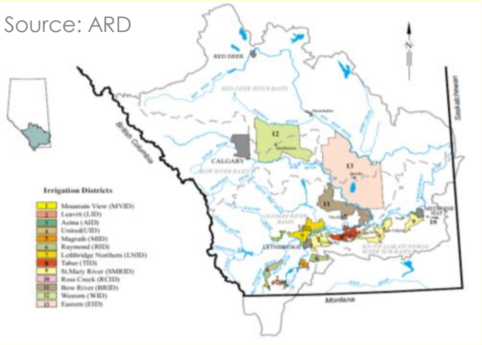

Systems modelling for irrigation in Alberta

Dr. Evan Davies, Civil and Env. Engineering
With Drs. Miles Dyck, Scott Jeffrey, Feng Qiu
and
Mohamed Ammar, Bijon Brown, Kai Wang, Dareskedar Amsalu, *Marie-Eve Jean, Xiaofeng Ruan, Dawn Trautman*

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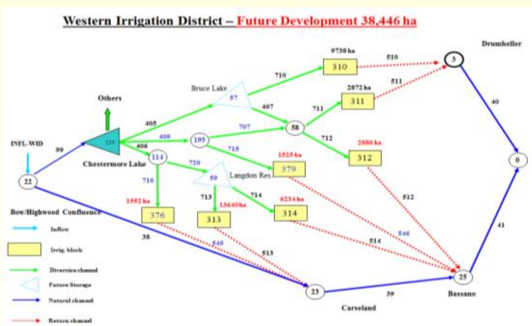
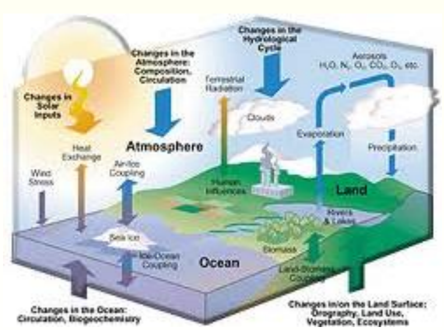
What is a System?

"A set of interconnected components that work together to perform a particular task or set of tasks."





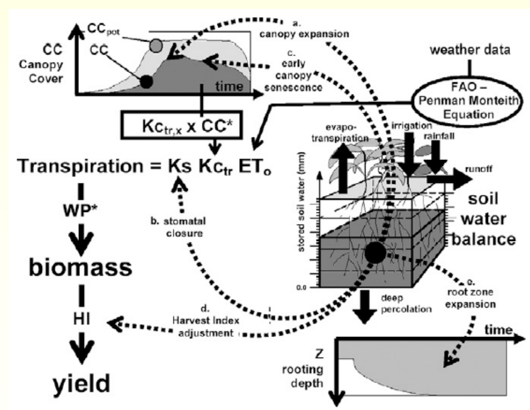
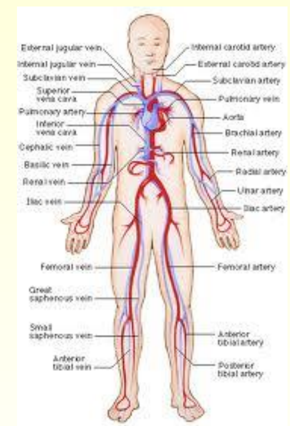


Fig. I. Calculation scheme of AquaCrop with indication

AquaCrop, Raes et al. (2009)



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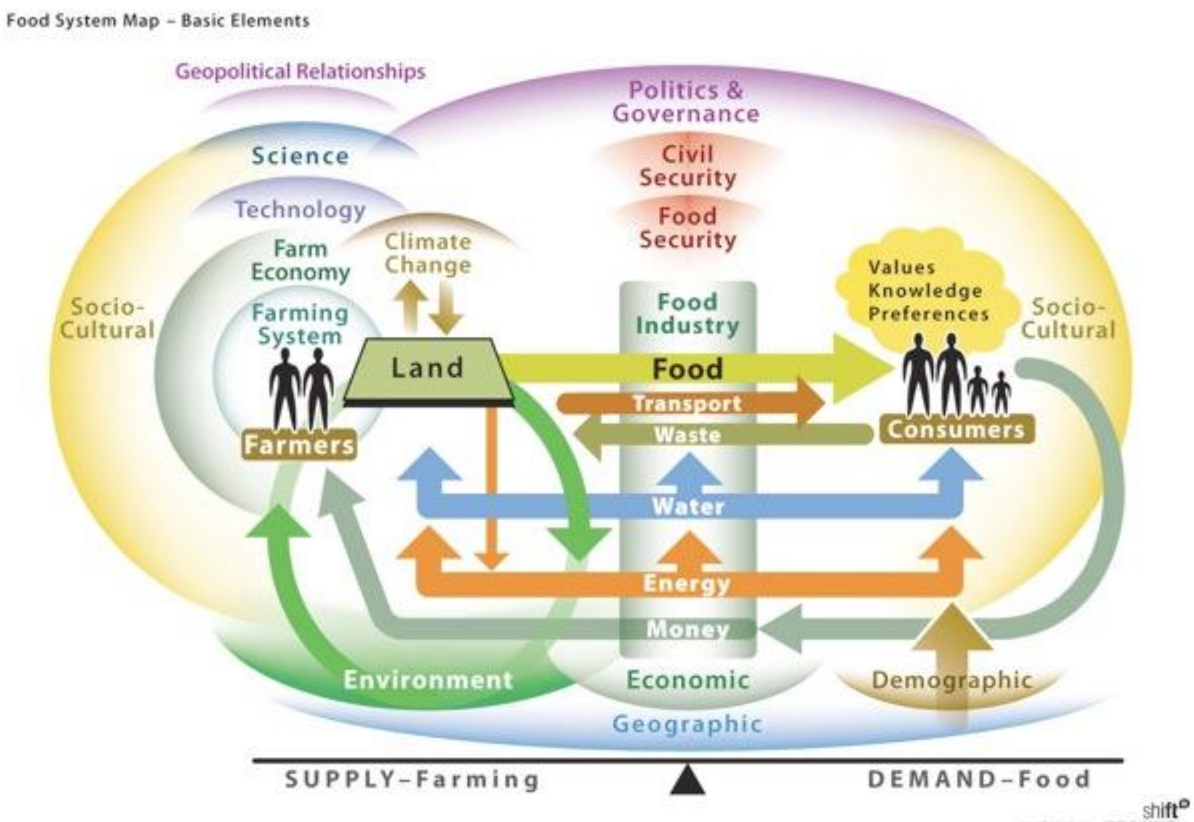
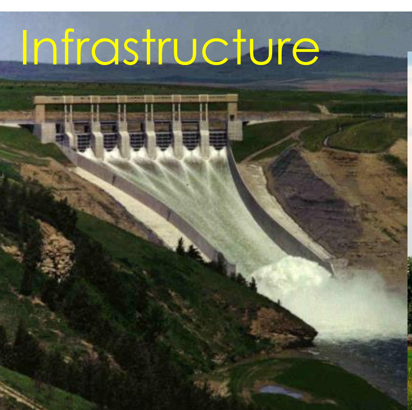
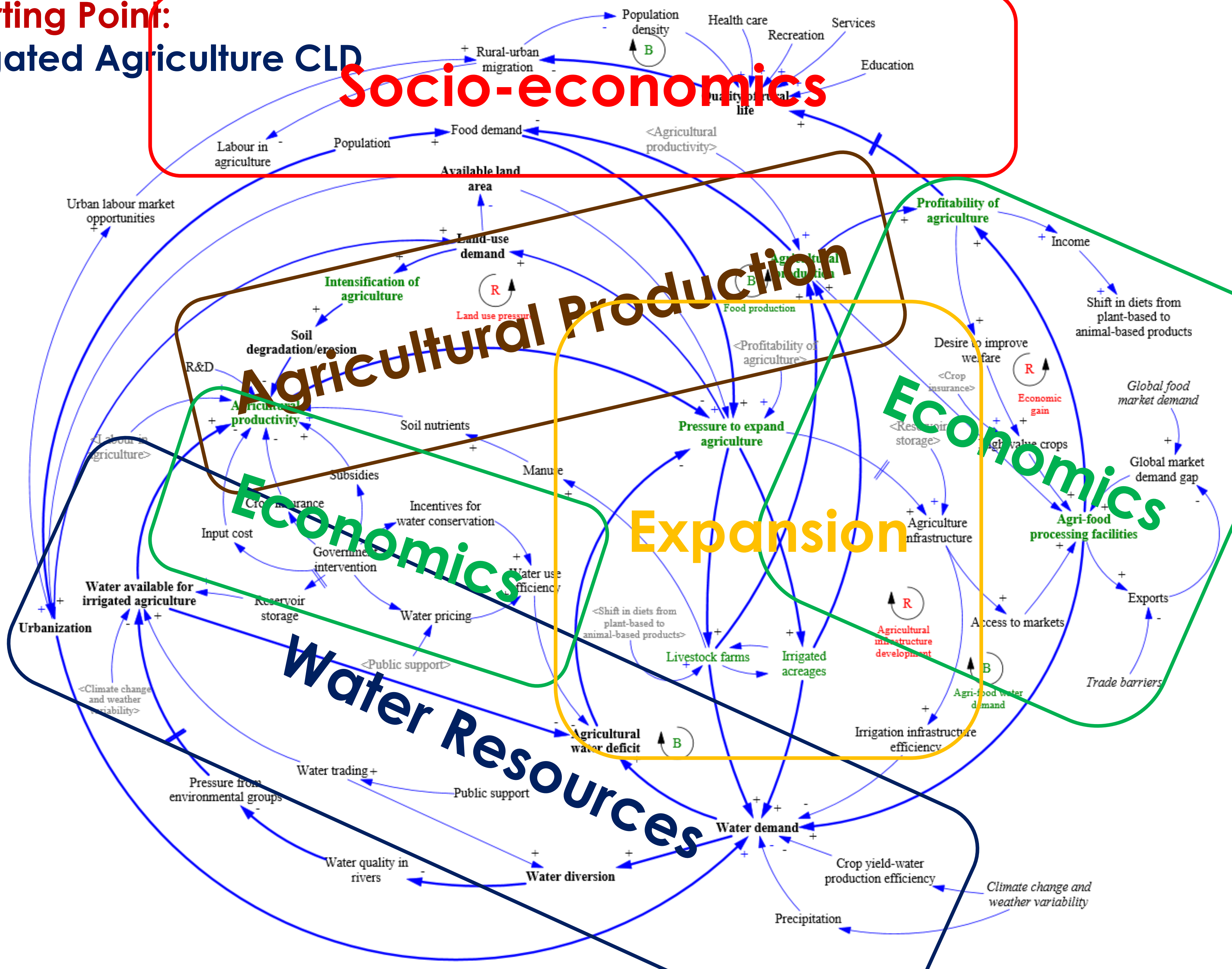
Irrigated Agriculture as a System





Starting Point:

Irrigated Agriculture CLD



Systems Thinking

- The <u>Key Questions</u> are,

  Which parts and connections cause a system to behave as it does??

  How can I manipulate those parts to achieve a desirable outcome?

Systems Models

- **Interdisciplinary**: Integrate information from a variety of disciplines into a single framework
- Simulate **complex**, **unpredictable** systems
- Serve as **exploratory**, **evaluative** tools:
  1. Improve understanding of causes of behaviour
  2. Evaluate effects of various strategies
  3. Provide flexible and fast simulation tools
  4. Aid identification and ranking of major uncertainties
  5. Supply tools for communication between scientists, the public, and policy makers

Sources: Edmonds (1998), Rotmans et al. (1997)

Systems Models for Irrigation in Alberta

- Focus: Short- and long-term (25 yrs) risks and opportunities for irrigated agriculture in the province, and analysis of trade-offs
  - "Big picture" research for planning purposes
  - SSRB as the context: population growth, limited water, climate change → *room for irrigation expansion?*
- "What if" approach: Consequences of choices
  - Results can help with scoping and ranking
  - Clarify cause-and-effect relationships

Sample Questions to be Addressed…

What are some alternative development directions for irrigation sector to 2040?

Is there room for irrigation to expand? Effects of expansion?

What happens if temperatures rise by 1, 2, or 5 °C through the next 25 years?

Find ANSWERS

How do crop yields change with improved on-farm technologies

If infrastructure improvements decrease water diversions, what might happen?

What might be some changes in crop mix in the long term? Their effects?

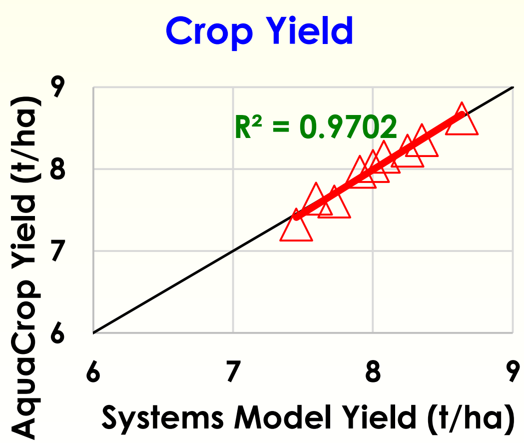
How can changes in water rights regimes affect crop choices and farm welfare?

Part 1: Process-based Crop Growth Model

Based on existing models: AquaCrop (Steduto et. al, 2009), CropSyst (Stockle et al., 2003), and DSSAT (Jones et al., 2003)

Simulates crop growth on a *weekly time-step* to allow multi-year-scale simulations of crop biomass and yield

Other crop models use daily time step (sometimes hourly)



Dry tuber yield for potato

R^2 = 0.97

RMSE = 0.071 t/ha

NRMSE = 0.88%

d =0.99

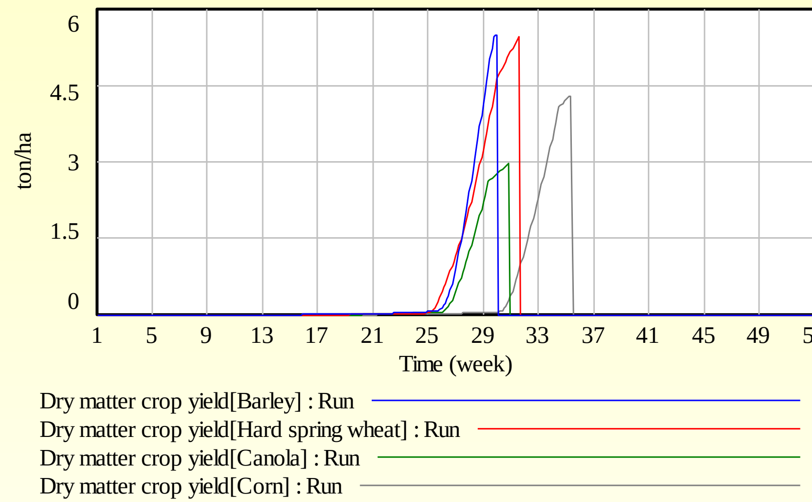
Mohamed Ammar's work

Examples of model results

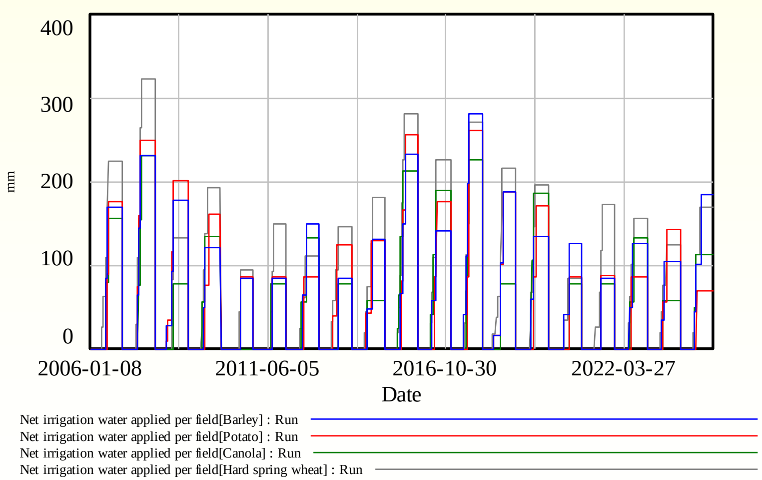
Crops validated:

- Barley/Barley silage
- Corn/Corn silage
- Potato
- Canola/canola seed
- Sugar beet
- Hard spring/durum wheat

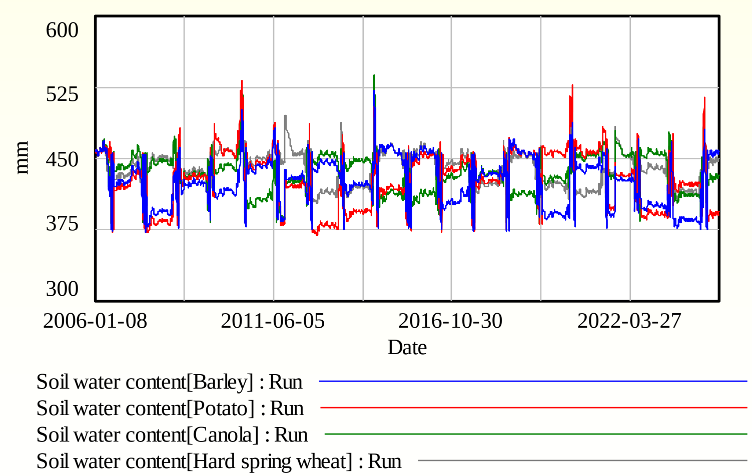
Dry matter crop yield



Net irrigation water applied per field



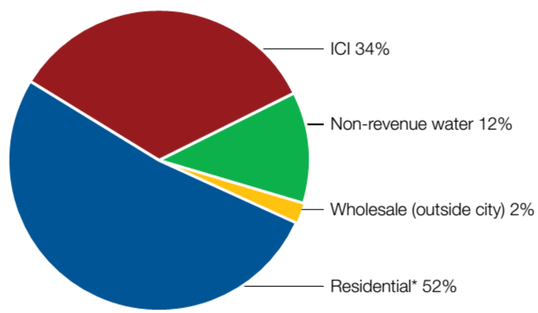
Soil water content



Part 2: Municipal and Industrial Water Demands

Figure 3.4

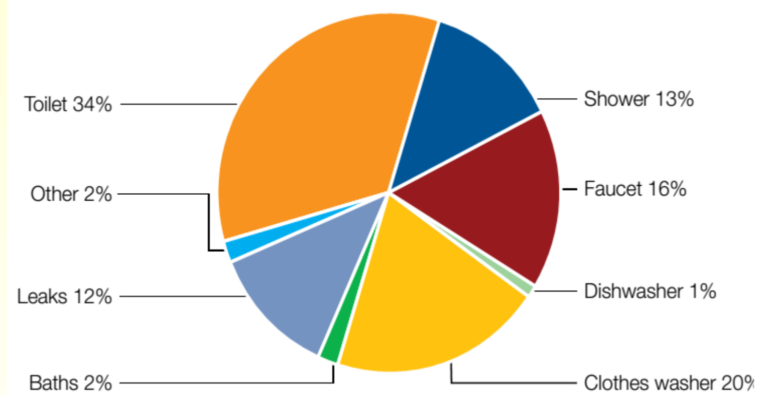
Calgary's water demand by sector (as percentage of total demand).



*Includes both single-family and multi-unit housing.

Figure 3.6

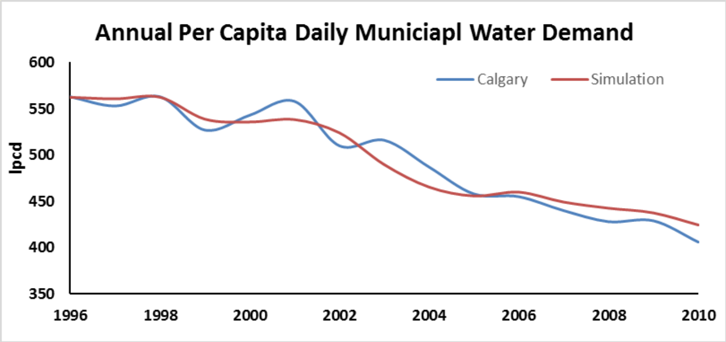
Water use in a typical apartment building.

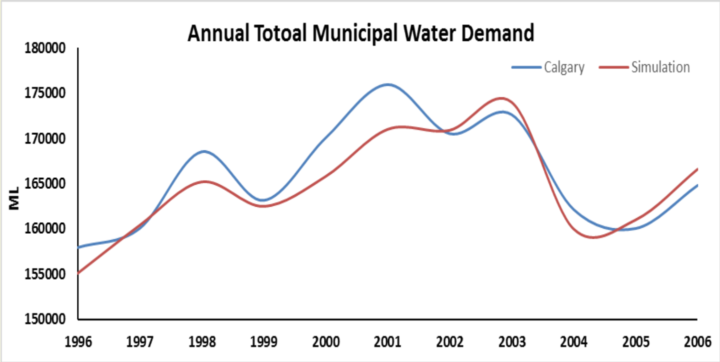


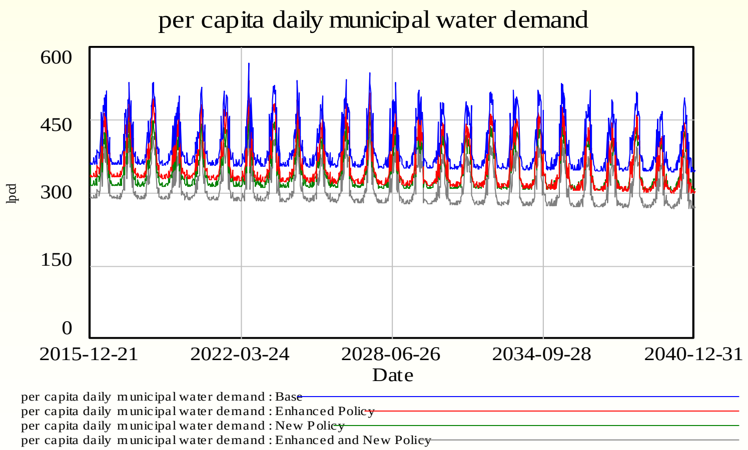
Model represents **water demands** in all these categories, and **policies or management actions that change the demands**

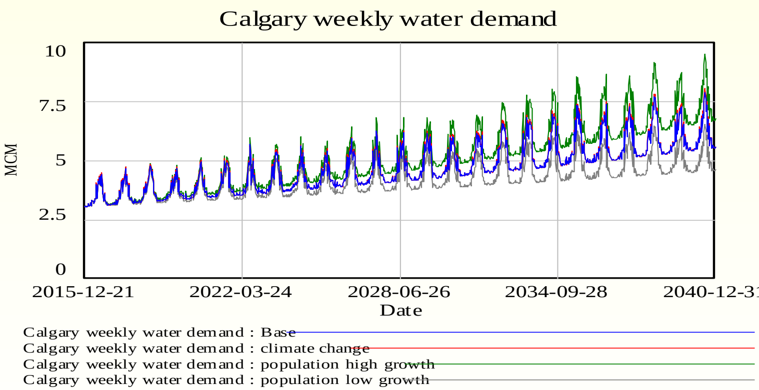
Kai Wang's work; Figures from Headwater Communications (2007)

Model Performance









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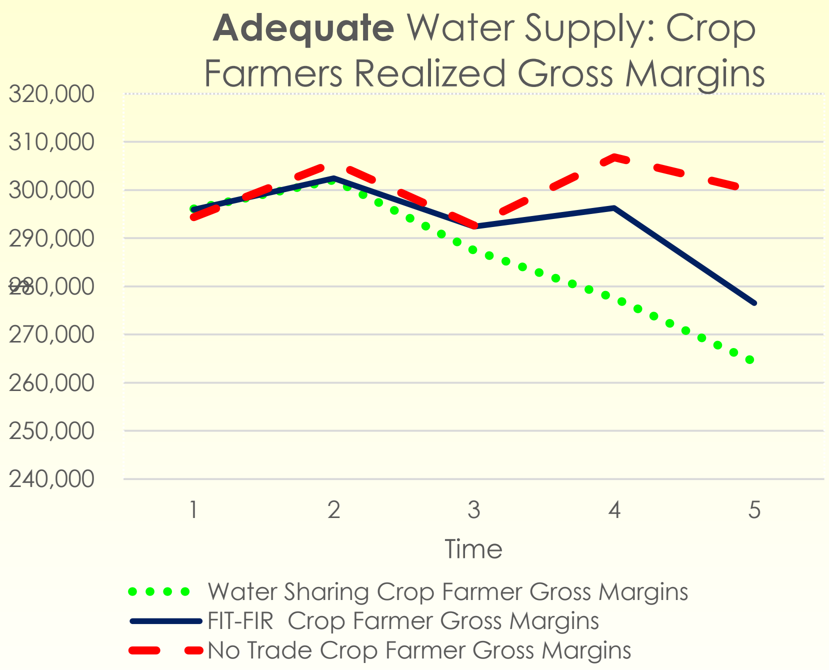
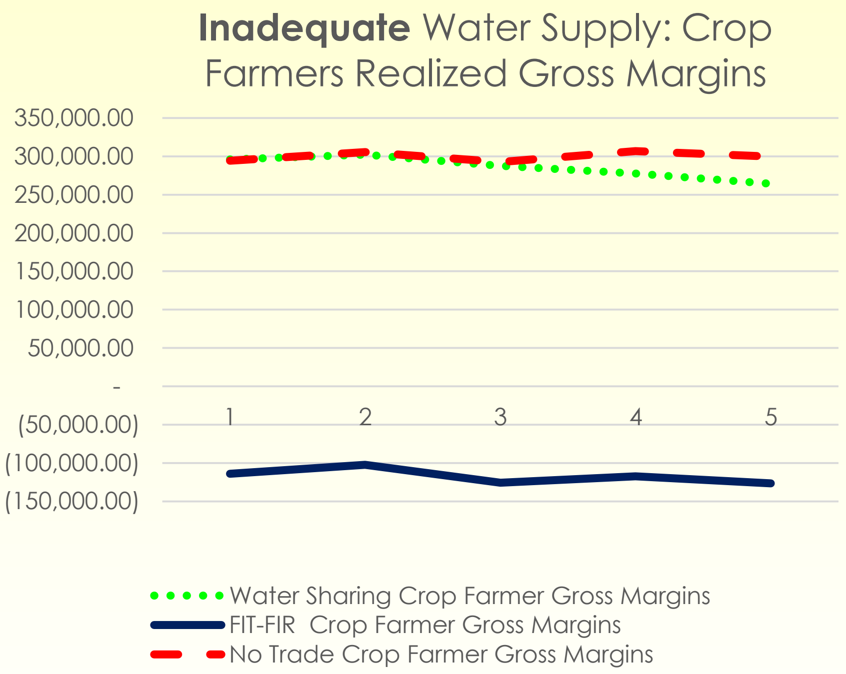
Part 3: Water Allocation and Cropping Decisions

- Compare current "FITFIR" system with a water sharing regime:
  - Assess impacts on water trading market
  - Examine situation under adequate and inadequate water supply conditions
- Estimate effects on cropping decisions
- Investigate effects of water policy on producers' land-use decisions
  - Which areas to irrigate and what to produce

Bijon Brown's work

Preliminary Results





Summary

	Adequate Water Supply (100 % of total annual allocation)			Inadequate Water Supply (20 % of total annual allocation)		
	No trading	Trading		No Trading	Trading	
	FIT-FIR	FIT-FIR	Water Sharing	FIT-FIR	FIT-FIR	Water Sharing
Crop Farmer Gross Margins	✓			✓		
Cattle Producer Feed Cost		✓			✓	
Water Market Trade Volumes	-		✓	-	✓	
Water Market Price Volatility	-	✓		-		✓

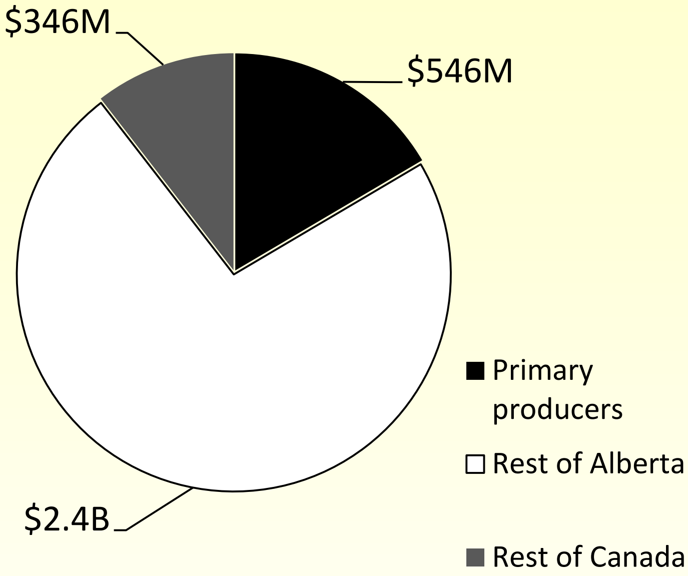
- Generally no benefit to farmers (crop and cattle) from switching regimes when water is adequate
- With inadequate water, crop farmers worse off under **FITFIR with trading** than under **no-trade** or a **water sharing** regime
- For water market stability, water sharing preferred especially in periods of water scarcity

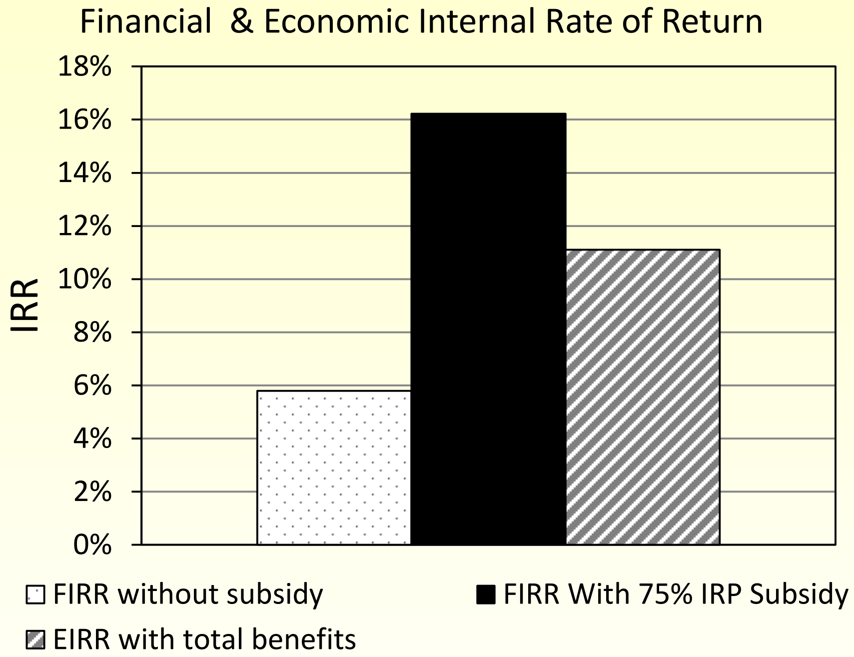
Part 4: Distribution of Benefits of Irrigation

1. Who benefits from Alberta's irrigation industry?
   - Estimates of direct and secondary economic impacts of crop and livestock production, food processing, infrastructure rehab
2. Should investment in Alberta's irrigation be expanded?
   - Cost-benefit analysis of economic viability of irrigation expansion

Dareskedar Amsalu's work

Preliminary Results





- Irrigation contributes (directly & indirectly) $3.3 billion to national economy
  - 17% of benefits accrue to producers
  - Remaining 83% accrue to other beneficiaries

- Expansion economically viable for producers with current 75% subsidy to rehabilitation
- Not viable without subsidy

Connections Between Projects

Dareskedar Amsalu
- Benefit-Cost Analysis
- Input-Output Modelling

Mohamed Ammar
- Systems model
  - Agricultural Production
  - Overall integration

Kai Wang
- Systems model
- Municipal/Industrial changes

Xiaofeng Ruan
- Determinants of land-use changes
  - Effects of socio-economic trends
  - Determinants of agricultural land-use

Bijon Brown
- Economic model
  - Water rights regimes
  - Crop mix changes

Marie-Ève Jean
- Reservoir management
- Alternative supply scenarios