IMPACT Model and Extensions

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EXTENSIONS OF THE IMPACT MODEL

- Increased modularity in model structure
- Water quality and other environmental indicators
  - Green and blue water footprints
  - Nitrogen and phosphorus loading
  - Carbon stocks
  - Species risk of extinction and endangerment
- Land use change
- Nutrition
- IMPACT-CGE linkage
- Open Sourcing

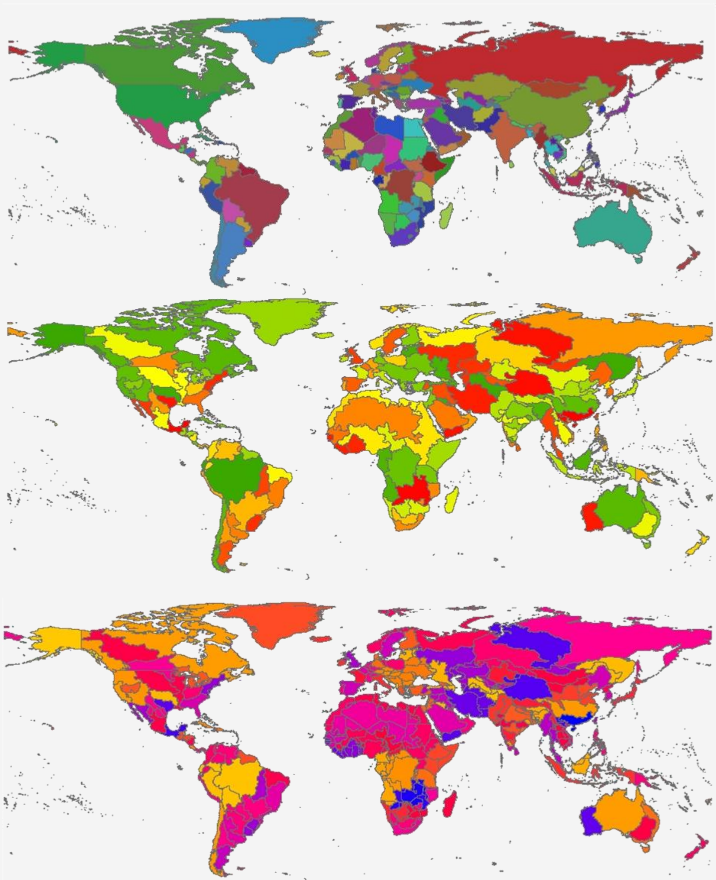
IMPACT 3 MODEL SYSTEM

1. Data estimation and management program
2. IMPACT 3 partial equilibrium multimarket global economic model
3. Linked modules/models
4. Simulation specification and execution program
5. Simulation output processing programs

IMPACT 3 SUITE OF MODELS

- Global multimarket model (core IMPACT)
  - Crop production, demand, international trade
- SPAM: Spatial Production Allocation Model
- Land-use model
- DSSAT Crop Models
- Malnutrition model
- Welfare module
- Water models
  - Hydrology
  - Water Basin Management
  - Water Stress on economy
- Sugar and oilseeds
  - Value chain: crops to processing activities
- Livestock/meat/dairy
- Links to GCM climate models

IMPACT 3 GEOGRAPHY



- 159 — Countries
- 154 — Water Basins
- 320 — Food Production Units

MODULARITY: INTERDISCIPLINARY WORK

- Modules can be discipline specific
  - May run on different time steps than the core model or other modules
  - Draw on disciplinary expertise, and do not require compromises to fit "inside" a model from another discipline. Can be validated at the discipline level.
  - E.g. water models linked to IMPACT
- How coordination is managed across modules and with the core model is crucial

DESIDERATA FOR **MODULAR MODEL SYSTEMS**

A “module” should be designed to:

- Read its own parameters;
- Initialize its own variables;
- Accept variables passed to it from other modules and the environment;
- Pass variables that are computed within the module to other modules or the main model;
- Own its set of state variables;
- Operate in “stand-alone” mode

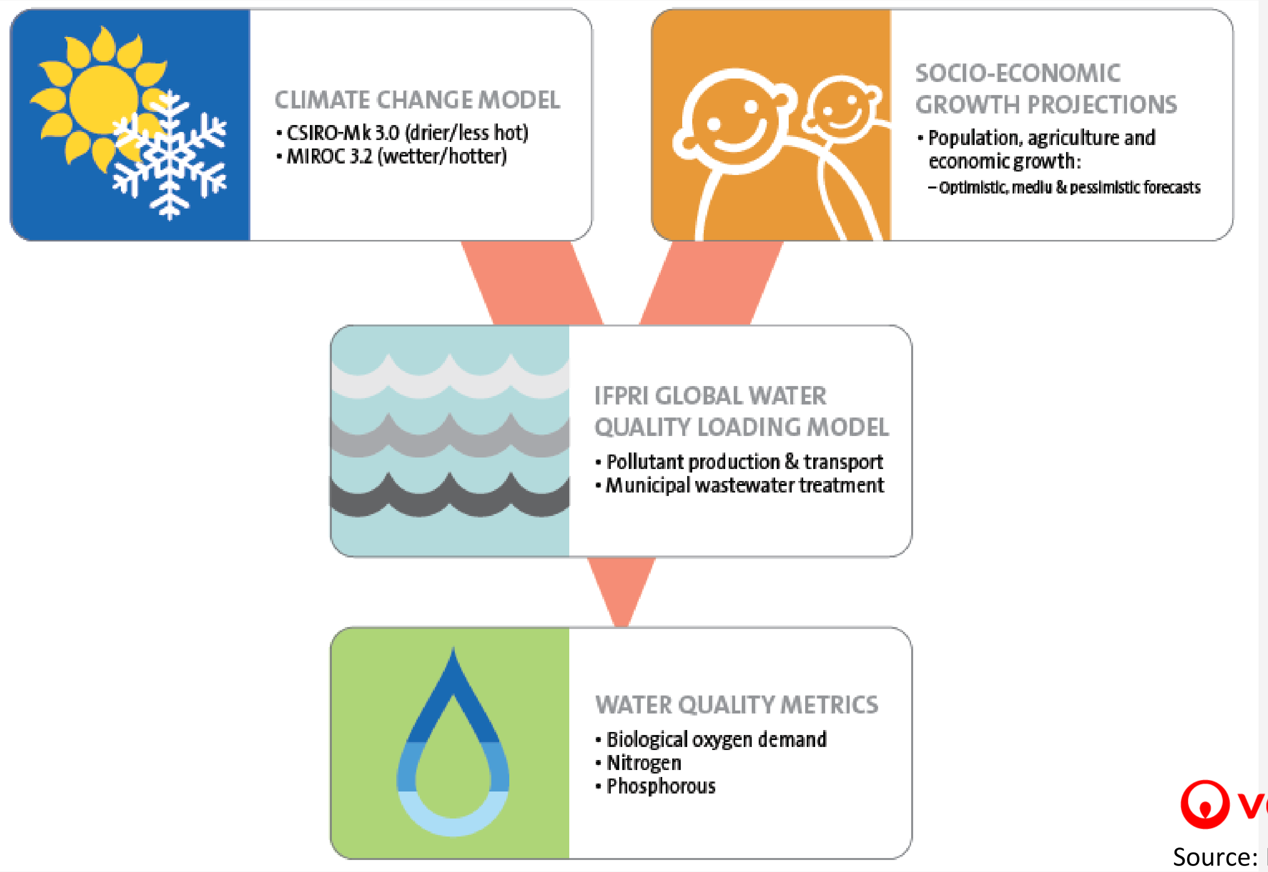
MODULARITY: LINKING MODULES

- Modularity = "a la carte" model system
  - Use the models you need, turn off those you do not need
  - Separate models can be run independently
  - Modules can run on different time steps
- Standardize data transfer
  - Information Flows
  - Dynamic or Iterative interaction
- "Data driven" model specification
  - IMPACT model can be run at any level of aggregation without changing the model code
  - Change input data and sets only: user need not even see the GAMS code

MODULARITY: LINKING MODULES

- Three ways to link modules:
  1. Exogenous: Information flows in one direction
     1. Hydrology, DSSAT, GCMs, SPAM ➔ IMPACT
     2. IMPACT ➔ Welfare, nutrition modules
  2. Linked dynamically: Two-way information flow between years
     1. Water stress on crops, **water quality**
     2. **Land use change**
  3. Endogenous: Module equations are solved simultaneously
     1. Livestock, sugar processing, oilseeds/oils
     2. Land allocation to crops

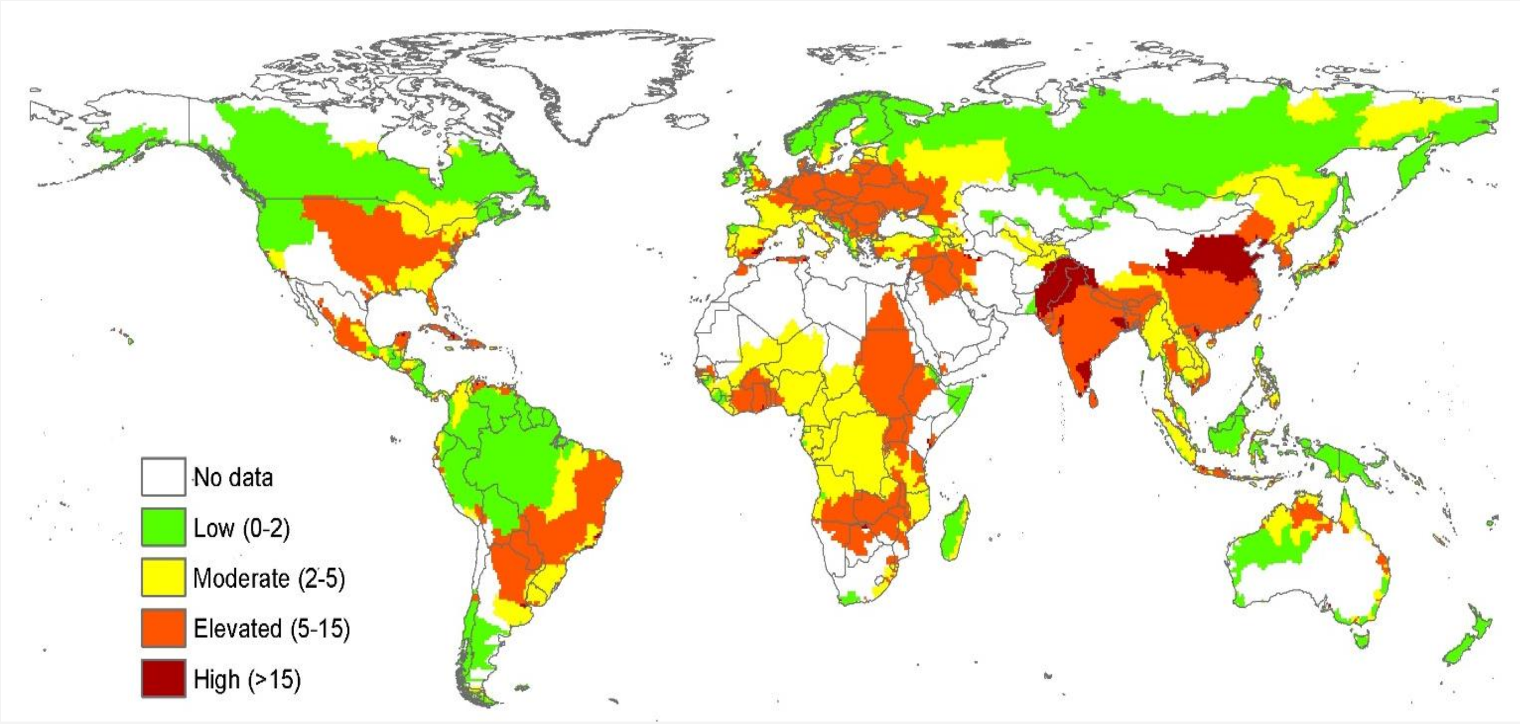
WATER QUALITY MODELING SCHEMATIC



VEOLIA

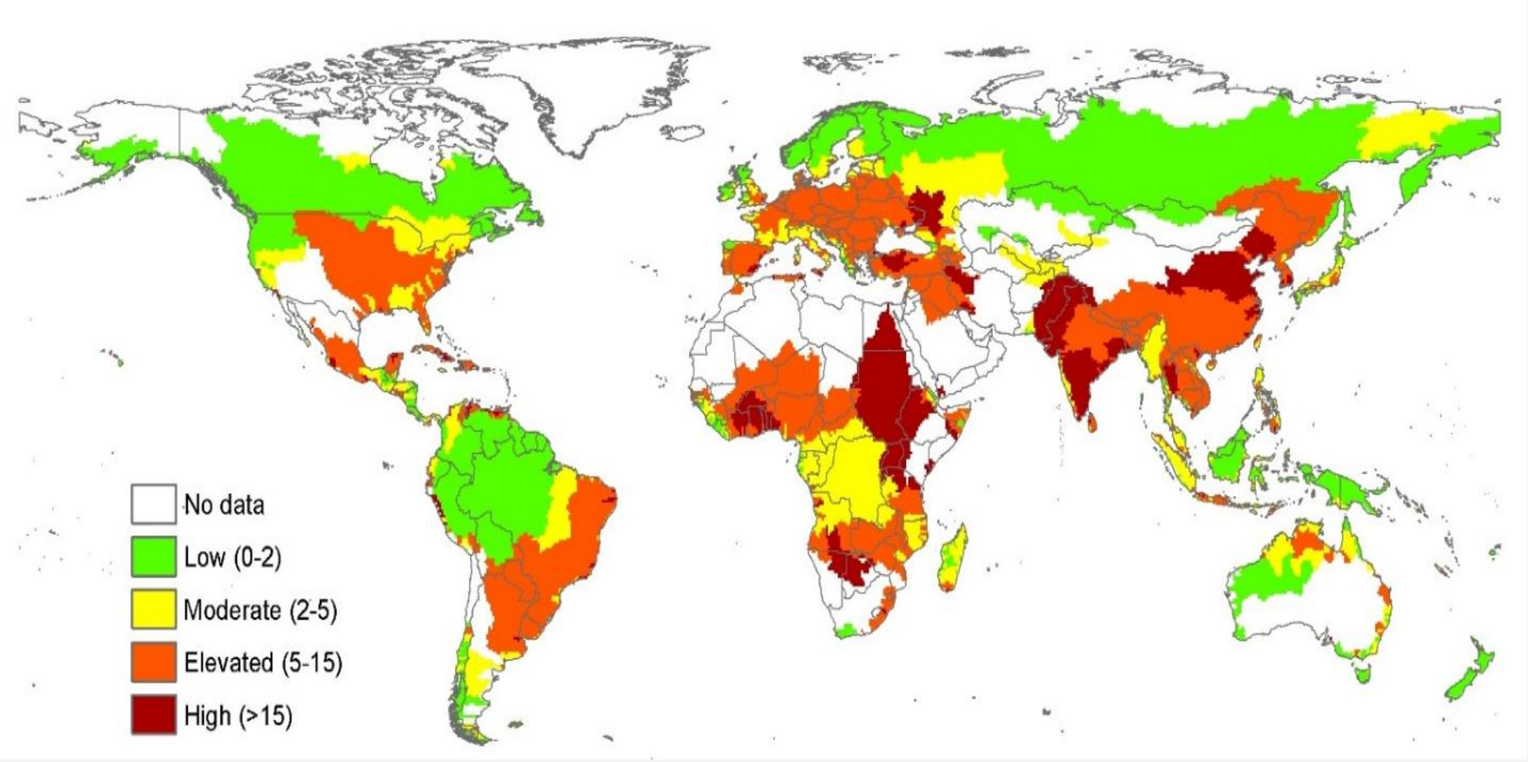
Source: IFPRI-Veolia (2015).

Water quality risk indices related to nitrogen pollution for major river basins of the world in the base period



Source: IFPRI-Veolia (2015).

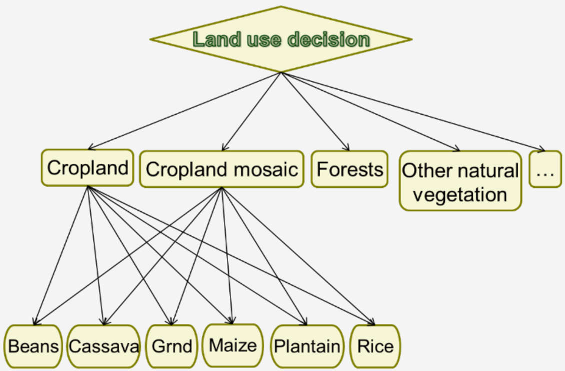
Water quality risk indices related to nitrogen pollution for major river basins of the world in 2050 (under the CSIRO-medium scenario)



Source: IFPRI-Veolia (2015).

LAND USE CHANGE METHODOLOGY

Theoretical foundation: Random utility model



- **Distinguishing feature:** By imposing a reasonable assumption on *the distribution of crop areas*, the model can provide crucial insights in the evolution of the crop mix under sparse data environment

- Structure and specification

  Upper level

  Choice variable:
  - Remote-sensing land use/land cover

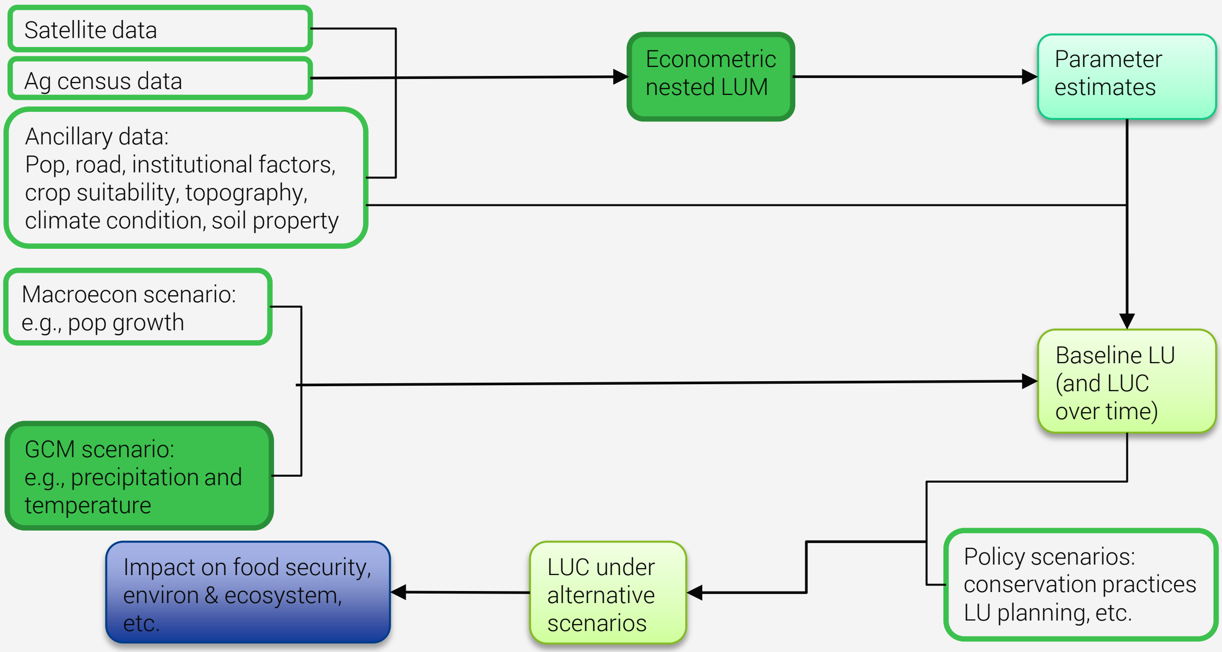
  Explanatory variables:
  - Transportation cost
  - Population density
  - Institutional variable
  - Climate
  - Topography
  - Soil

  Lower level

  Choice variable:
  - Crop areas at subnational level

  Explanatory variables:
  - Crop biophysical suitability
  - Crop price

APPLICATION: COUNTRY LEVEL MODELS



IMPACT AND NUTRITION ASSESSMENT: NEXT STEPS

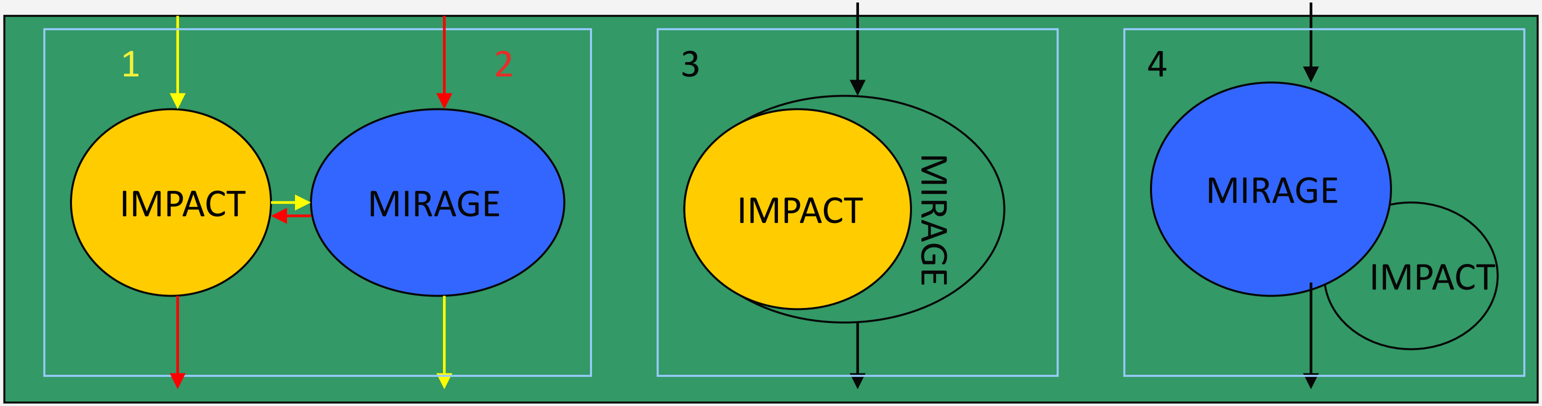
- Incorporation of coefficients to provide estimates of micronutrient composition of each food commodity in IMPACT, and overall diet diversity
  - Approach:
    - IMPACT output is consumption of raw commodity
    - Estimate micronutrient composition as mediated through final uses of the product
    - Testing alternative data sets
- Disaggregation of demand and demand equations by income or wealth class.
  - Did prototype of this for a few countries with HarvestPlus
  - Data intensive, and complex dynamics of income changes by class over time

LINKING IMPACT AND CGE: CHARACTERISTICS OF THE TWO MODELS

IMPACT (PE)	MIRAGE (CGE)
Detailed partial equilibrium model of agricultural sector with exogenous capital growth	Multi-sector general equilibrium model with endogenous labor and capital
More disaggregated agricultural commodities (wheat, maize, rice, sorghum…to cassava)	Groups of agricultural commodities (oilseeds, coarse grains)
Disaggregated spatial allocation of crop production at sub-national level (324 units)	National representation for many countries based on GTAP data base
Details on physical use of land and water, trade wedges, with resulting trade	Details on characteristics of trade barriers and trade reform
Iterative year-by-year demand and supply equilibration	Solution in five year blocks

DIFFERENT APPROACHES **TO LINK MODELS**

1. Sequential use of IMPACT results in MIRAGE for particular scenarios
2. Sequential use of MIRAGE results in IMPACT (national income and labor/fertilizer prices)
3. Add new sectors (labor) to IMPACT based on the MIRAGE model representation
4. Bring some features of IMPACT into MIRAGE



SOFT LINKING PE AND CGE

- Advantages of a simple sequential linkage
  - Better representation of agriculture and trade
  - Possibility to base CGE simulation of technology on a spatio-temporal disaggregation of productivity effects
- CGE modeling to focus on
  - Economy-wide impacts of the scenarios
  - Links between agricultural and non-agricultural sectors
  - General equilibrium welfare measures

Make IMPACT Open Source (in planning stage)

WHY CONVERT GLOBAL AGRICULTURAL AND WATER MODELS TO **OPEN SOURCE?**

- Transparency will be critical to future model uses
  - Community that does global modeling of agricultural and natural resource futures has historically not shared its underlying code, with the exception of GTAP (https://www.gtap.agecon.purdue.edu)
  - Different models have reported dramatically different results with no way to understand why the results differ
    - Acceptable in the past when agriculture was relatively unimportant in global considerations
    - But with critical attention being paid to food security challenges, it will not be acceptable in the future
    - Independent observers can review details of the code - more credible results from any model outputs
    - Results will be utilized in more responsible ways in policy dialogue

WHY CONVERT GLOBAL AGRICULTURAL AND WATER MODELS TO **OPEN SOURCE?**

- Model improvements
  - In a set of models as complex as those in the global agricultural models
    - Ability to find and fix problems is directly related to the number of people
      - who have access to,
      - interest in, and
      - understanding of the code
  - Opening up access to the code - more problems will be found and fixed quickly
  - New users will want to add new functionality
    - One of the key advantages to open sourcing software
    - Should be a key feature of the implementation of open sourcing chosen

WHY CONVERT GLOBAL AGRICULTURAL AND WATER MODELS TO **OPEN SOURCE?**

- General movement to open source and free distribution
  - Growing pressure from our donors to make all data and models that generate those data freely available
  - For example, Gates Foundation's data collection efforts (being undertaken under the LSMS auspices) must be made publicly available within a year of collection
  - These rules will likely be also adopted for modeling