Extended Continental-scale Hydroeconomic Optimization model (ECHO)

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Towards Innovative Solutions through Integrative Water Futures Analysis

East Africa Future Water Scenarios to 2050
Entebbe, 4 Dec 2018
Water management options to support future socio-economic growth under a changing climate

Many options are available: efficiency; recycling; reservoir expansion, desalination, etc.

What option is best to implement, where and when? How much will it cost?

There is a need for a tool that is able to identify the least-cost, sustainable and robust combination of options.

Source: Wada et al, 2014
ECHO modeling framework

**Economic Optimization**
- Minimize Total Investment and O&M Costs of Water Management Options over all BCUs for the Period 2010-2050
- subject to:
  - Resource Constraints
  - Technical Constraints
  - Policy Constraints

**Optimal Solution**
- Spatially Explicit Information on the Least Cost Combination of Water Management Options to Balance Water Supply and Demand at the BCU Level

**Climate Forcing Data**
- RCPs
  - Temperature, Precipitation, etc.

**Network Identification**
- Linkage Between BCUs

**Hydrological Futures**
- Runoff, Discharge, Groundwater Recharge, etc.

**Basin Country Units (BCUs)**
- Assessment of Existing Capacity of Management Options
  - Several Methods
    - Global Sectoral Models, Econometric Models, Previous Studies, etc.

**Future Sectoral Water demands**
- Agriculture, Domestic, Manufacturing and Electricity

**Socio-economic Developments**
- SSPs
  - GDP, Population Growth, etc.

**Economic and Performance Parameters of water management options**
- Investment costs, O&M costs, Water Efficiency, Electricity Intensity, etc.
ECHO key principles

ECHO optimization model:

• economic objective function
• representation of the most relevant biophysical and technological constraints of water systems

ECHO objective function:

• minimizes the total investment and operating costs
• wide variety of water management options
• long-term planning horizon (e.g., a decade or more),
• all sectoral water demands across sub-basins

Starting from existing facilities, towards projections of the infrastructure capacity and activity/efficiency levels of various water management options
ECHO includes representations of **essential biophysical** and **technological features** at the sub-basin level:

- **various water supply sources** (surface water, groundwater, and non-conventional water such as recycled wastewater),
- **sectoral demands** (irrigation, domestic, manufacturing, and electricity), and
- **infrastructure** (surface water reservoirs, desalination plants, wastewater treatment plants, irrigation systems, and hydropower plants)
Multi-scale modeling incorporating basin-level decision making

Flow accumulation + Sub-basin units → Network
## Water management options included in ECHO

<table>
<thead>
<tr>
<th>Supply enhancement</th>
<th>Demand management</th>
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<tbody>
<tr>
<td>Build/enlarge dams</td>
<td>Efficient irrigation technologies (shifting from flood to sprinkler or drip irrigation)</td>
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<tr>
<td>Renewable groundwater pumping</td>
<td>Improving conveyance efficiency (e.g., canal lining, automated canal infrastructure)</td>
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<td>Reuse of wastewater</td>
<td>Efficient domestic water appliances</td>
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<td>Intra-basin transfer</td>
<td>Better crop management (e.g., laser land leveling, deficit irrigation, mulching, improved crop varieties)</td>
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<tr>
<td>Options</td>
<td>Electricity intensity (KWh/m³)</td>
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<tr>
<td><strong>Supply-side options</strong></td>
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<td>Surface water diversion</td>
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<td>Groundwater pumping</td>
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<td>Desalination</td>
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<td>Recycling</td>
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<td>Surface water reservoirs</td>
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<td><strong>Demand-side options</strong></td>
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<td>Sprinkler irrigation</td>
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<td>Drip irrigation</td>
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<tr>
<td>Improved irrigation management</td>
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<tr>
<td>Improved domestic and manufacturing management</td>
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</table>
Spatially-explicit existing capacity of water management options
ECHO model outputs

Optimal combination of water management options

Projections of water withdrawals by sector

Investment and operating costs

Projections of water withdrawals by source
Half our planet’s population still suffer from water insecurity

Absent/unreliable water supply

Poor sanitation

Floods & droughts

Poor irrigation and food production