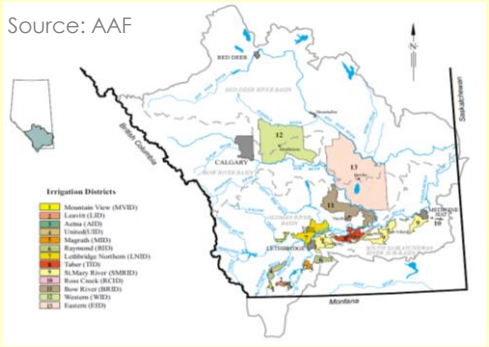

Systems Modelling for Irrigation in Alberta

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Session 2A: Managing Our Water for Long Term Sustainability of Our Agriculture Sector

UNIVERSITY OF ALBERTA

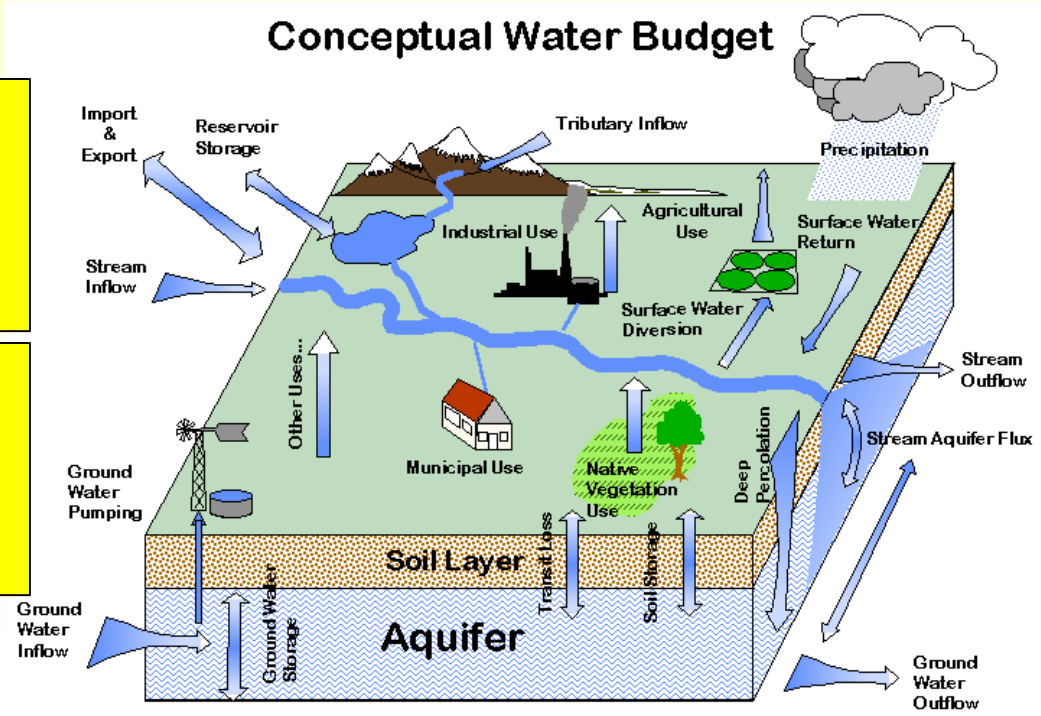
ALBERTA LAND INSTITUTE

Introduction: Water Management Occurs in River Basins

- **Computer models** provide important tools for exploring agricultural and water resources scenarios in real time

They can help to guide decisions related to water reliability, scarcity and demand

They can help to create and assess policies that will ensure sustainable expansion of irrigation



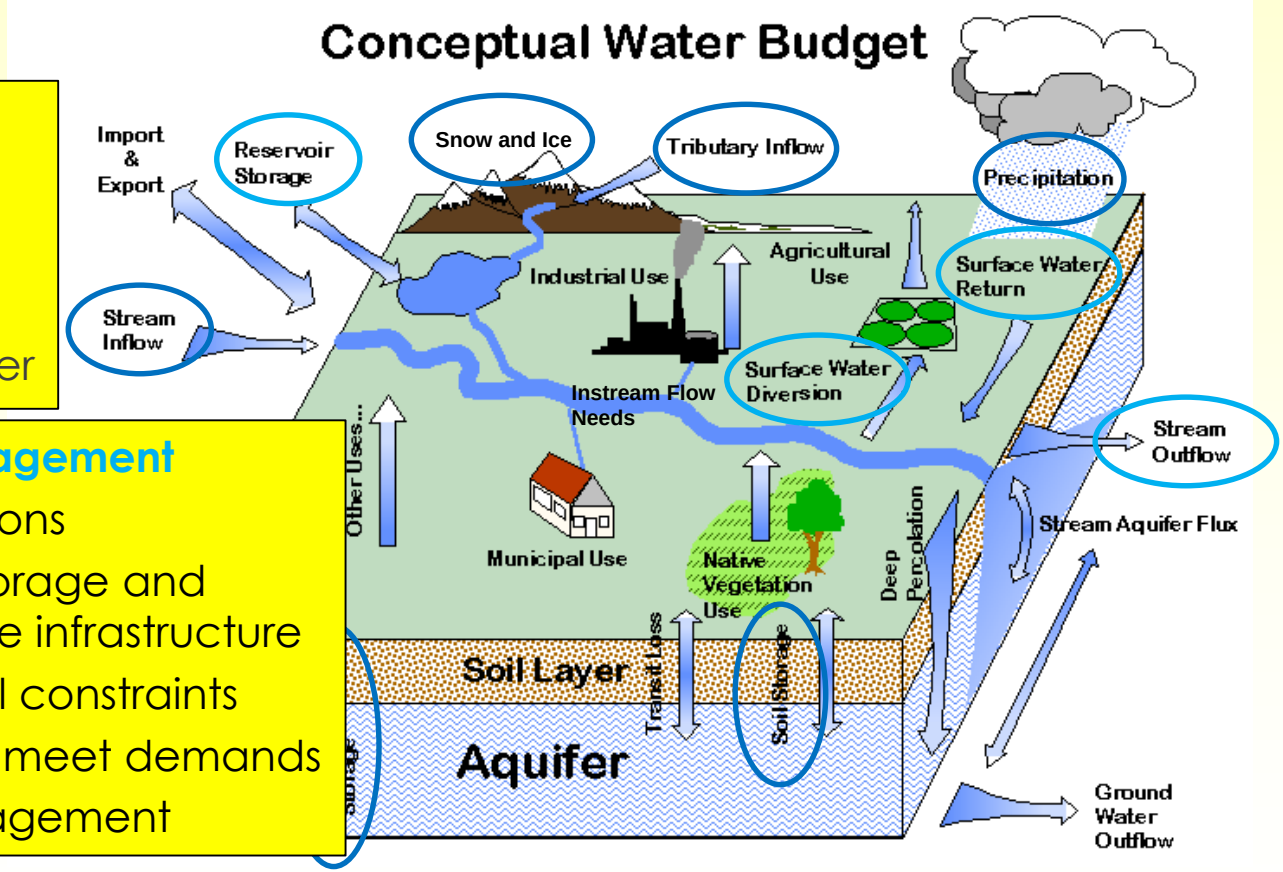
https://www.water-research.net/index.php/the-hydrological-cycle-water-budgets

Water Management Occurs in River Basins

Models typically represent dynamics & drivers of water supply & demand

Water Supply

- **Hydrology**
  - Rainfall
  - Snow pack
  - River flows
  - Groundwater
- **River Basin Management**
  - River diversions
  - Reservoir storage and conveyance infrastructure
  - Operational constraints
  - Releases to meet demands
  - Flood management

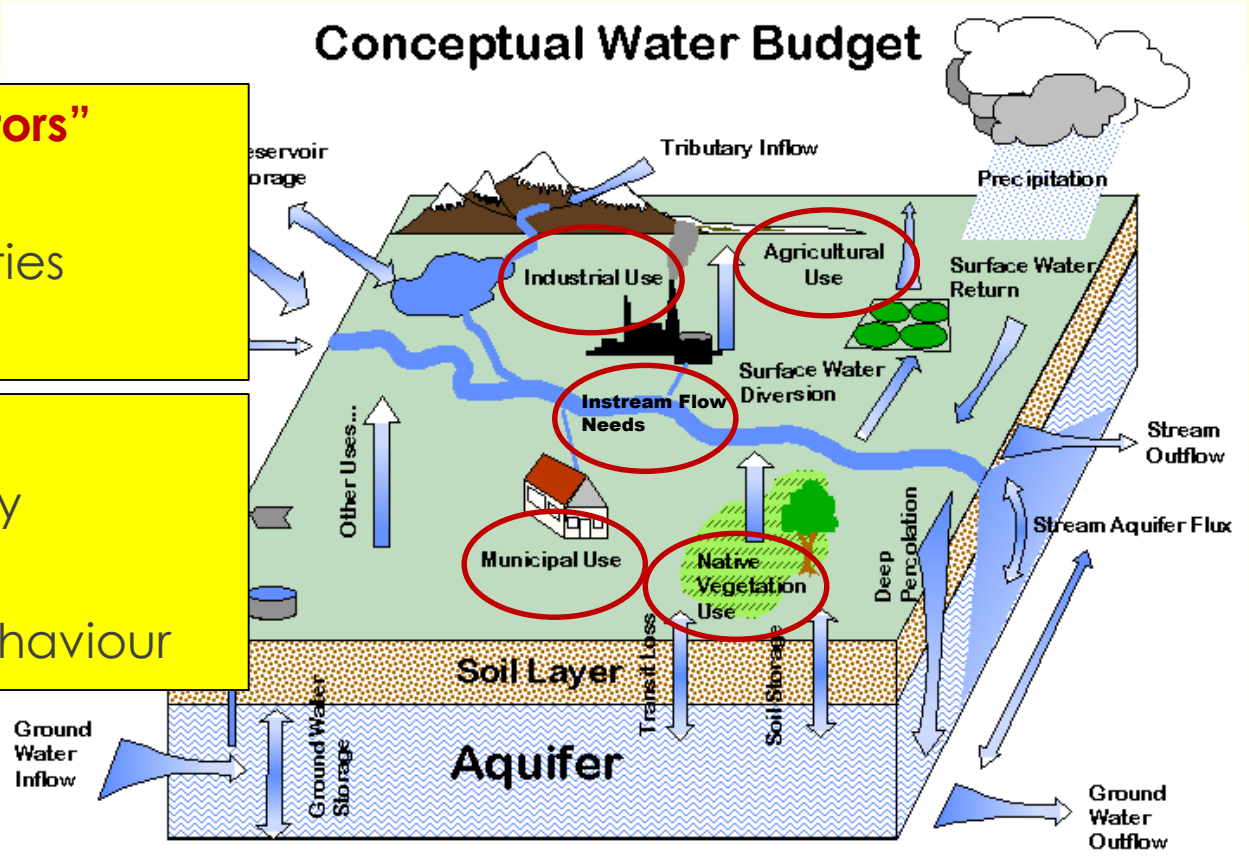


https://www.water-research.net/index.php/the-hydrological-cycle-water-budgets

Water Management Occurs in River Basins

Water Demand

- **Demand "sectors"**
  - Irrigation
  - Municipalities
  - Industry
- Affected by
  - Technology
  - Climate
  - Human behaviour



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South Saskatchewan River Basin

Over the **next 25 years**, we expect to see changes in,

Water Supply & Water Demand

- Hydrology
  - Altered rainfall
  - Earlier snow melt
  - Glacier retreat
  - Lower river flows
- River Management
  - New reservoirs?
  - Flood control
  - Conveyance changes
  - Changes in water license regime?

- Increasing Demands
  - Irrigation expansion
  - Growing cities
  - Economic development

ALI Study Motivation:
"Connections between irrigated agriculture, infrastructure, socio-economic and environmental factors, climate change and policy alternatives are complex, poorly understood, and unpredictable…"

Our Study

"SYSTEMS MODELLING FOR SUSTAINABLE LAND AND WATER POLICY IN ALBERTA'S IRRIGATION SECTOR"

"Systems modelling for sustainable land and water policy in Alberta's irrigation sector"

- Research team:
  - *Professors*: Drs. Miles Dyck, Scott Jeffrey, Feng Qiu, and me
  - *PhD*: Mohamed Ammar, Bijon Brown and Kai Wang
  - *MSc*: Dareskedar Amsalu and Marie-Eve Jean
  - *PDF/RA*: Xiaofeng Ruan and Dawn Trautman
- Work funded by ALI (2013-17)
- For more information, see https://www.albertalandinstitute.ca/research/research-projects/project/irrigation

Systems Modelling for Irrigation in Alberta

- **Aim**: Assess possible development pathways for Alberta's irrigation sector over the next 25 years
  - Is there room for irrigation expansion?
  - What are the opportunities, challenges and trade-offs?

- **For decision support**: Evaluate consequences of policy alternatives, changing agricultural practices and infrastructure, and climate change

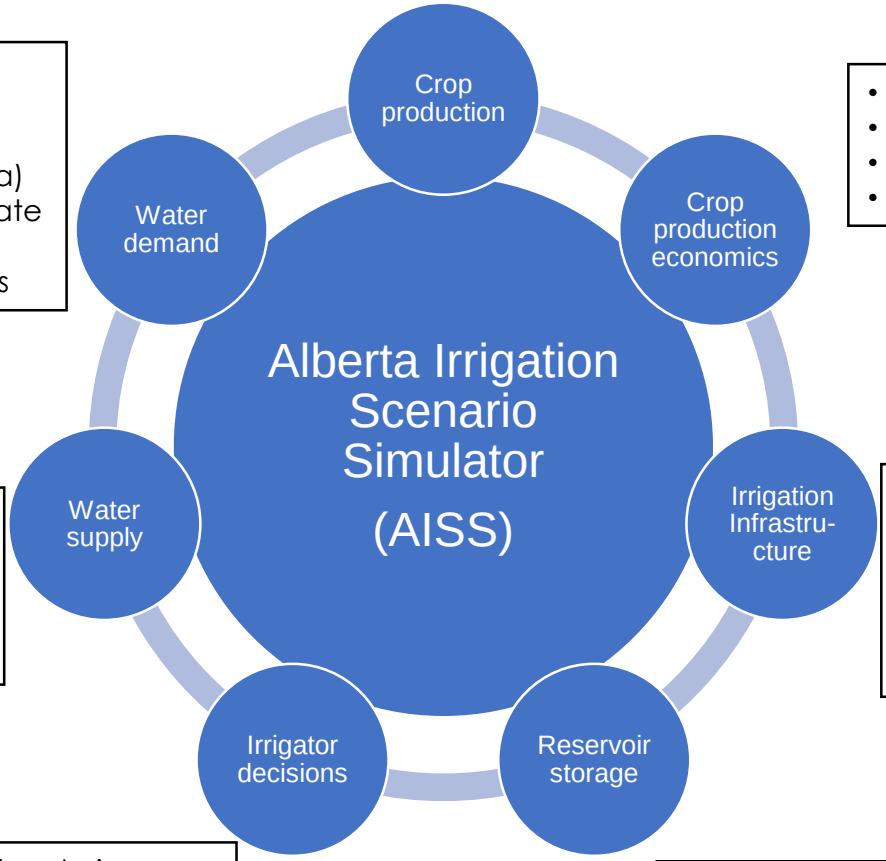
- **Study Results**:
  - Created three new **simulation models**:
    - Alberta Irrigation Scenario Simulator (*AISS*)
    - Calgary Water Management Model (*CWMM*)
    - Agent-based water allocation model
  - Analyzed historical land-use conversions
  - Conducted a cost-benefit analysis for irrigation expansion

New Simulation Model:

- Process-based
- Accurate, fast and detailed
- Uses weekly time step
- Runs to 2040

- AquaCrop growth engine
- **Crop yields and biomass**
- **Total production**
- Effect of increased CO_2 on crop yields
- Higher yields with advances in agronomy
- Both irrigated and dryland production

- **Net/Gross weekly water demands for six crops** (barley, potatoes, wheat, canola, sugar beets, alfalfa)
- Water demands at farm gate
- Water demands at headworks/diversion points



- **Variable costs of production**
- **Revenue**
- Margins
- Irrigation pumping costs

- Uses **weekly river flow inputs** from the SWAT hydrological model (M. Faramarzi)
- Can include **climate change** projections

- **Changes in infrastructure**
  - Crop irrigation technologies
  - Conveyance systems
  - "New technologies" with higher efficiency

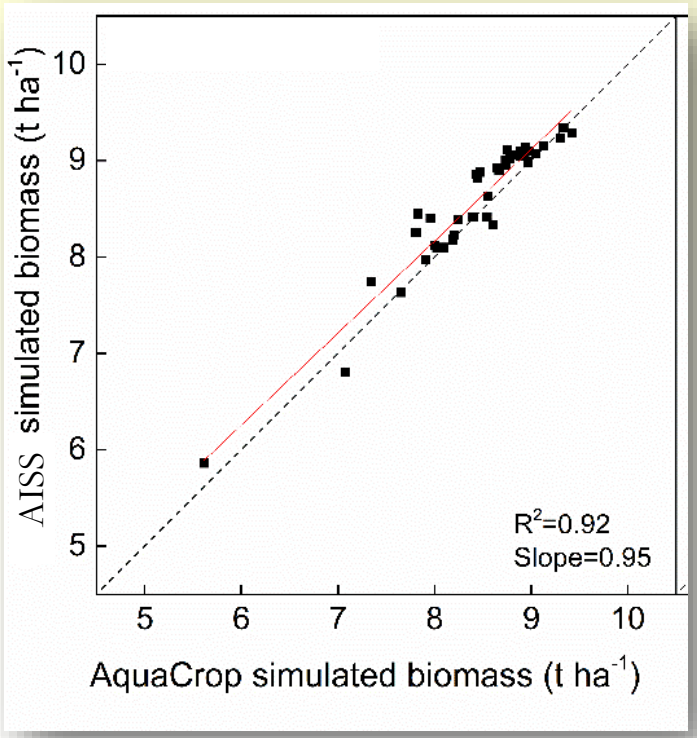
- Irrigator decisions to improve farm-level technology
- Crop mix optimization

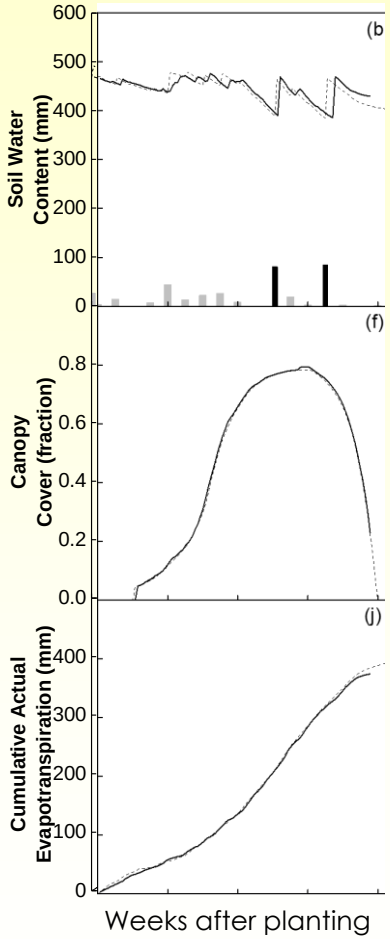
- Simplified reservoir storage
- Diversions for irrigation
- Evaporation losses

For more detail, please see Mohamed Ammar's poster

AISS Crop Model Validation

Comparisons with
FAO's *AquaCrop* model





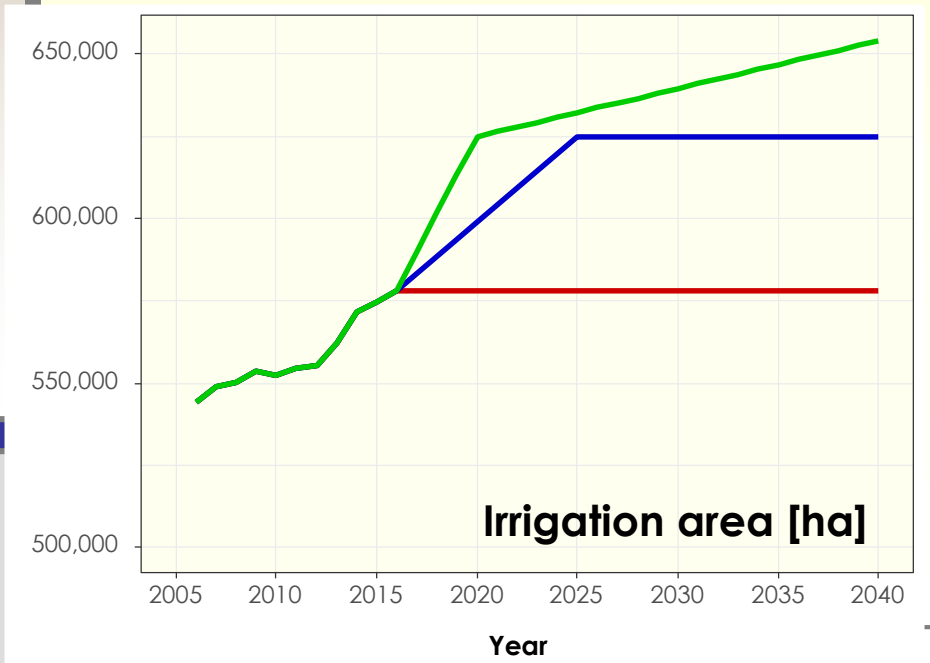
Soil water content

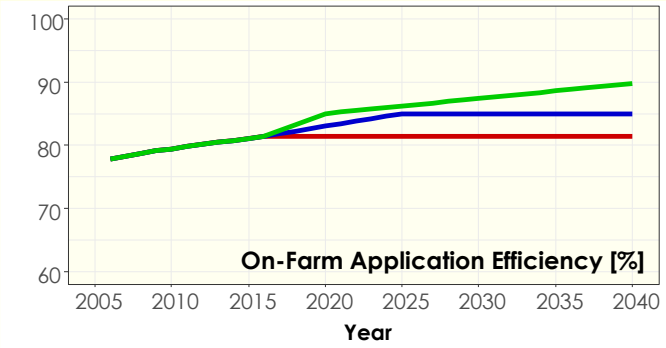
Canopy cover

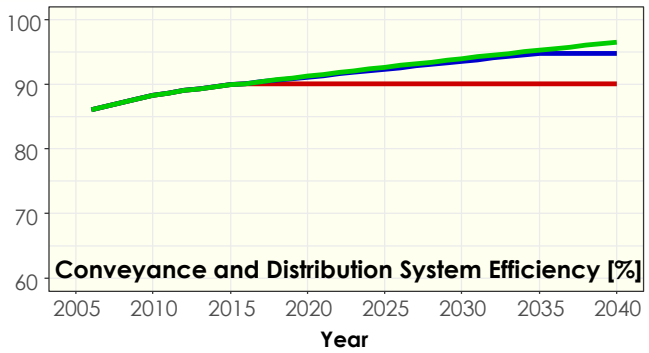
Actual ET

AISS Application Examples

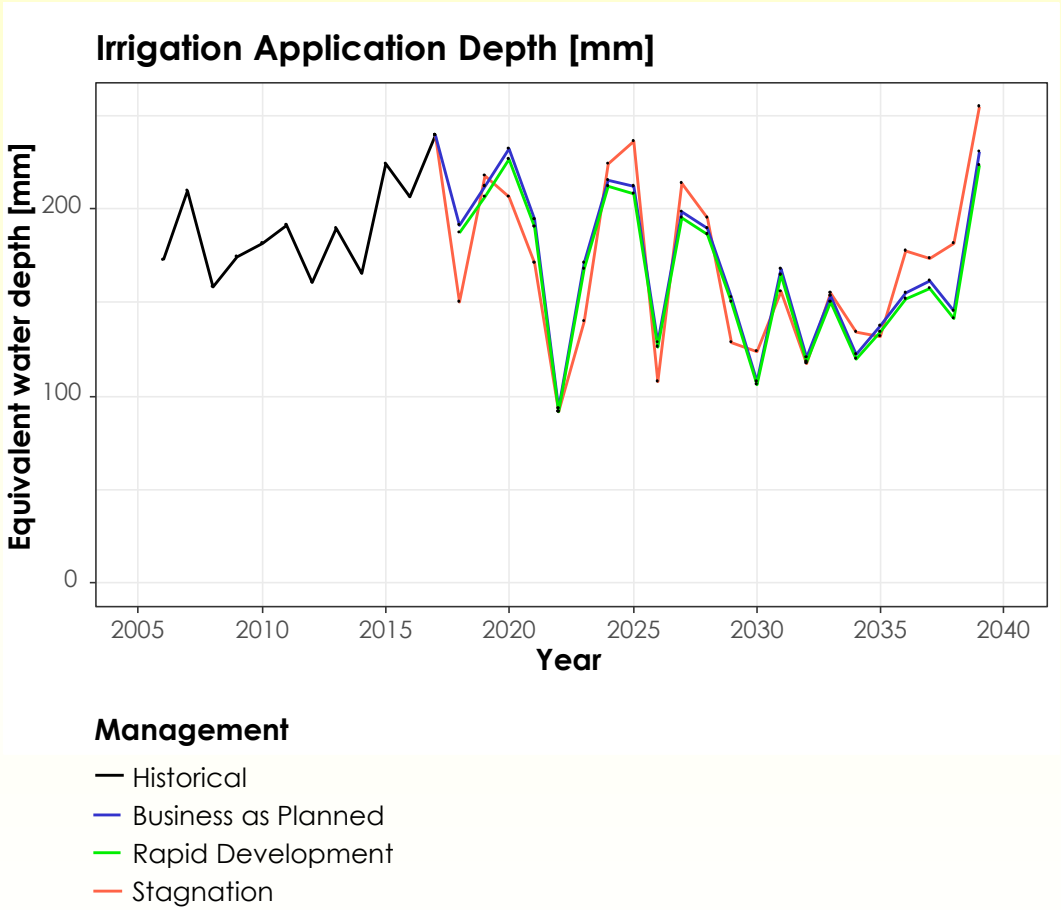
1. Assessed **three irrigation expansion scenarios**
   i. "*Business as planned*": AAF "Strategy for the Future" targets for 2025-35
   ii. "*Rapid development*": AAF targets reached 5 years early, further growth
   iii. "*Stagnation*": no area or efficiency changes after 2017
2. Investigated effects of **climate change**
3. Simulated **crop mix** changes





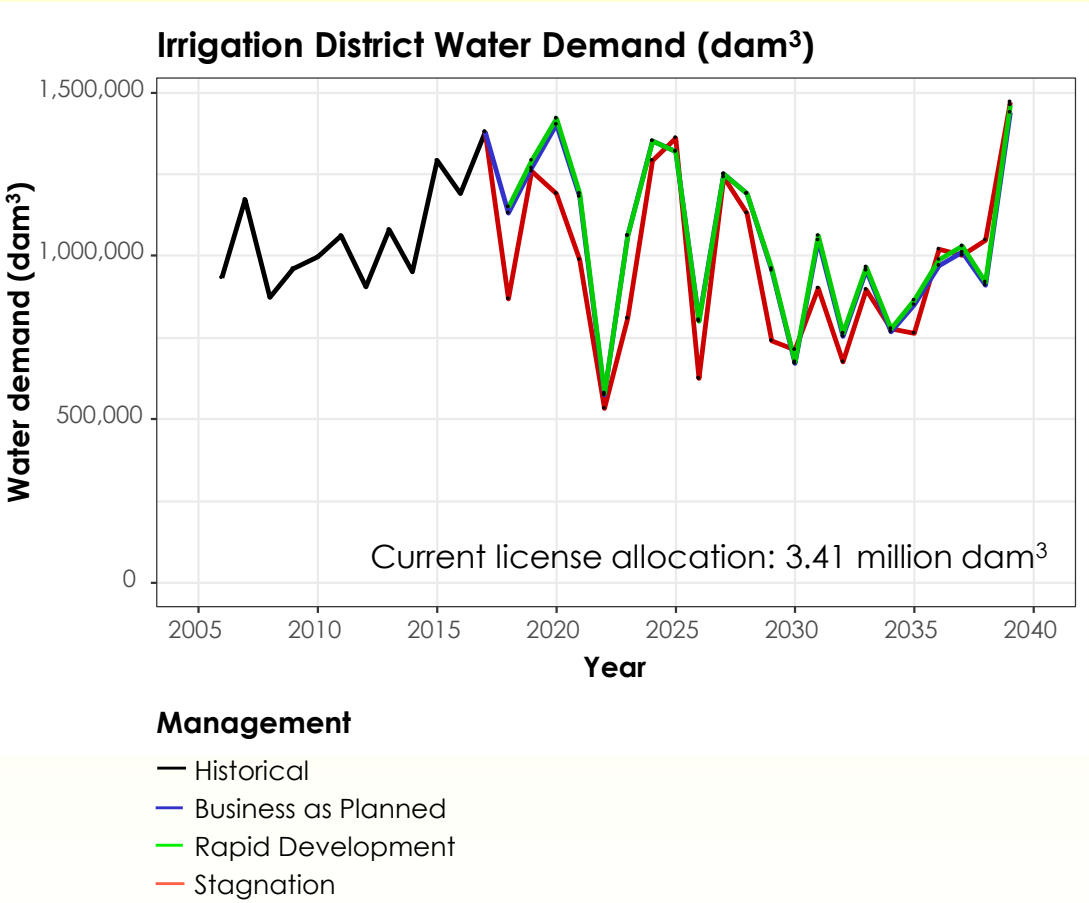


Irrigation Expansion Scenarios



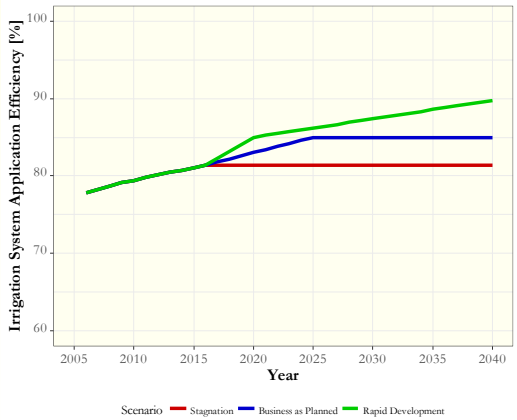
Greater Efficiency leads to less water application per hectare

Irrigation Expansion Scenarios



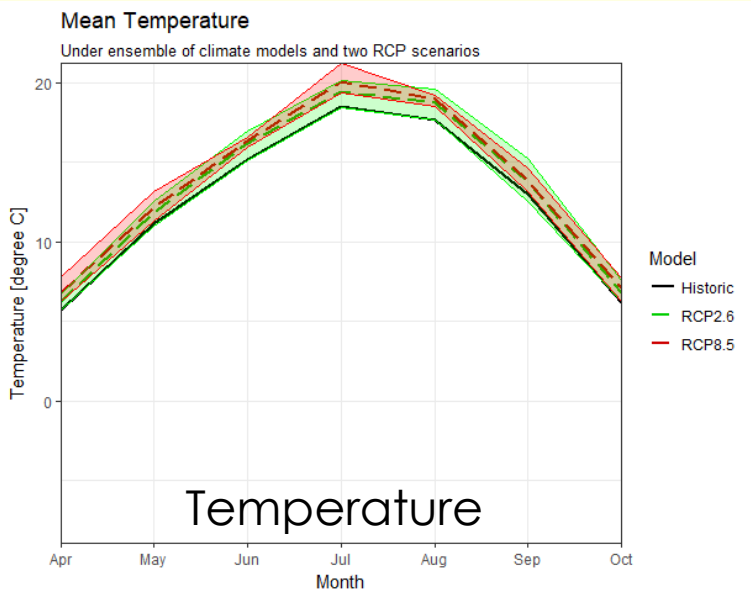
Water demand is very similar in all three scenarios

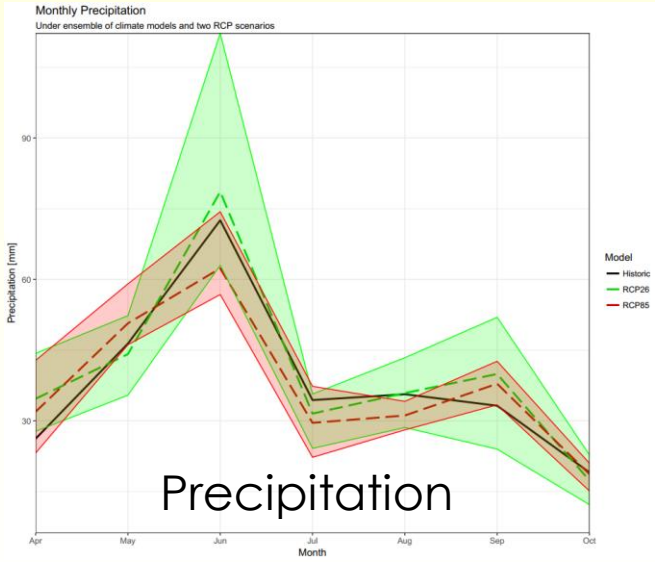
But… irrigated area is **12% larger** in the Rapid Development scenario



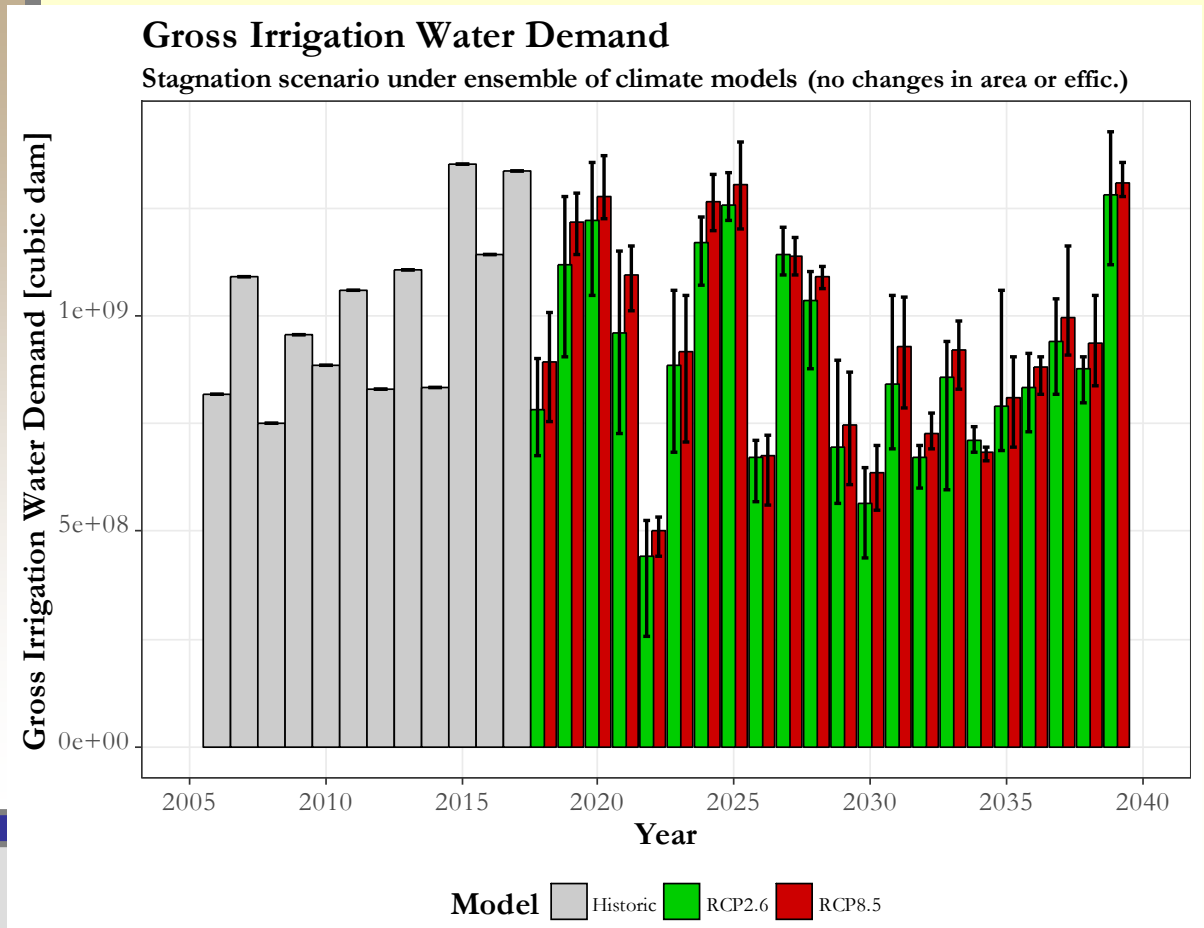
Climate Change Effects

- Investigated climate change effects with
  - Output from **three GCMs**
  - Two levels of climate change: **RCP2.6** and **RCP8.5**





Climate Change Scenarios

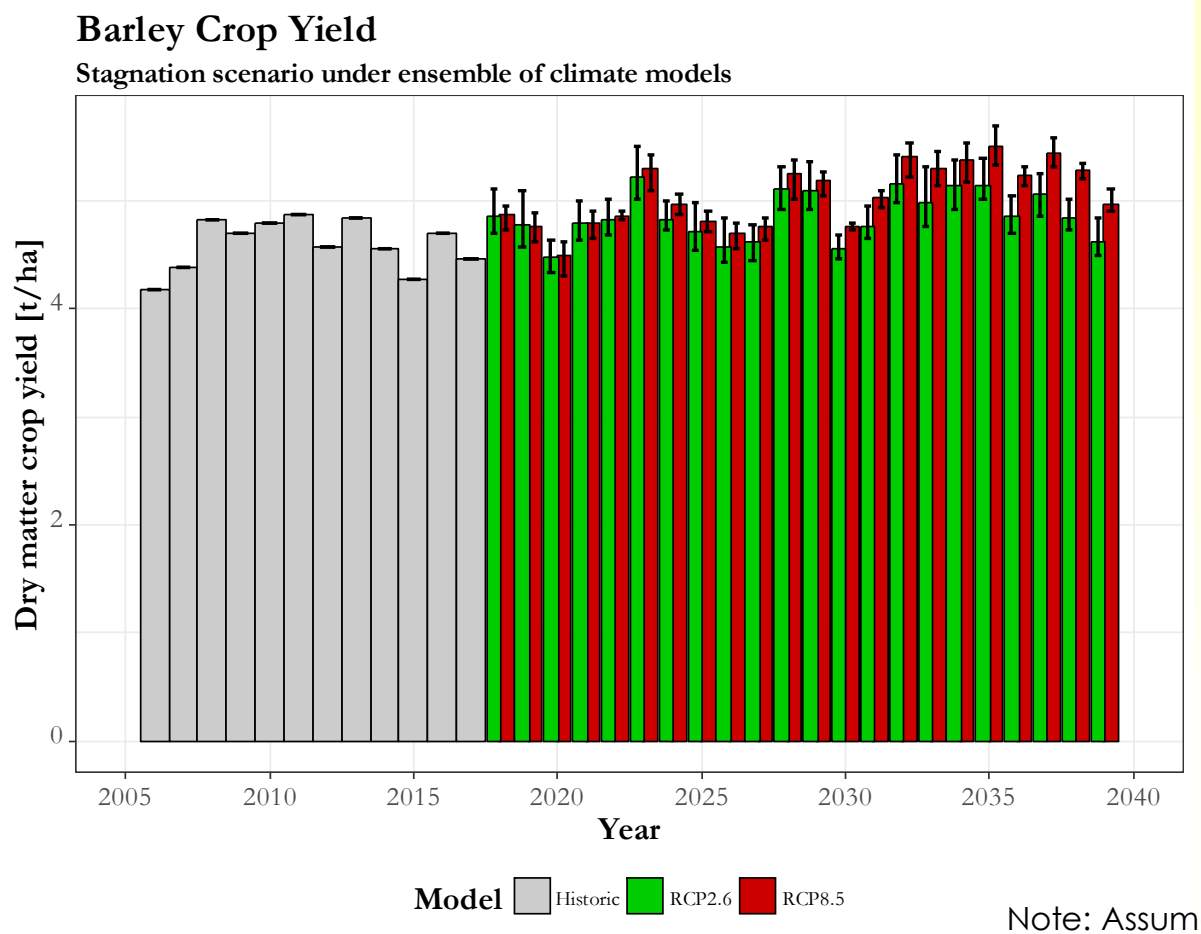


Only "Stagnation" scenario is shown

Demands increase with climate change

Note: Demand includes crop water consumption, irrigation application losses, and conveyance losses

Climate Change Scenarios



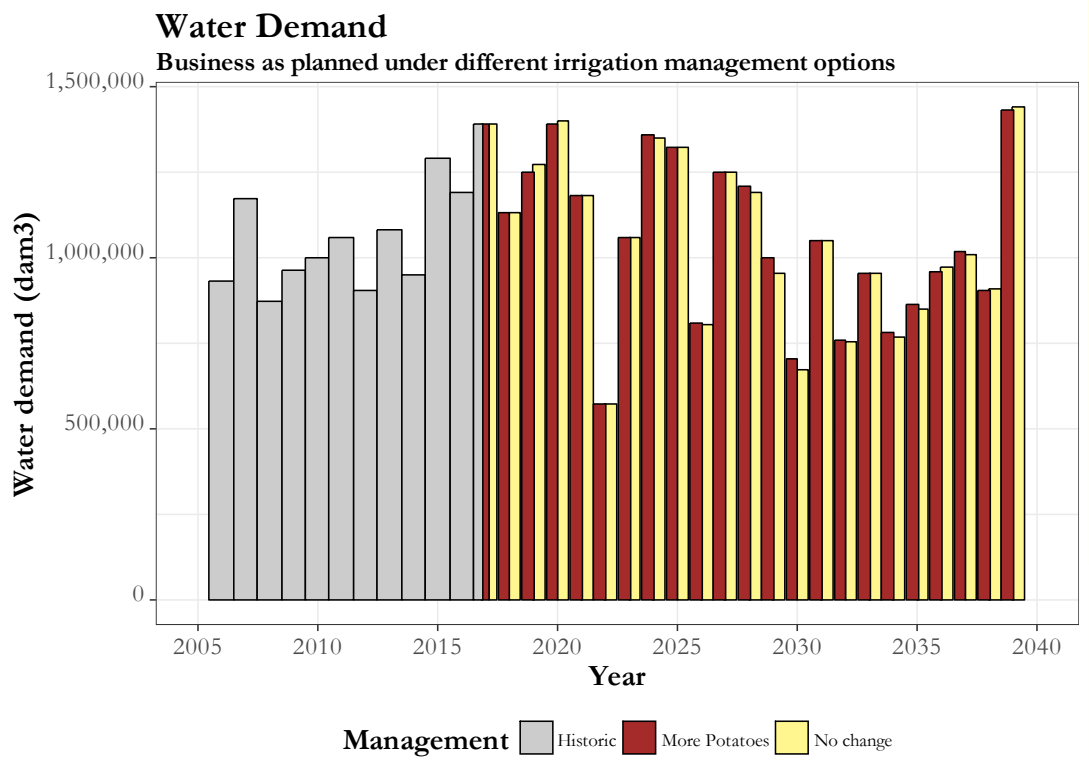
Only "Stagnation" scenario is shown

Crop yields are similar to today, but increase slightly with greater atmos. [CO_2]

Note: Assumed no advances in crop genetics or changes in harvest index

Crop Mix Change Scenario

- New Cavendish Farms potato processing plant will open in Lethbridge in 2019:
  - Will add 3800 ha to current 21 000 ha of potatoes grown in AB
- *What if potato area nearly doubled, alfalfa shrank by 20% over ten years?*



Conclusions

- Our project has started to link agricultural and municipal water demands, agricultural production and economics, water allocation schemes, government policies, and irrigation infrastructure at a river basin scale
- The models and analyses can provide a greater understanding of the opportunities, challenges and trade-offs associated with irrigation expansion
- Coupled with water supply scenarios, AISS can provide results to inform provincial irrigation and water policy
  - Simulate developments in irrigated agriculture to 2040
  - Evaluate potential consequences of policy alternatives, as well as changing agricultural practices, infrastructure and climate