

Exploring the Interplay of Global Change and Socio-Biosphere Dynamics in the Yangtze Basin

System Dynamics Approach

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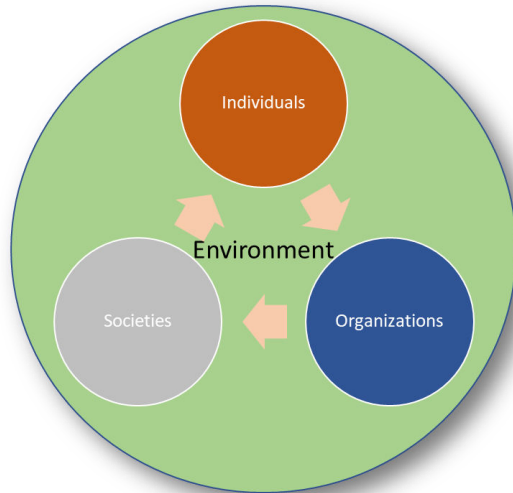
2 | GLOBAL CHANGE



- Global change
 - Population dynamics (migrations and growth)
 - Land use change (urbanization)
 - Climate change
- Infrastructure (hard)
 - Water
 - Energy
 - Transport
 - Communications
- Infrastructure (soft)
 - Institutional
 - Social
 - Cultural

Complexity

3 | SYSTEMS APPROACH



information
resources

- Addressing **COMPLEXITY**
- The systems of interest are social systems of:
 - Individuals
 - Organizations
 - Societies and
 - Environment.
- Flows connecting the subsystems:
 - Resource, and
 - Information.
- Information is used to determine resource use by subsystems.
- Values provide meaning to information flows.

new thinking

Water Resources Management: A Systems View

One would expect that "water resources management" is the management of water resources. But the language behind the concept is simpler than the complex social and ecological systems in which water resources and people that govern them live. Prof. Slobodan Simonovic explains how a systems view can make sure that we understand what it is that we are trying to manage.

Freshwater sustains life and all social and environmental processes. Yet freshwater systems are imperiled, and this threatens both human well-being and the health of ecological systems. This crisis is caused by the ways in which we mismanage water. Mismanagement is caused by a faulty

way they do. They are decision makers in their own right, with a direct role in water resources use and management. Organizations are the mechanisms people use to produce outcomes that individuals cannot produce. Organizations are structured to achieve goals. Structure defines information

resources, information and values. These connect individuals, organizations, society and environment, linking the four subsystems. Only information and resource flows link people and organisations.

Value systems – the means through which different values are attached to in-

Simonovic, *Stockholm Water Front*, 1:12, 2009

4 | ANEMI MODEL

A bit of history

- **Modification of WORLD model 2000**

Simonovic, S.P., (2002) "World Water Dynamics: Global Modeling of Water Resources", *Journal of Environmental Management*, 66(3):249-267.

- **Birth of ANEMI**

- **Ver 1 Evan Davies 2010**

Davies, E.G.R, and S.P. Simonovic, (2010) "ANEMI: A New Model for Integrated Assessment of Global Change", the *Interdisciplinary Environmental Review* special issue on Climate Change, 11(2/3):127-161.

- **Ver 2 Khaled Akhtar 2013**

Akhtar, M.K., J., Wibe, S. P. Simonovic, and J., MacGee, (2013) "Integrated Assessment Model of Society-Biosphere-Climate-Economy-Energy System", *Environmental Modelling & Software*, 49:1-21.

- **Ver 3 Patrick Breach 2020**

Breach, P.A. and S.P. Simonovic (2021) "ANEMI: A Tool for Global Change Analysis", *PLOS ONE*, 16(5): e0251489, open access <https://doi.org/10.1371/journal.pone.0251489>

- **Global Change Explorer**

- **Ver 1 Andre Schardong 2020**

Simonovic, S.P. (2023), "Global Change Explorer—A Web-Based Tool for Investigating the Complexities of Global Change". *Environ. Sci. Proc.* 25, 31. <https://doi.org/10.3390/ECWS-7-14170>

- **ANEMI_Yangtze**

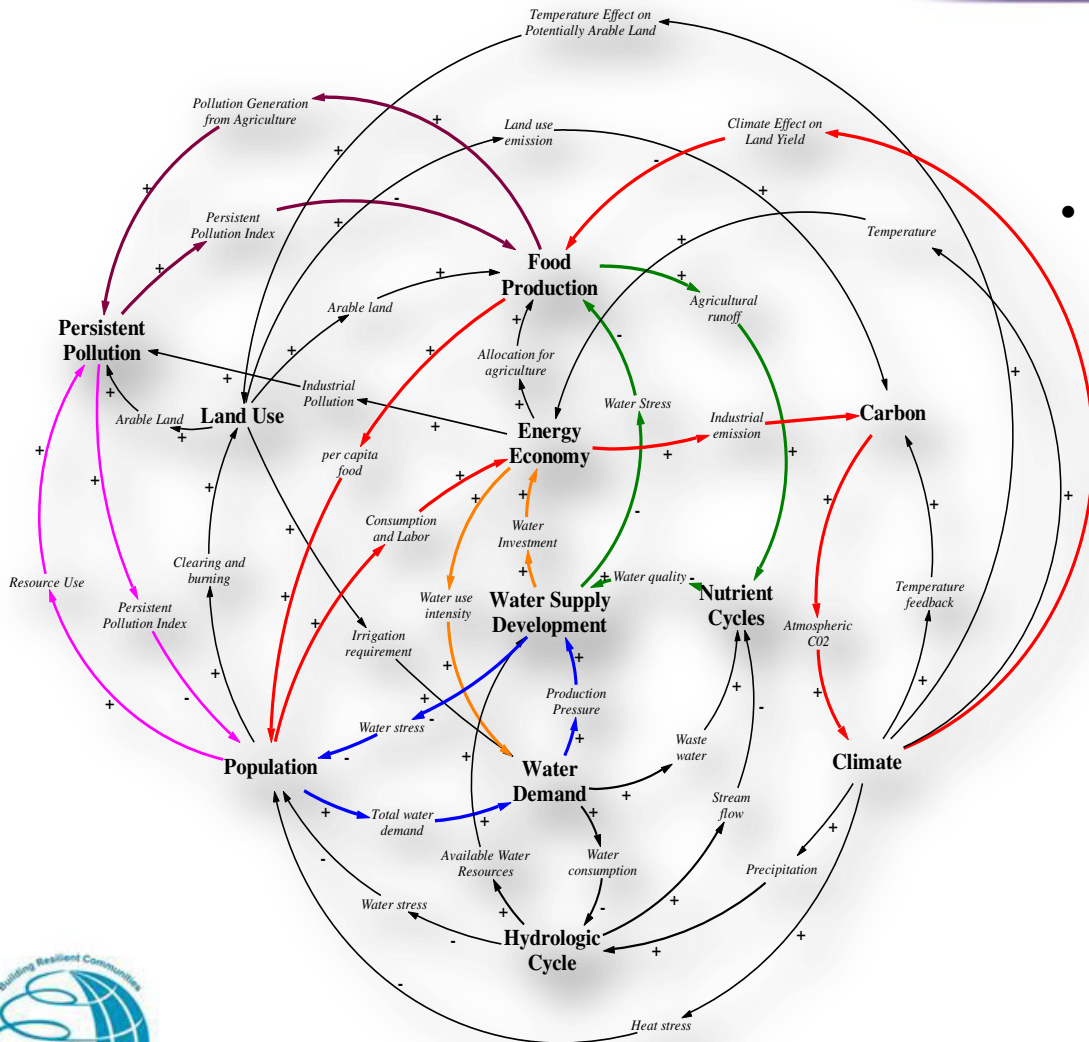
- **Ver 1 Haiyan Jiang 2021**

Jiang, H., S. P. Simonovic, and Z. Yu (2022) "ANEMI_Yangtze: An Integrated Assessment Model of the Yangtze Economic Belt - Model Description", *Geoscientific Model Development (GMD)*, 15:4503-4528, open access <https://doi.org/10.5194/gmd-15-4503-2022>



5 | ANEMI MODEL

Model structure



- 12 model sectors including
 - Climate
 - Carbon Cycle
 - Population
 - Land Use
 - Food Production
 - Sea Level Rise
 - Hydrologic Cycle
 - Water Demand
 - Energy-Economy
 - Water Supply Development
 - Nutrient Cycles
 - Persistent Pollution



Breach, P.A. and S. P. Simonovic (2020). [ANEMI 3: Tool for investigating impacts of global change](#). *Water Resources Research Report no. 108*, Facility for Intelligent Decision Support, Department of Civil and Environmental Engineering, The University of Western Ontario, London, Ontario, Canada, 134 pages. ISBN: (print) 978-0-7714-3145-6 ; (online) 978-0-7714-3146-3.

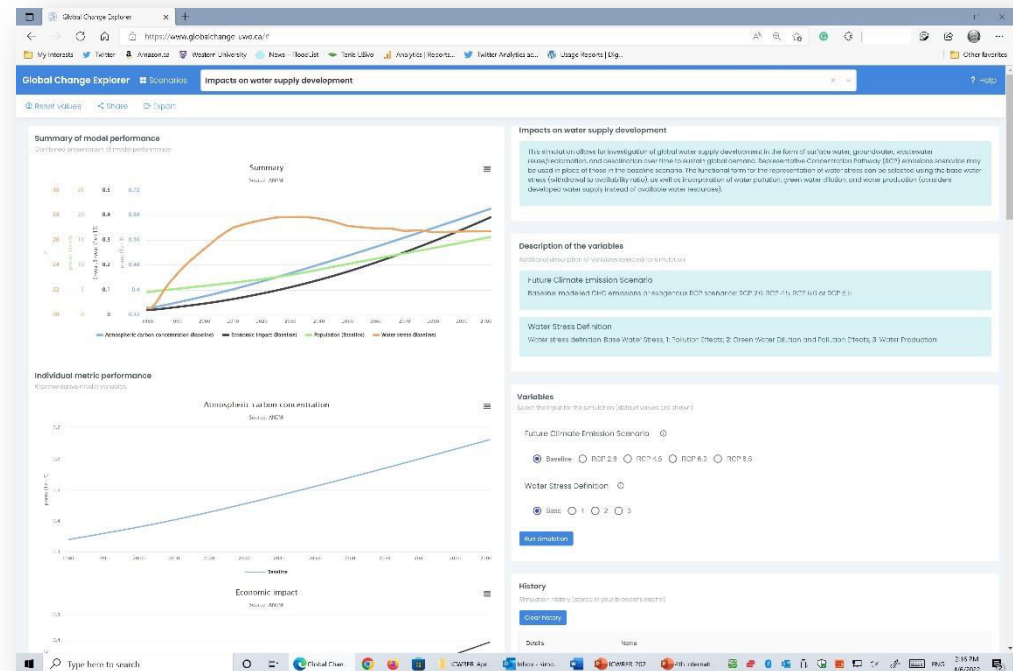
6 | ANEMI MODEL Simulations

- Experiment 1 – Climate Change Impacts
 - Water availability
 - Food Production
 - Economic Output
- Experiment 2 - Population Dynamics and Limits to Growth
 - Evaluating potential limits to growth through depletion of natural resources and pollution
- Experiment 3 – Food production
 - Evaluating climate change impacts on food production
- Experiment 4 - Water Supply Development In the Context of Global Change
 - Analyzing feedbacks between water supply development and the Earth system as well as the role of conventional vs alternative water supplies
- Experiment 5 - Water Quality Effect on Water Supply
 - Evaluating the effects of water quality on water supply development

7 | GLOBAL CHANGE EXPLORER

Web-based ANEMI

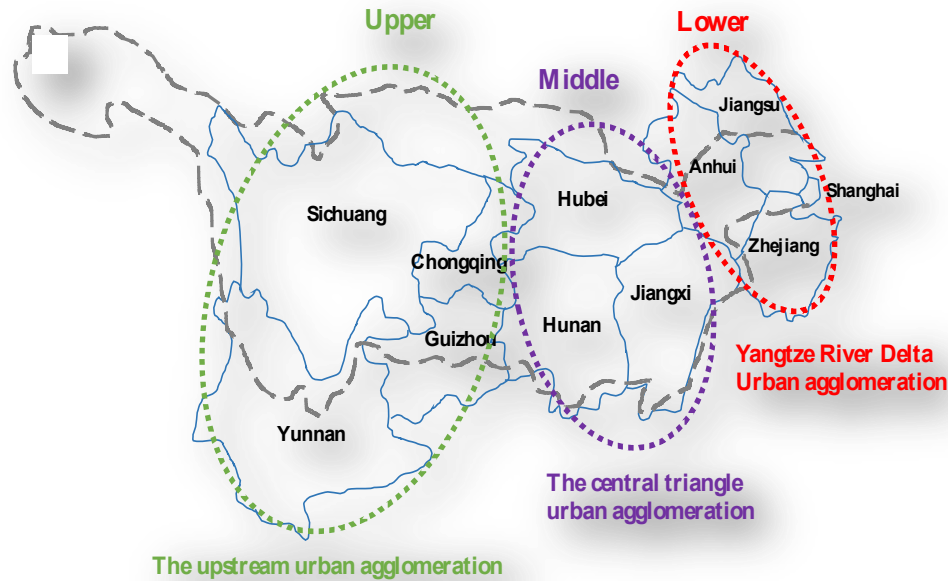
- <https://www.globalchange-uwo.ca/>
- Features
 - Preloaded scenarios
 - Pre-selected variables
 - Simplified and user-friendly interface for:
 - Modifying the pre-loaded scenarios
 - Visualization of the results
 - And exporting data
 - ANEMI model in the background



8 |

ANEMI_Yangtze MODEL

Basin-level impacts



Climate change



Energy crisis



Food security



Water pollution

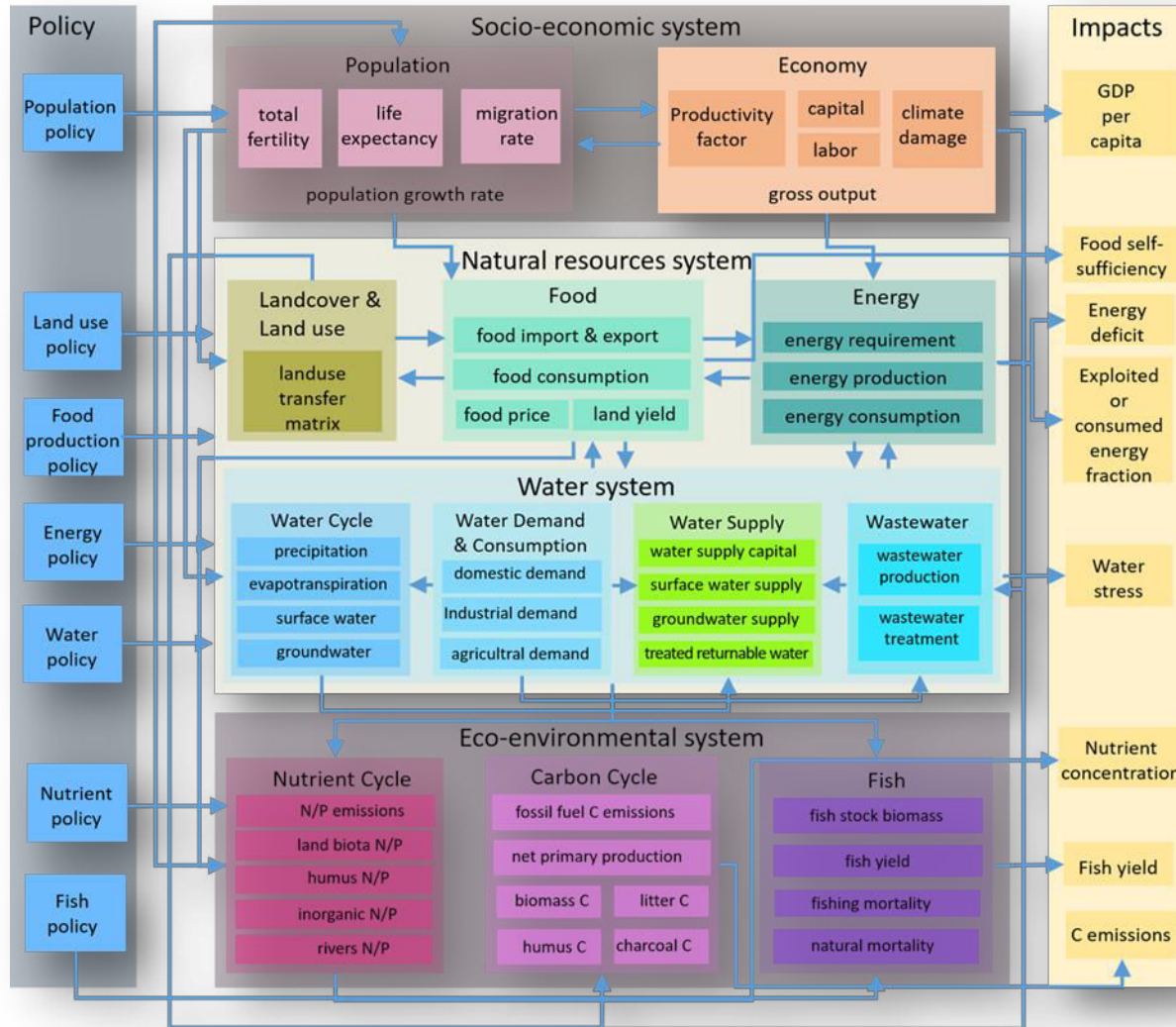


Fish depletion



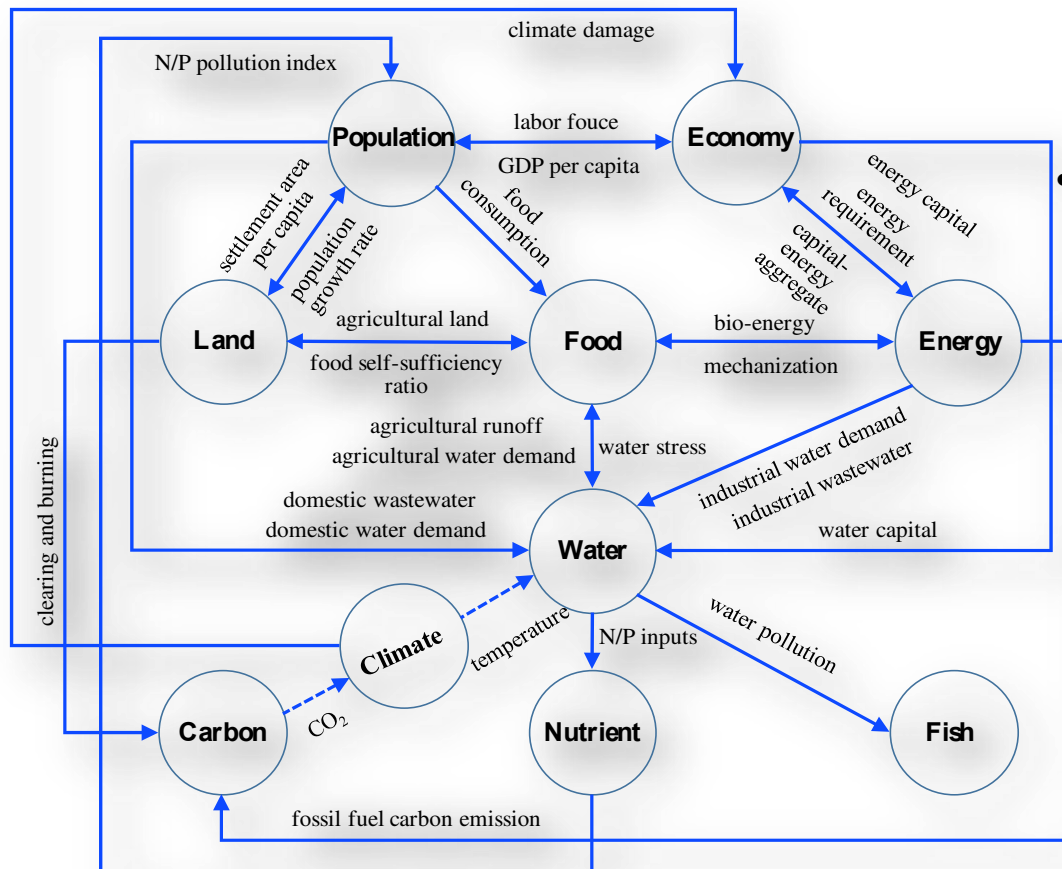
9 | ANEMI_Yangtze MODEL

Basin-level impacts



10 | ANEMI_Yangtze MODEL

Basin-level impacts



- 10 model sectors
 - Climate
 - Carbon Cycle
 - Population
 - Land Use
 - Food Production
 - **Water**
 - Energy
 - Economy
 - Nutrient Cycles
 - Fish

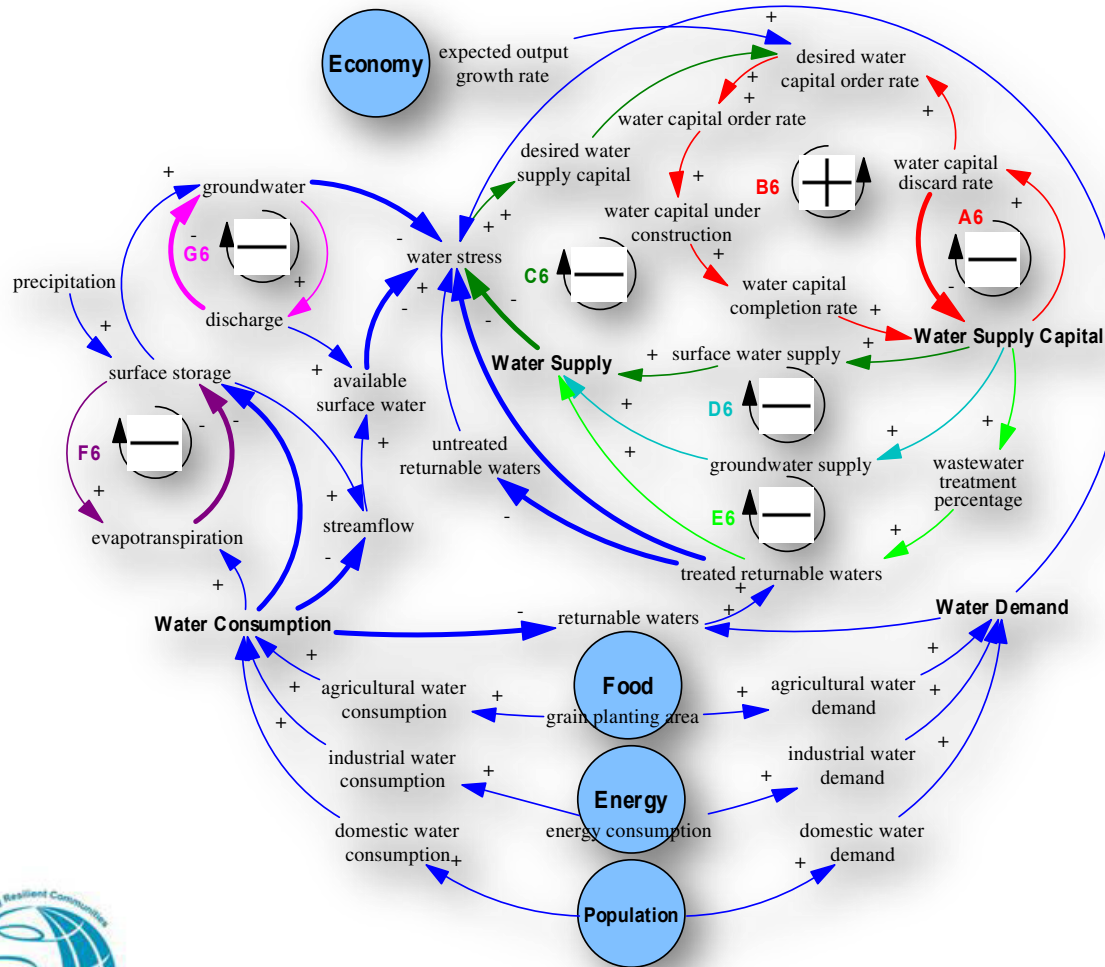


Jiang, H. and S. P. Simonovic (2021). ANEMI_Yangtze - A regional integrated assessment model for the Yangtze Economic Belt in China. *Water Resources Research Report no. 111*, Facility for Intelligent Decision Support, Department of Civil and Environmental Engineering, London, Ontario, Canada, 75 pages. ISBN: (print) 978-0-7714-3155-5; (online) 978-0-7714-3156-2.

Jiang, H., S.P. Simonovic, Z. Yu, and W. Wang (2021) "Main Challenges Facing the Sustainable Development of the Yangtze Economic Belt and Its Implications for Global Emerging Economies", *Environmental Research Communications*, 3(11) 115005, open access <https://iopscience.iop.org/article/10.1088/2515-7620/ac35bd>

11 | ANEMI_Yangtze MODEL

Basin-level impacts



- **A6** – depreciation of water supply capital
- **B6** – counteracts the effects of depreciation
- **C6, D6, E6** – impact on water stress by investment in water supply
- **F6** – movement of water (precipitation and evaporation)
- **G6** – effects of discharge on groundwater

12 | ANEMI_Yangtze MODEL

Simulations

- S_base scenario
 - Current policy investigations (one-child policy; no fishing ban; N/P removal efficiency = 0)
- S_climate scenarios (2)
 - Impacts of future climate under RCP 4.5 and RCP 8.5
- S_population scenarios
 - Impacts of two-child and three-child policies
- S_ecoenvironment scenario
 - Evaluation of increased N/P removal efficiency (0 to 0.6 for N; 0 to 0.7 for P)
 - Fish ban 2, 5, and 10 years
 - Fish mortality 0.6 and 0.7

13 | ANEMI_Yangtze MODEL

Basin-level findings

- Climate change
 - No significant increase of water stress (industrial demand >> agricultural demand)
 - Under RCP4.5 impacts on food, economy and energy limited
 - Under RCP8.5 impacts are harmful
- Population policy
 - Population peaks around 2030, 2080, and 2100 under the one-, two- and three-child policies
 - GDP per capita drops
 - Serious energy deficit
 - Food self-sufficiency ratio falls from 0.7 to 0.39 by 2100
 - Water scarcity (if surface water is considered as the only source) and increase of water pollution
 - Use of groundwater and wastewater reuse greatly reduce the water stress
- Ecoenvironment policy
 - Increased nutrient removal can save million of lives
 - Overfishing is the most critical and even 10 yr ban can not prevent fish stock depletion

14 | RESOURCES

Availability

- ANEMI
 - Model and technical documentation available to public
 - <https://zenodo.org/record/4025424>
 - <https://github.com/FIDSUWO/anemi>
- Global Change Explorer
 - <https://www.globalchange-uwo.ca/>
- ANEMI_Yangtze
 - <http://doi.org/10.5281/zenodo.4764138>
- Model developed in Vensim system dynamics simulation tool
- <https://vensim.com/>

15 | RESOURCES

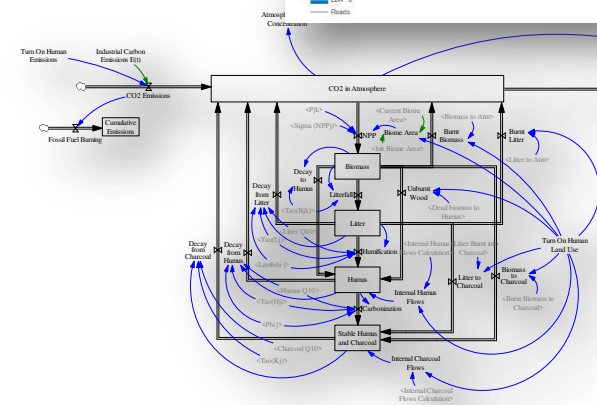
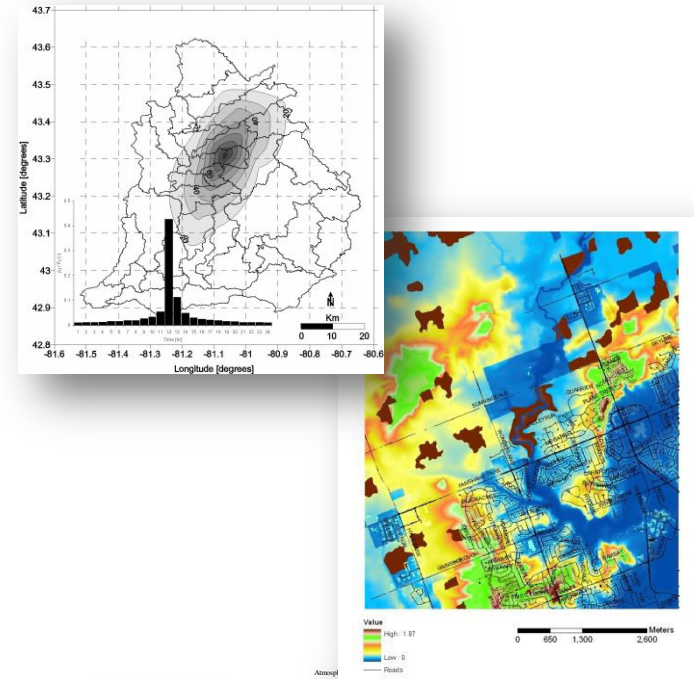


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www.slobodansimonovic.com



- Research:
 - *Subject Matter* - Systems modeling; Risk and reliability; Water resources and environmental systems analysis; Computer-based decision support systems development.
 - *Topical Area* - Reservoirs; Flood control; Hydropower energy; Operational hydrology; Climatic Change; Integrated water resources management.
- 75 research projects
- 12 visiting fellows
- 21 PosDoc
- 24 PhD and
- 45 MESC



17 | Slobodan P. Simonović Publications



- ~ 620 professional publications
- 272 in peer reviewed journals
- 3 major textbooks

- Water Resources Research Reports 117 volumes – <https://ir.lib.uwo.ca/wrrr/>
- > 115,000 from 189 countries downloads since 2011

