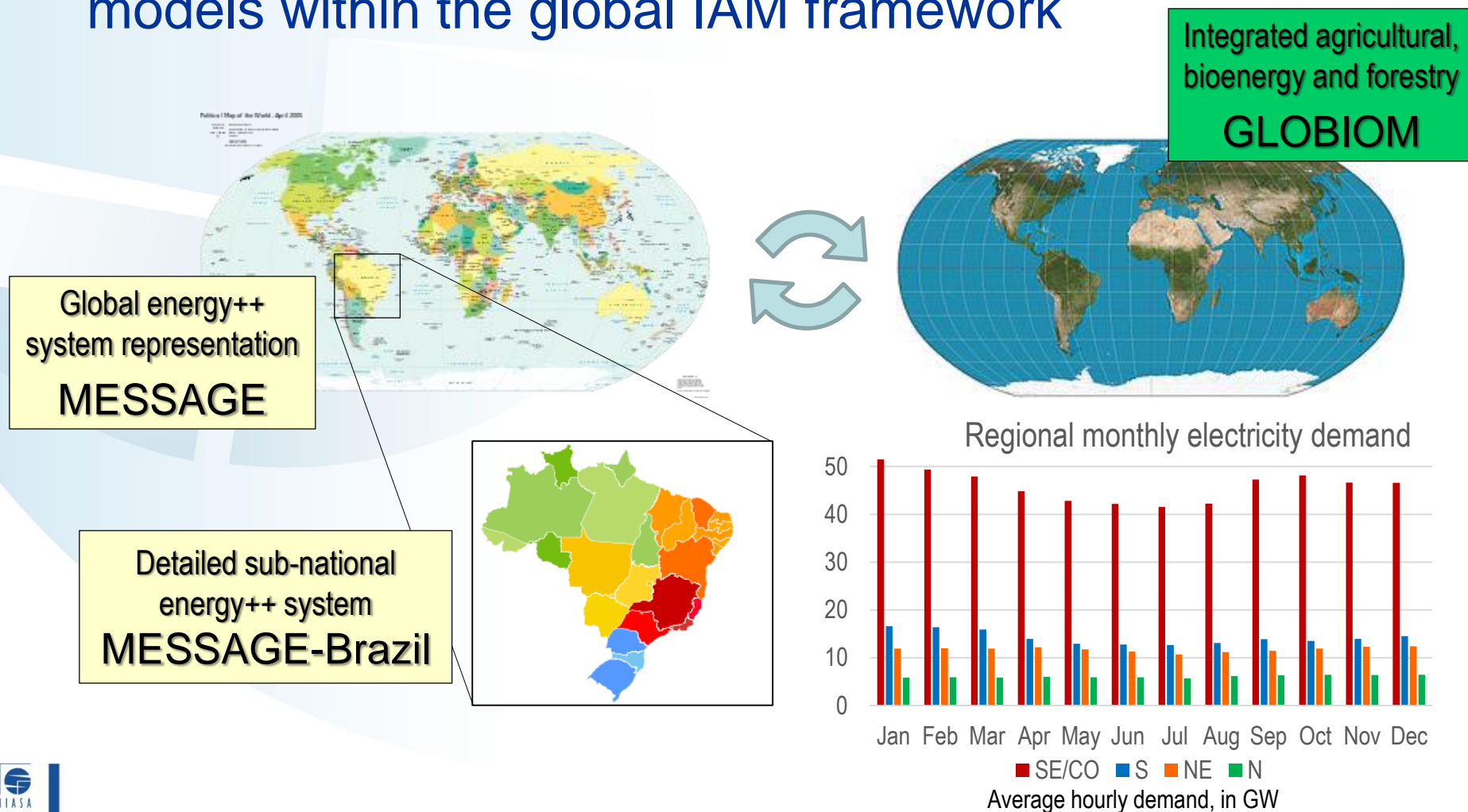


# Global ISI-MIP data vs local flow information Upper Indus Basin



# A model integration methodology

Develop “nesting” methodology of (sub-)national models within the global IAM framework

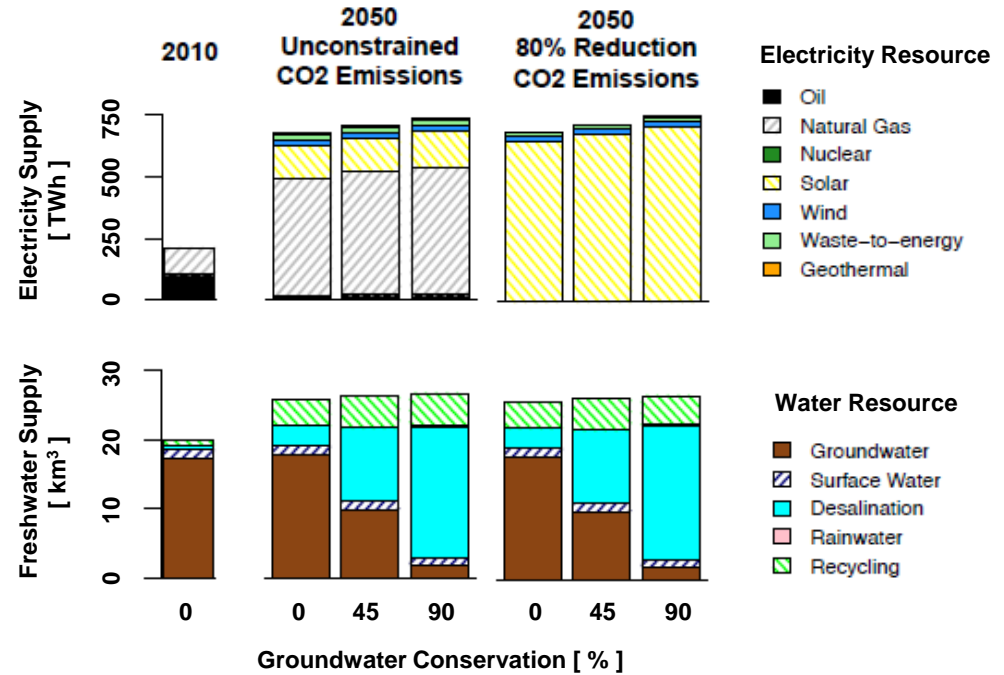
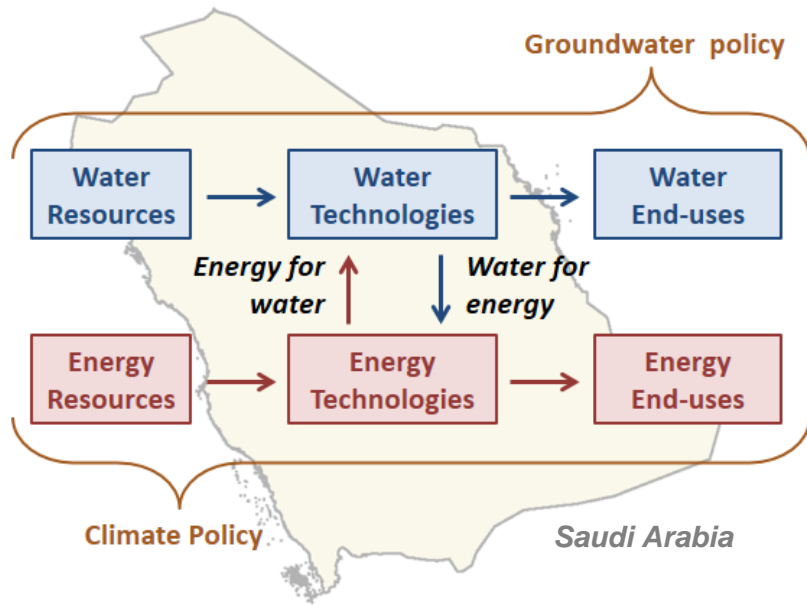




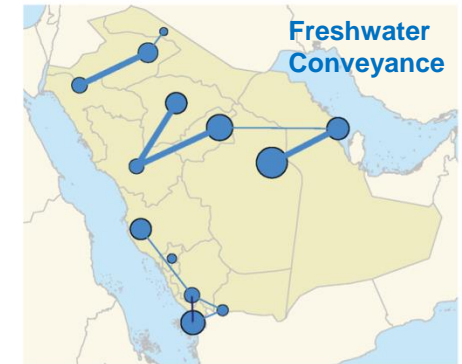
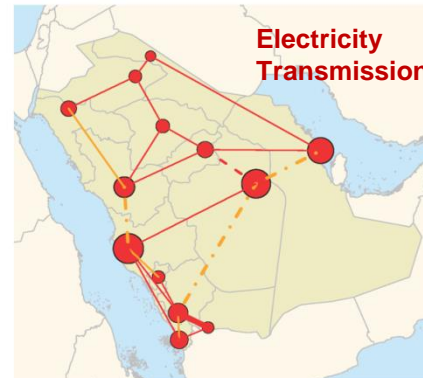
# **Systems Integration**

**(Example: water-energy nexus in Saudi Arabia)**

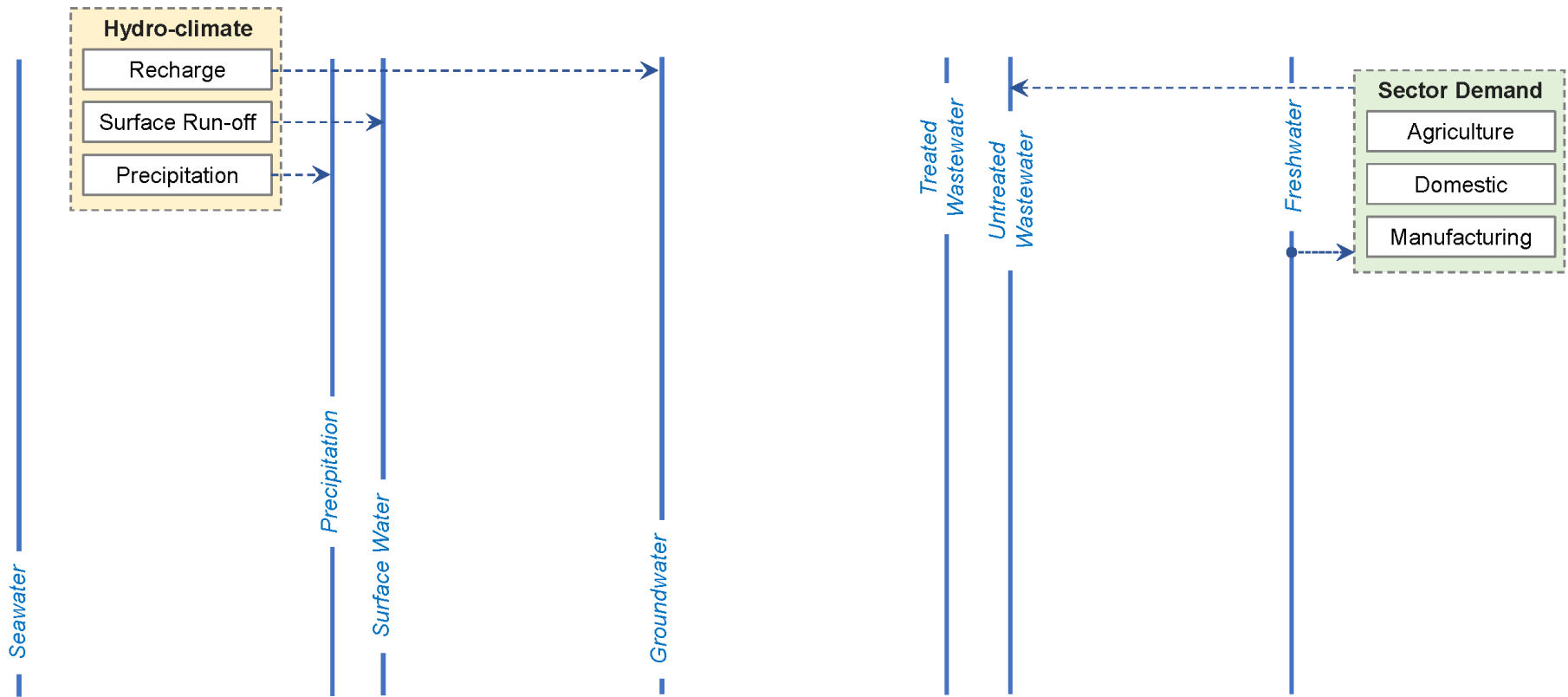
# Water constrained low-carbon energy pathways



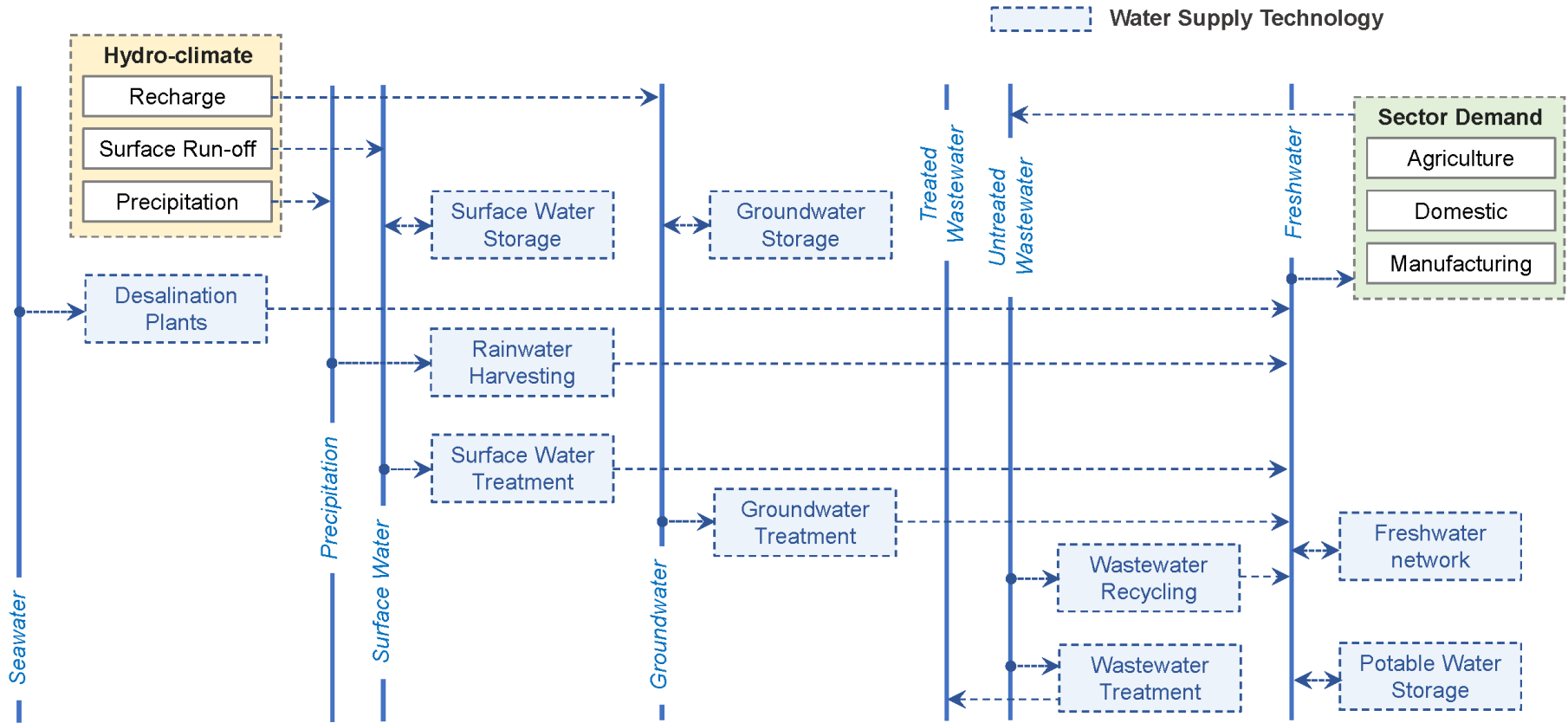
- Integrated long-term development scenarios



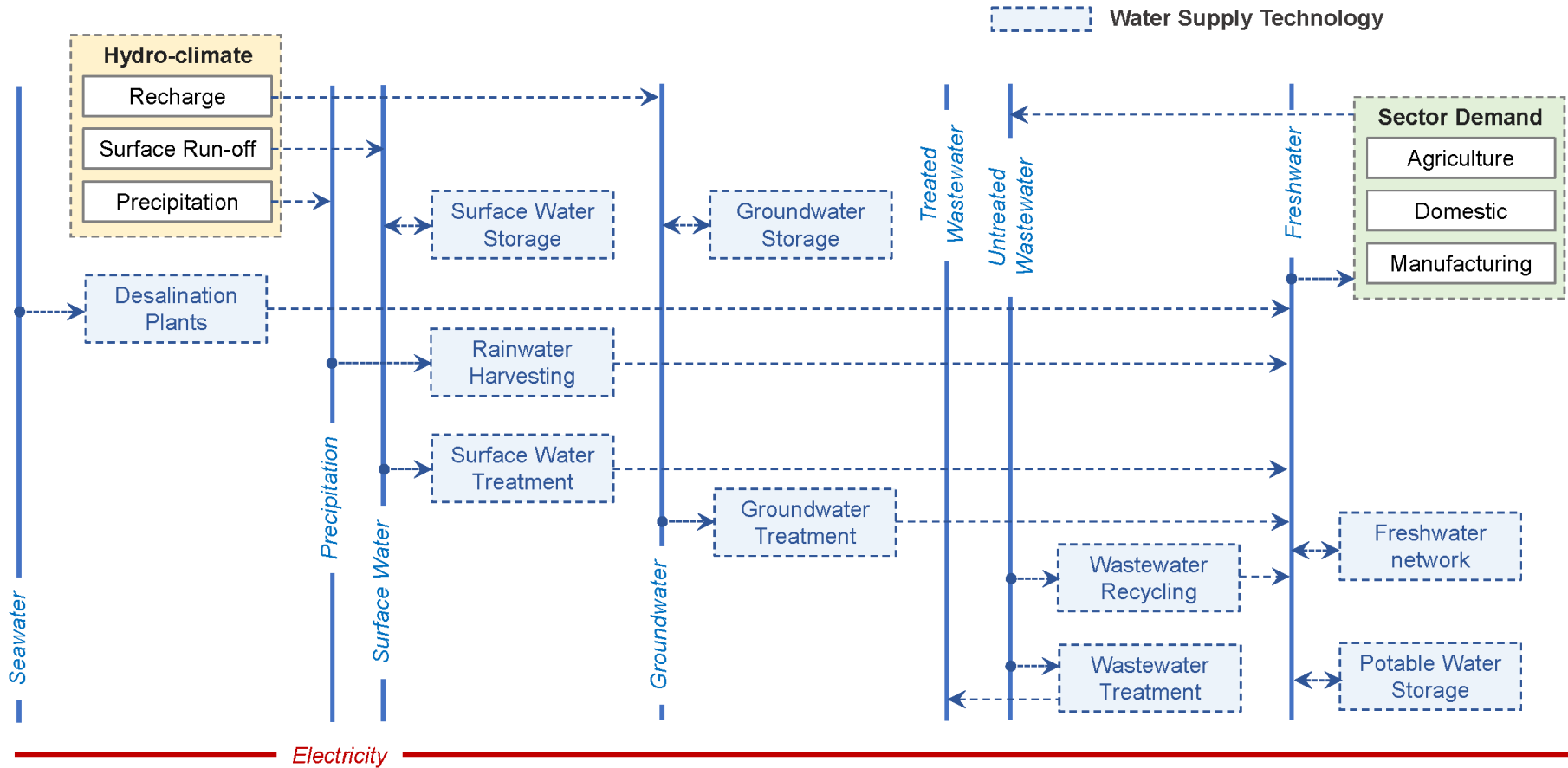
# Integrated water-energy systems modeling



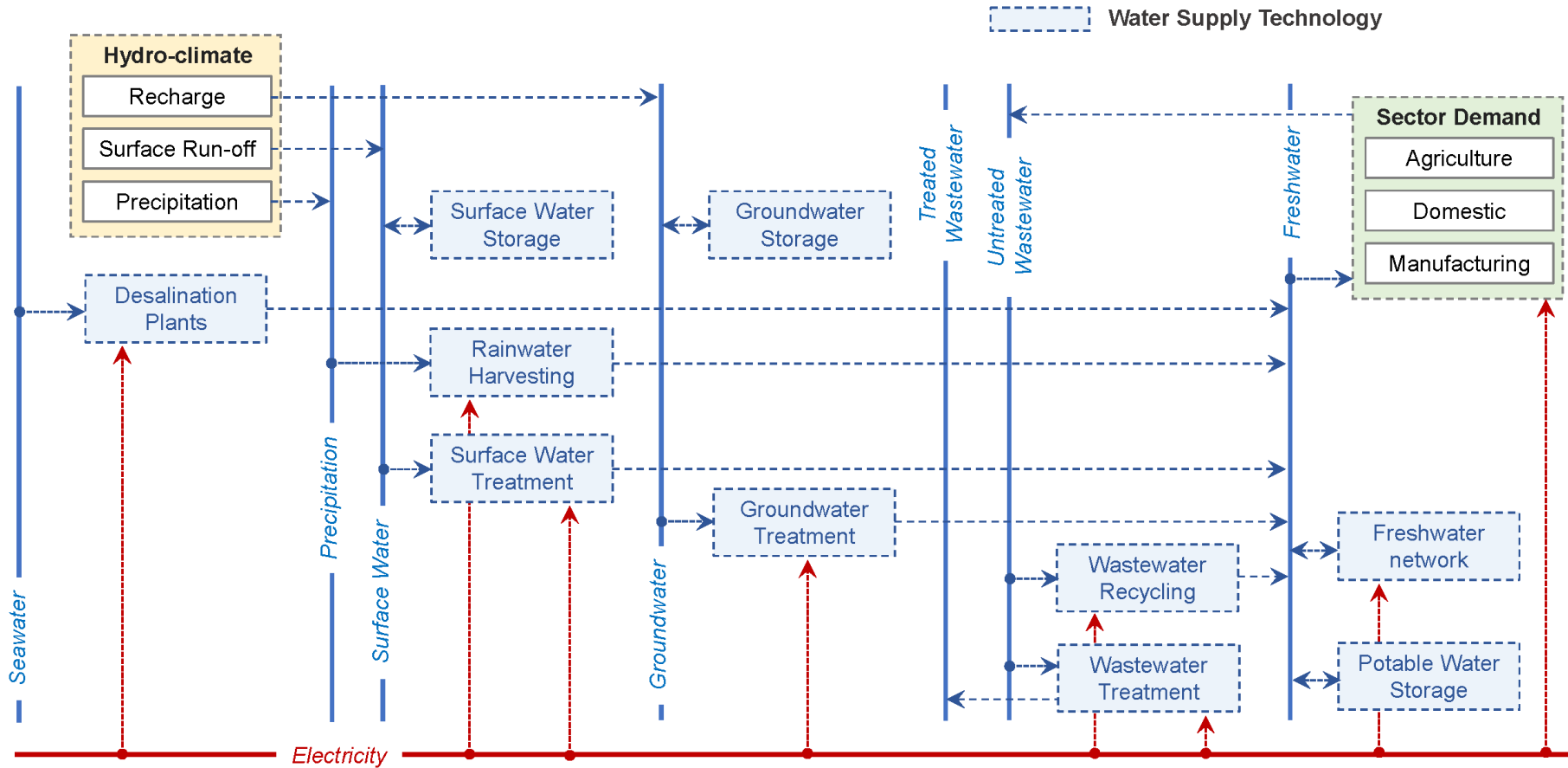
# Integrated water-energy systems modeling



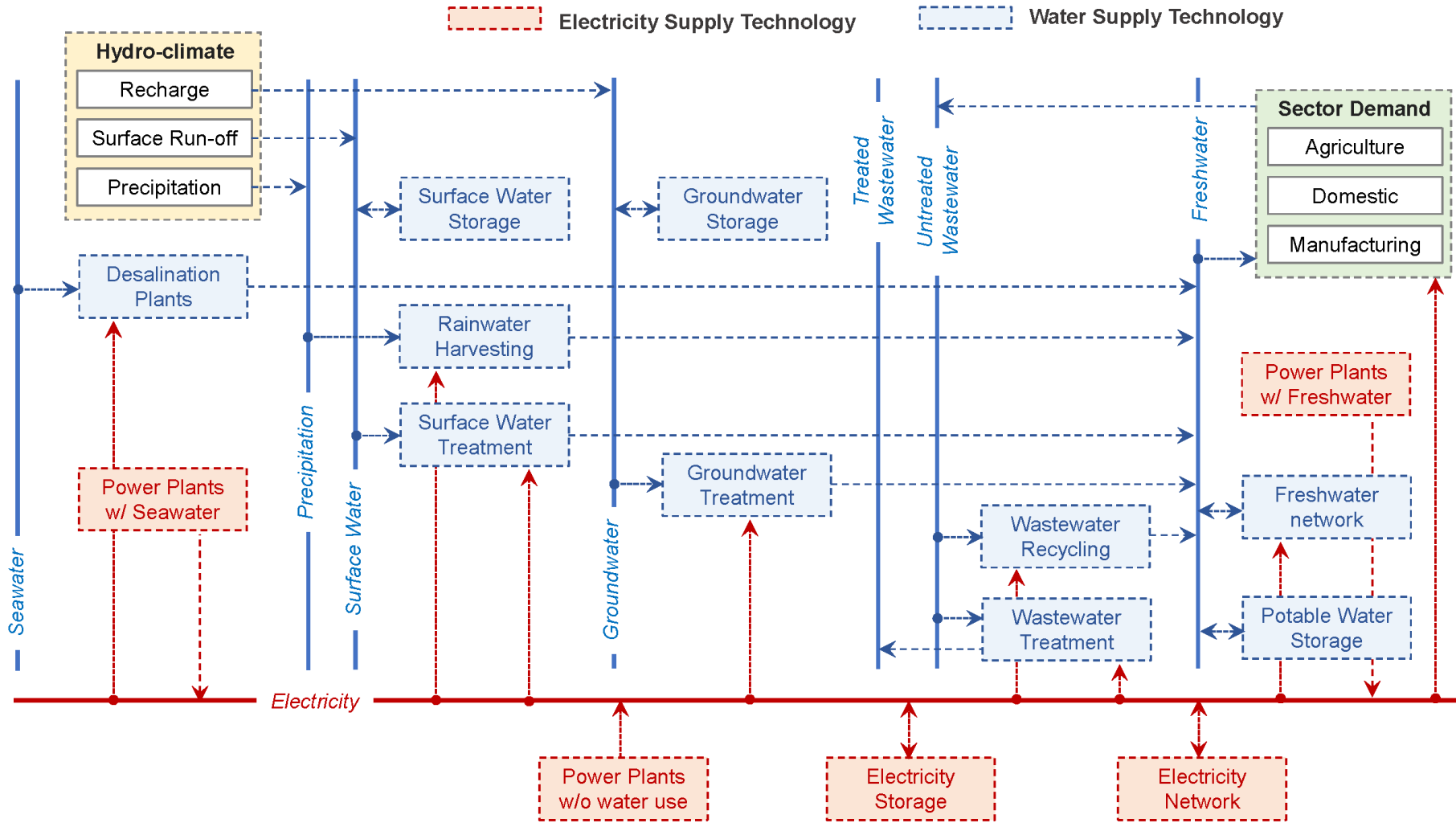
# Integrated water-energy systems modeling



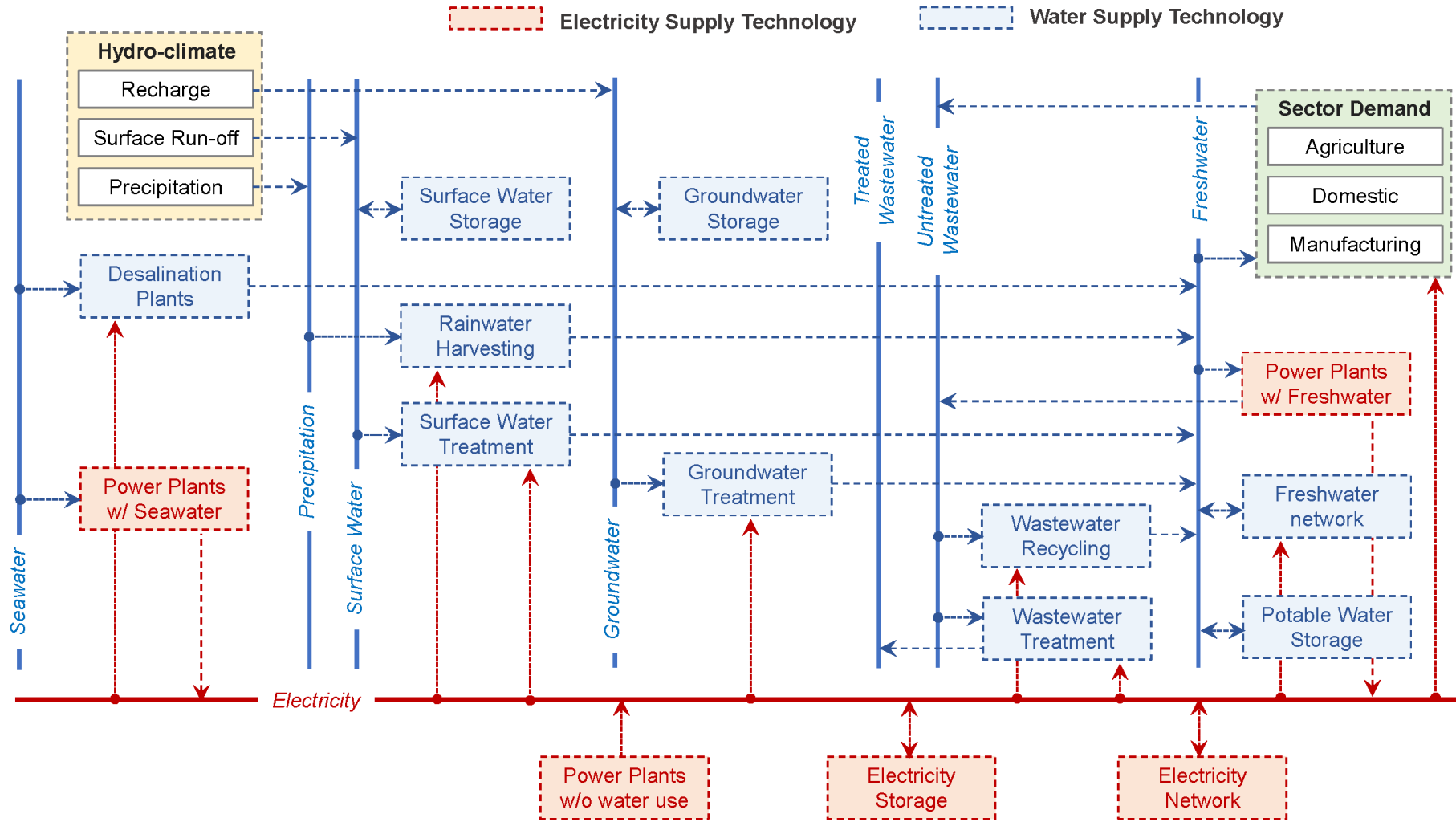
# Integrated water-energy systems modeling



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# Integrated water-energy systems modeling

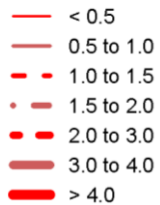




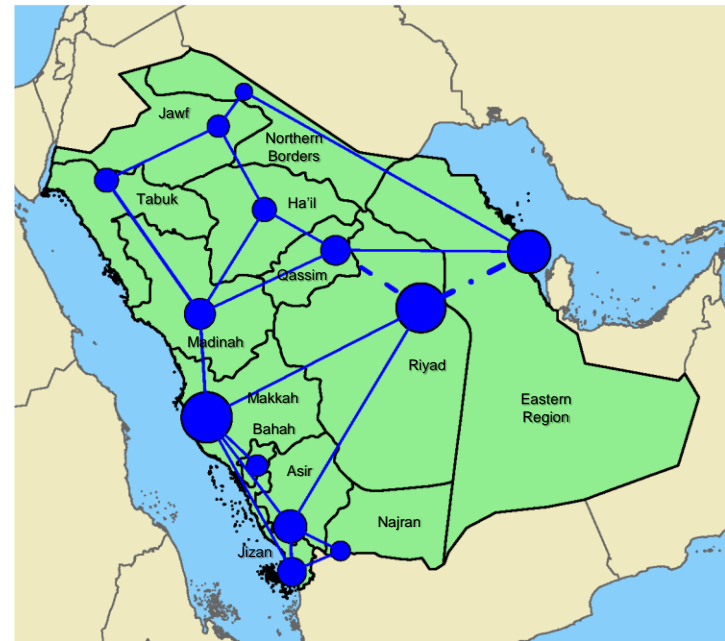
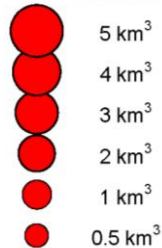
# Transmission – 2010 (base year)



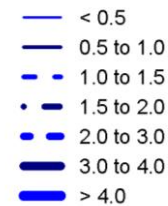
Water Transmission [ MCM / day ]



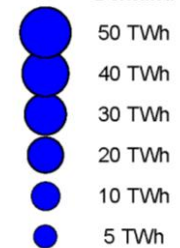
Withdrawal



Electricity Transmission [ GW ]

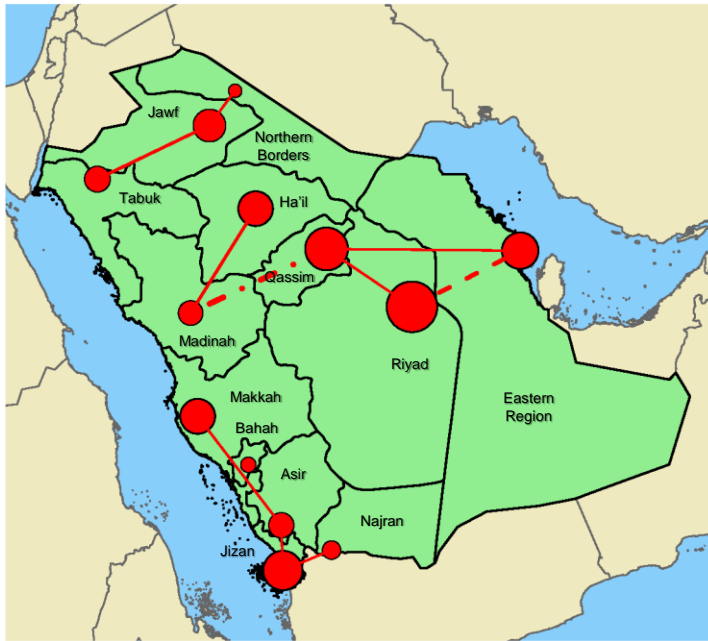


Demand

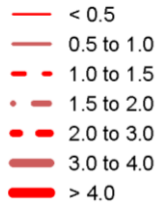


# Transmission Results – 2050

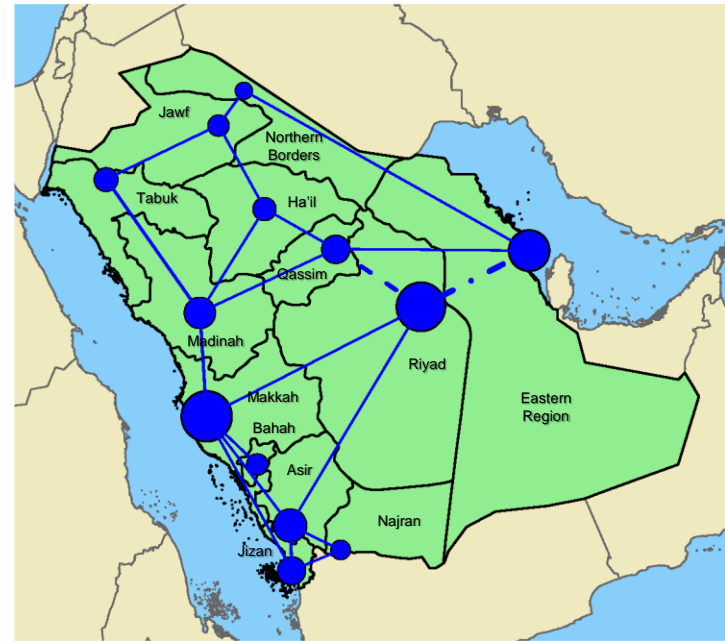
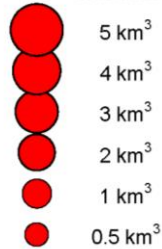
## Water and GHG baseline



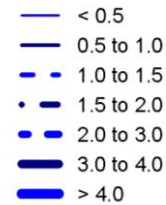
Water Transmission [ MCM / day ]



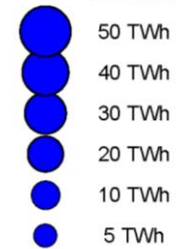
Withdrawal



Electricity Transmission [ GW ]

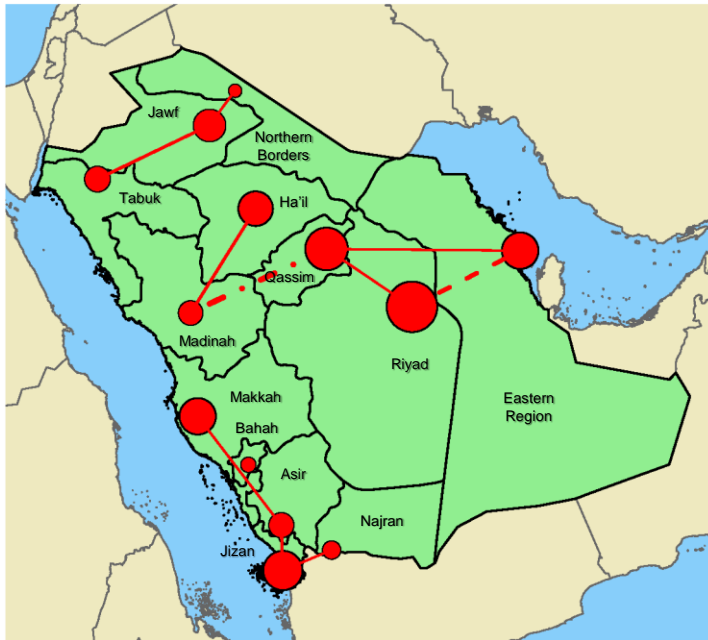


Demand

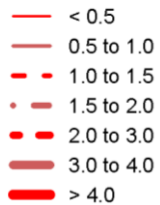


# Transmission Results – 2050

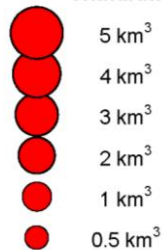
## GHG mitigation only



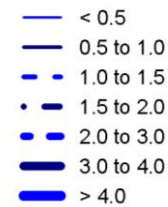
Water Transmission [ MCM / day ]



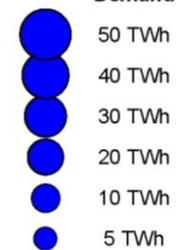
Withdrawal



Electricity Transmission [ GW ]

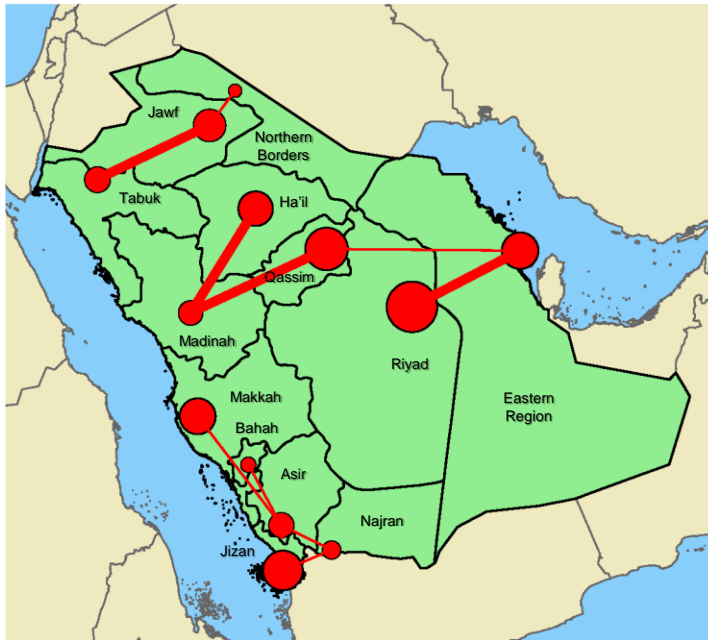


Demand

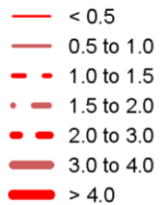


# Transmission Results – 2050

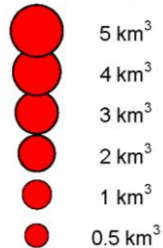
## Sustainable water management + GHG mitigation



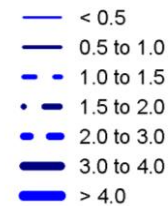
Water Transmission [ MCM / day ]



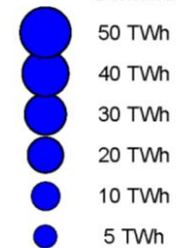
Withdrawal



Electricity Transmission [ GW ]



Demand





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science for global insight

# Thank you!



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