A SIMULATION GAMING MODEL FOR INTEGRATED RIVER BASIN MANAGEMENT

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OUTLINE

- Background
  - River Basin Management
  - River Basin Management Models
- Approach
  - Simulation Gaming
- Sample Study
  - Bow River Basin Simulation Gaming Model (BRSGM)
- Next Steps

RIVER BASIN MANAGEMENT

- Objectives
  - Achieve water security for all purposes
    - Social, economic, environmental
  - Manage risks
    - Flood, drought

(IHP et al., 2009)

- Challenges
  - Population and economic growth
  - Existing water allocation system
  - Climate change uncertainties

(Rijsberman 2006, Wagener et al. 2010)

RIVER BASIN MANAGEMENT MODEL

- Developed as decision support tools with focus on:
  - Water supply: MIKE-BASIN, WRMM, WEAP
  - Water demand: AquaCrop, Qi and Chang (2011)
  - Water systems: Prodanovic and Simonovic (2009), van Delden et al. (2007)

APPROACH: SIMULATION GAMING

- Definition
  - Experimental, rule-based, interactive environments
  - Players learn by taking actions and by experiencing their effects
  - Feedback mechanisms built into and around the game

Mayer (2009: 825)

- Objectives
  - Entertainment, training, motivation, assessment, education and learning, and decision support

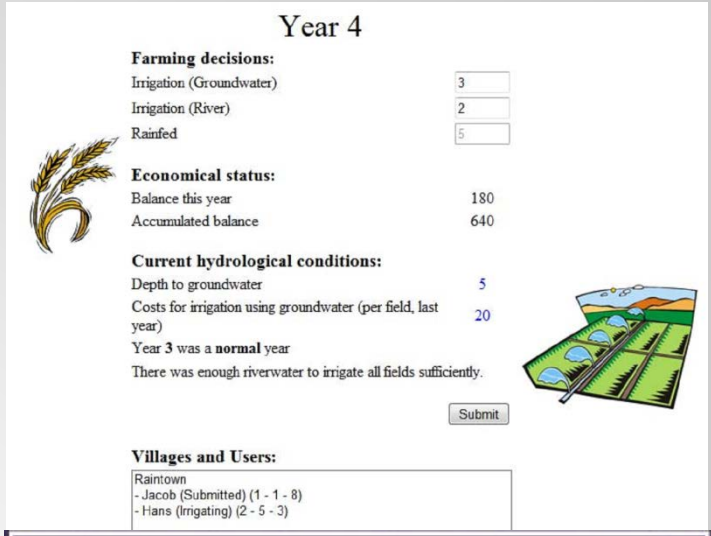
Mayer and Veeneman (2002)

APPROACH: SIMULATION GAMING

- Characteristics/Advantages
  - Condenses complex issues in both space and time
  - Provides safe experimental environment (without "real" consequences)
  - Motivates players' curiosity and imagination
  - Generates surprising feedback results (sometimes)
  - Integrates researchers, decision makers, and stakeholders

APPROACH: SIMULATION GAMING

- Water Related Games
  - Irrigation management: Irrigania Game (Seibert and Vis, 2012)
  - Drought management: Invitational Drought Tournament (Hill et al. 2014)
  - Basin-scale management: Ravilla Game (Rusca et al., 2012)



APPROACH: SIMULATION GAMING

- Theoretical Bow River Basin Simulation Game
  - Workshop
    - Researchers: professors, graduate students
    - Potential stakeholder: Government of Alberta, AARD, AESRD, Bow River Basin Council, City of Calgary, Irrigation Districts
  - Multidisciplinary teams
  - Management policies: water, land, financial, technology
  - Basin scale water sustainability
  - Consensus-building

BOW RIVER BASIN SIMULATION GAMING MODEL (BRSGM)

- Model Purposes
  - Education (basin scale water management)
    - Identify challenges/problems
    - Test available policies & their effectiveness
    - Improve water sustainability
    - Understand trade-offs
    - Achieve collaboration
  - Motivation
    - Motivate imagination and exploration
    - Develop new policies
    - Test new organization/institutional arrangement

BOW RIVER BASIN SIMULATION GAMING MODEL (BRSGM)

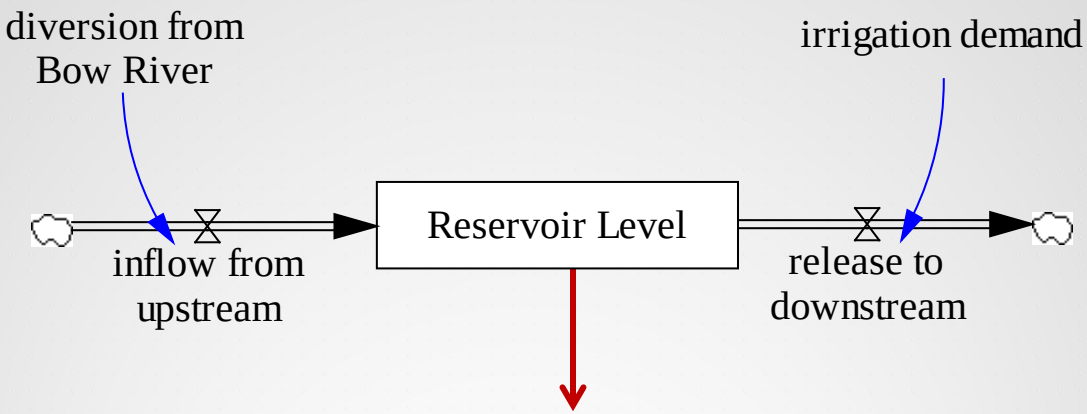
- Model Characteristics
  - Offers a clear & broad picture
  - Generates results quickly with acceptable accuracy
  - Compares both current and cumulative results
  - Has user-friendly interfaces
  - Is easily configured for other basins

BOW RIVER BASIN SIMULATION GAMING MODEL (BRSGM)

- Modelling Methodology – System Dynamics
  - Jay Forrester, mid 1950's (Forrester, 1961)
  - System structure: stock and flow dynamics, material and informational delays, and nonlinear feedbacks (Sterman, 2000)
  - Education, public participation, policy analysis (Williams et al., 2009; Tidwell et al., 2004; Stave, 2003)
  - Water resources management, energy policy analysis, climate change assessment, urban planning, and business (Winz et al., 2009; Mirchi et al., 2012; Davies and Simonovic, 2011)

BOW RIVER BASIN SIMULATION GAMING MODEL (BRSGM)

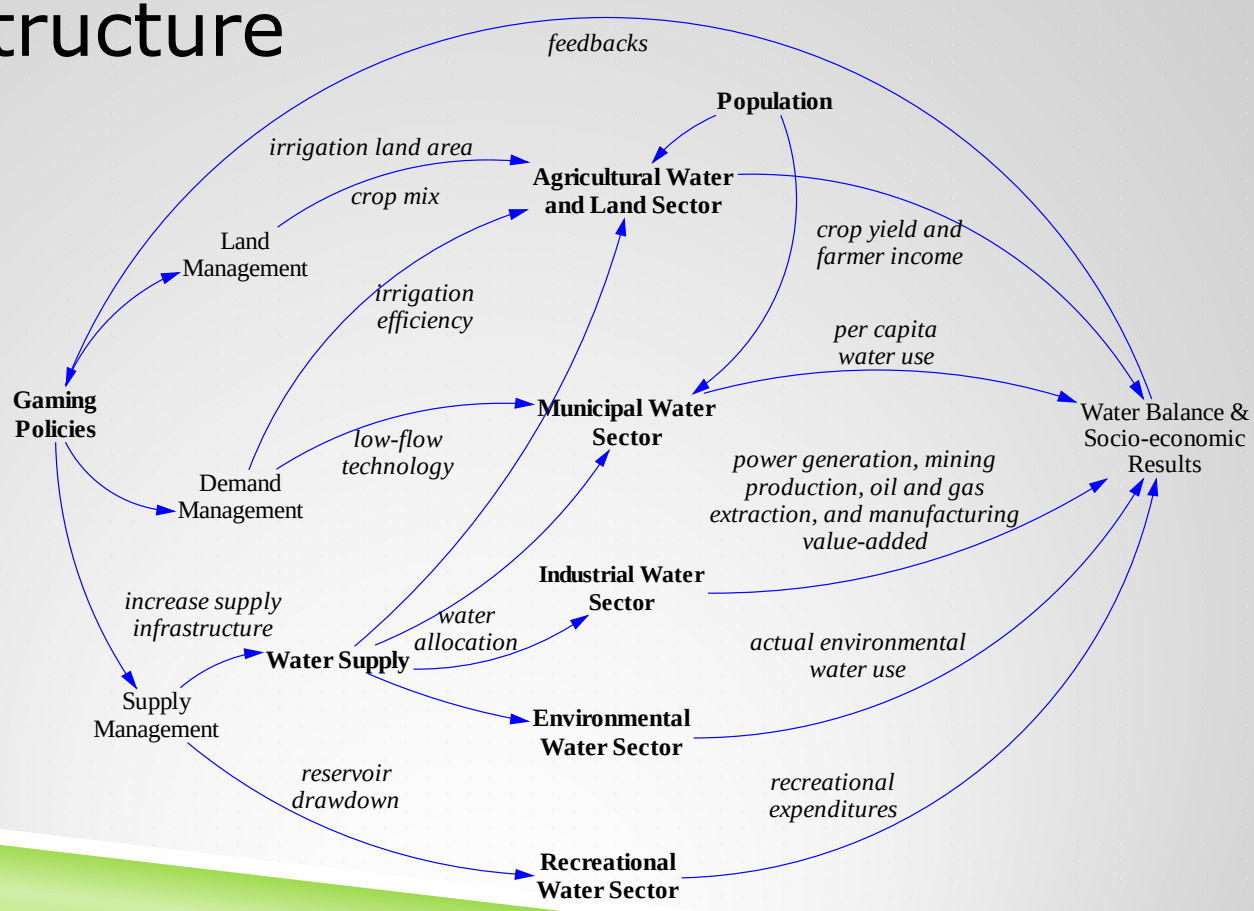
- Modelling Methodology – System Dynamics



$$RL_t = RL_0 + \int_0^t (If(t) - Re(t))dt$$

BOW RIVER BASIN SIMULATION GAMING MODEL (BRSGM)

- Model Structure



BOW RIVER BASIN SIMULATION GAMING MODEL (BRSGM)

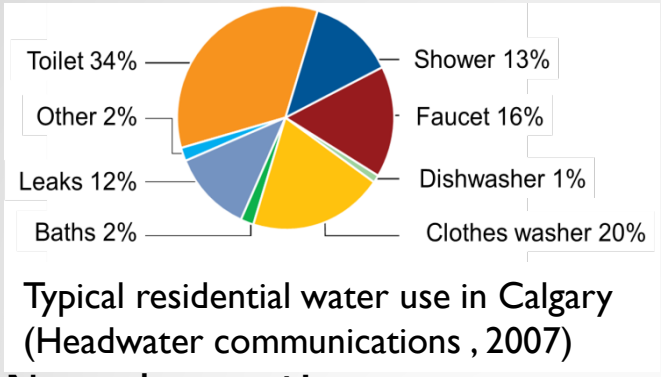
- Main Components

Adaptation option	Adaptation type	Details	Cost
Water Management			
Enhance irrigation water delivery system and application efficiency by 25%	Long-term strategy that takes 5 years to implement. This strategy will be completed prior to the scenario	300,000 acres have been converted to high efficiency irrigation and 1000 kms of canal have been lined with concrete to reduce seepage	$193,000,000
Financial Management			
Relief payout to producers	Short-term emergency response strategy aimed at reducing immediate economic and social stress in the agricultural sector	Provide an emergency payout of $35 per acre to producers affected by drought	$100,000,000
Land Management			
Promote green cover	Long-term operation management strategy aimed at changing land use in the basin	Provide producers with $85 per acre over 10 years to covert 150,000 acres of marginal annual cropped land at-risk of soil degradation to perennial cover	$12,750,000

- Supply
  - Base renewable flow
  - Reservoir storage
  - Inter-basin diversions (a policy option)

BOW RIVER BASIN SIMULATION GAMING MODEL (BRSGM)

- Main Components
  - Demand
    - Municipal
      - Domestic:

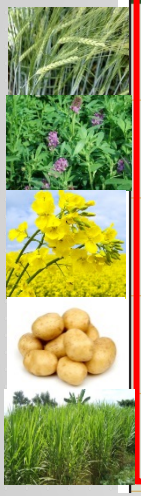


Typical residential water use in Calgary (Headwater communications , 2007)

      - Non-domestic
    - Industrial
      - Mining
      - Power generation
        - thermal
        - hydro
      - Oil & gas extraction
      - Manufacturing

BOW RIVER BASIN SIMULATION GAMING MODEL (BRSGM)

- Main Components
  - Demand
    - Agricultural



CROPS	IRRIGATION DISTRICTS		
	AID	BRID	
Cereals	1,520 34.7%	84,779 36.2%	76 2
Forages	2,403 54.9%	39,161 16.7%	12 4
Oil Seeds	135 3.1%	25,198 10.8%	52 1
Specialty Crops	118 2.7%	67,557 28.8%	42 1
Other*	200 4.6%	17,632 7.5%	8 0

(ARD, 2012)

- Livestock

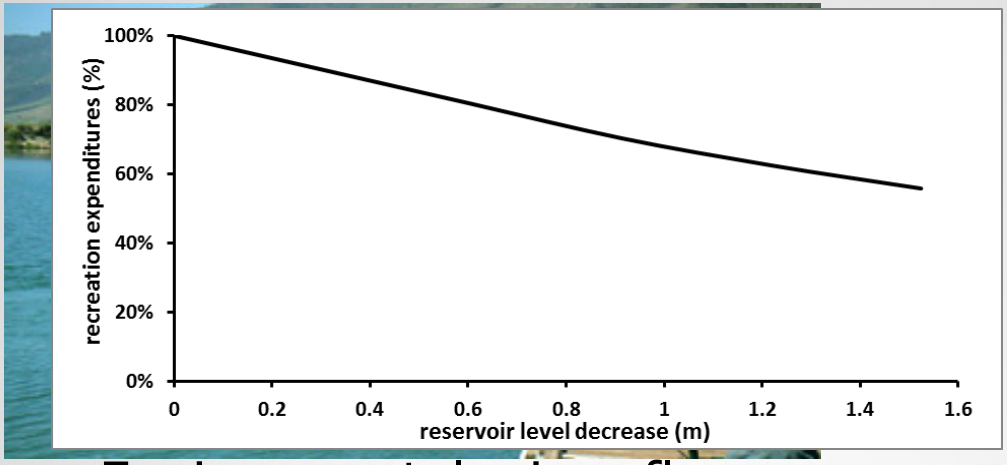
Table 5-9 Estimated Livestock Populations in the Bow Basin and Alberta, 2001

Livestock Species	Basin Total	Alberta	% Alberta
Hens and Chicken	652,531	12,175,246	5.4%
Turkey	1,123	864,438	0.1%
Cattle	532,515	6,615,201	8.0%
Calves	160,052	2,169,607	7.4%
Pigs	148,015	2,027,533	7.3%
Sheep and Lamb	19,014	307,302	6.2%
Horse and Ponies	11,640	159,962	7.3%
Bison	1,327	79,731	1.7%
Deer	204	8,331	2.5%
Elk	683	31,304	2.2%

(AMEC, 2007)

BOW RIVER BASIN SIMULATION GAMING MODEL (BRSGM)

- Main Components
  - Demand
    - Recreational: reservoir park

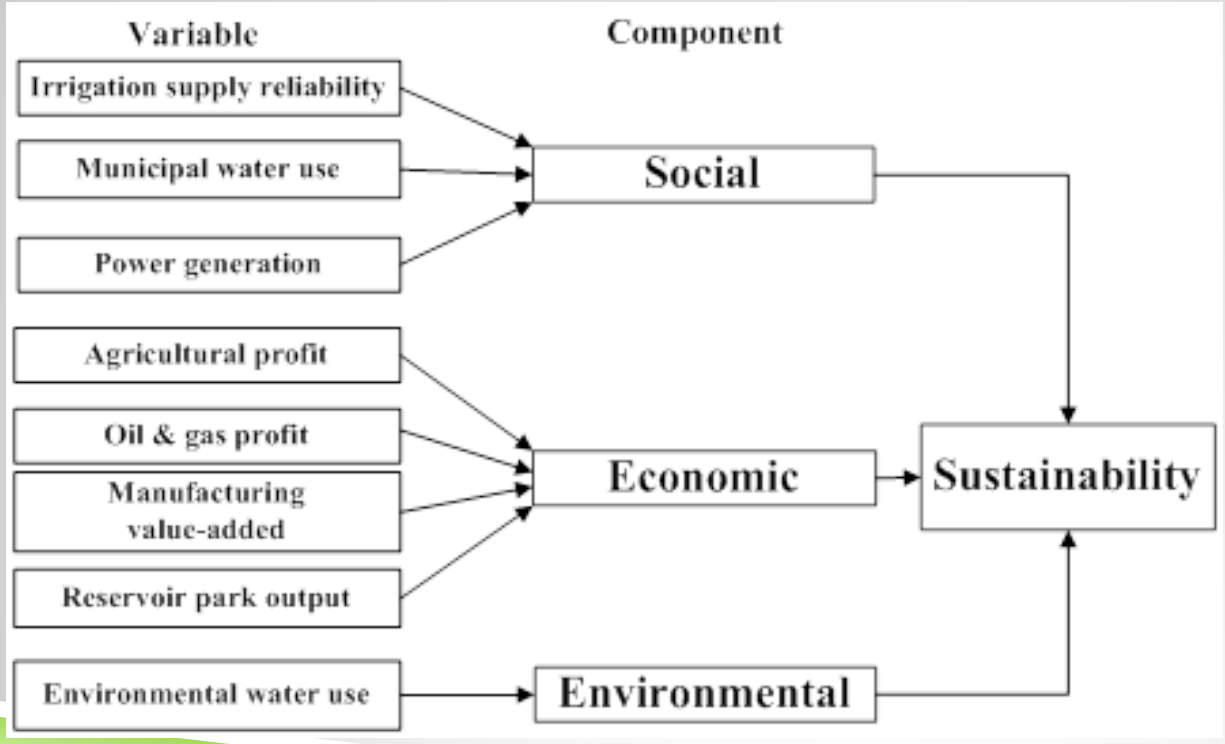


    - Environmental: river flow

Trade-off:
Water stored for recreation
vs.
Water released for irrigation or environment

BOW RIVER BASIN SIMULATION GAMING MODEL (BRSGM)

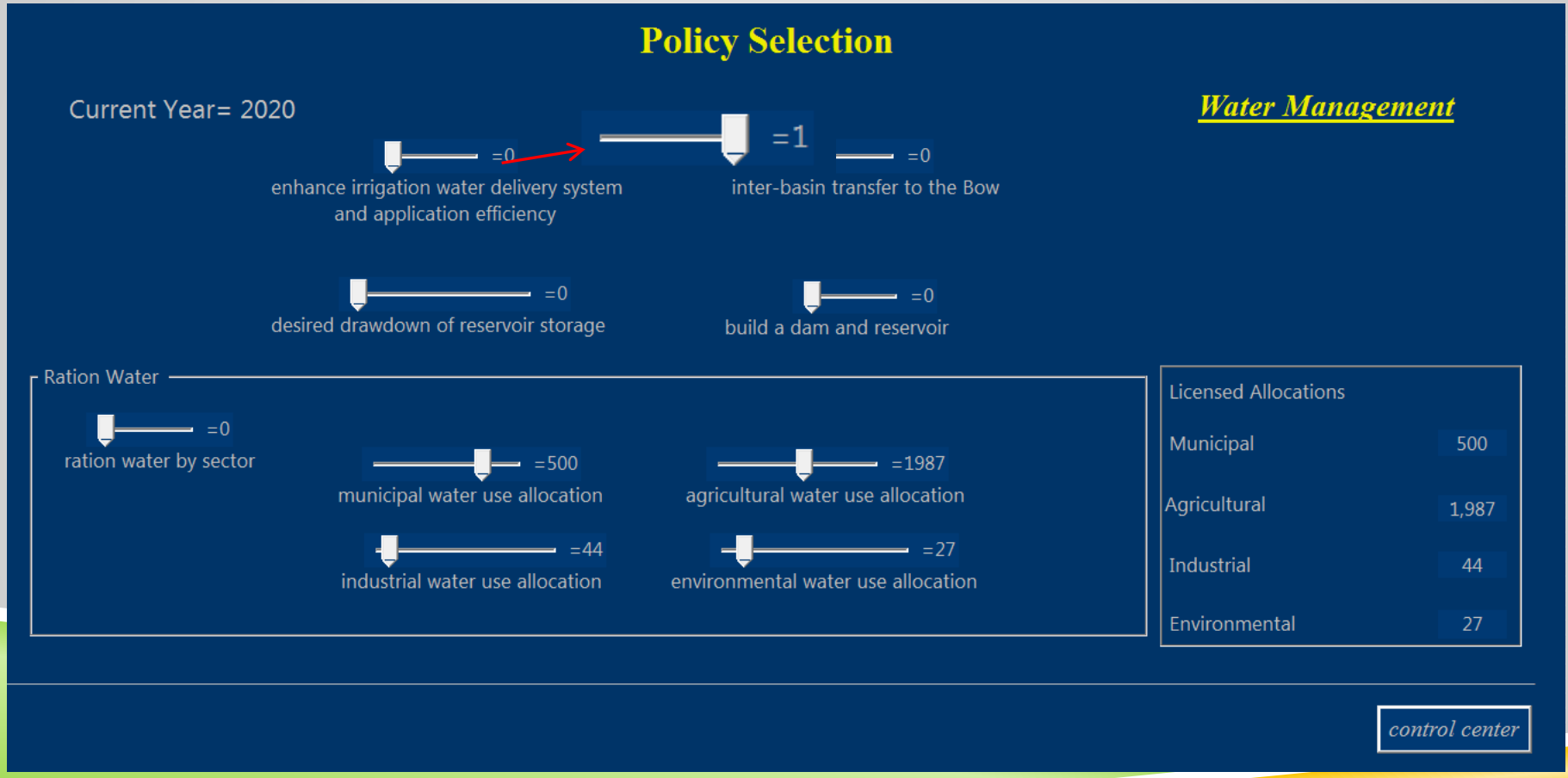
- Key Outputs



Simonovic & Fahmy (1999)
Cardwell et al. (2006)
UNESCO & IHP (2009)
GWP & TAC (2011)

BOW RIVER BASIN SIMULATION GAMING MODEL (BRSGM)

- User-friendly Interface

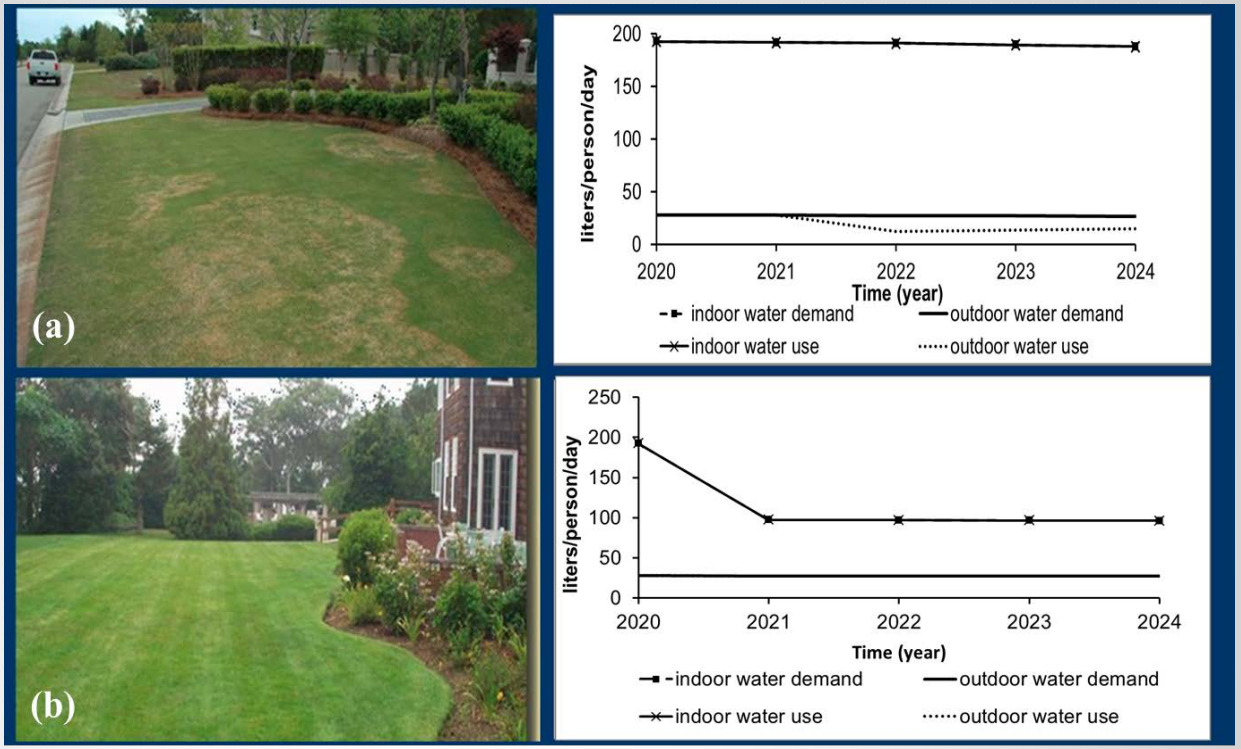


BOW RIVER BASIN SIMULATION GAMING MODEL (BRSGM)

- Simulation Examples

Team A:
water rationing

Team B:
water rationing
grey water treatment and reuse

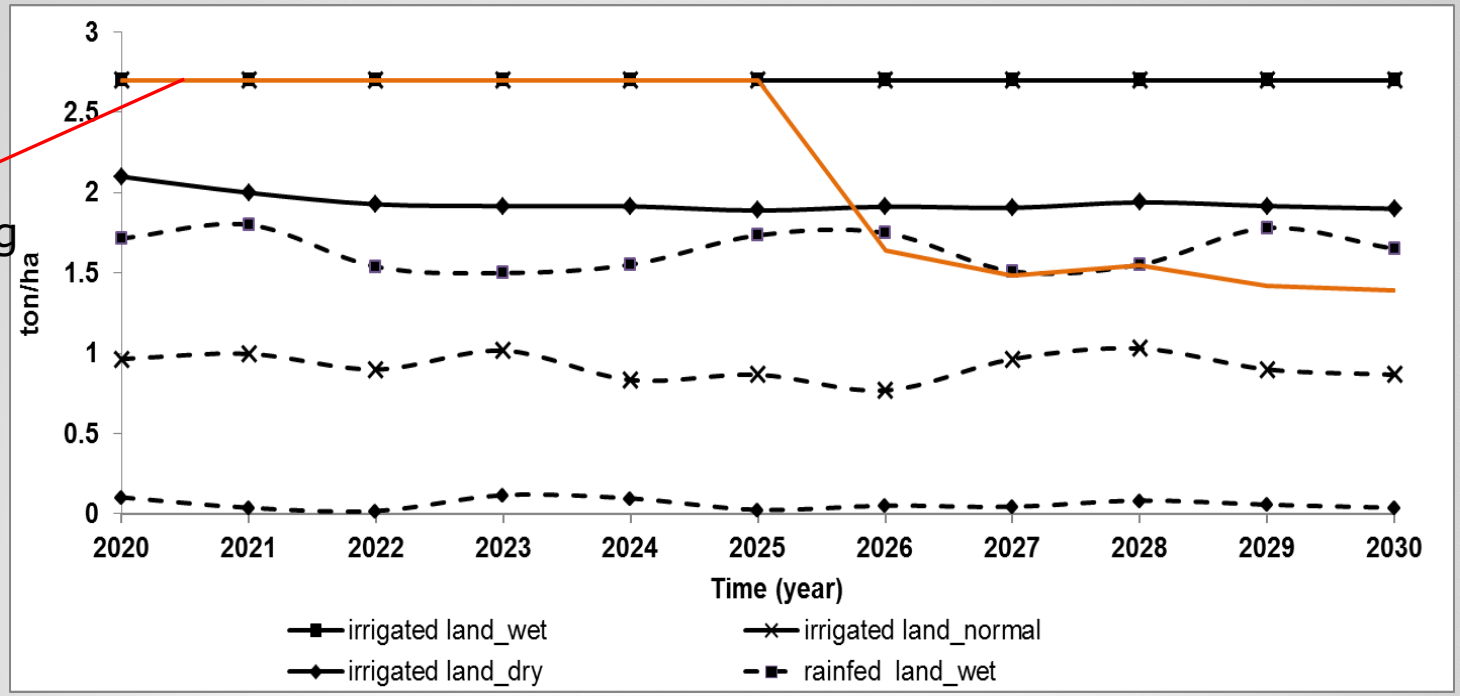


Domestic water use comparison of different policy combinations under hypothetical 2020-2024 drought

BOW RIVER BASIN SIMULATION GAMING MODEL (BRSGM)

- Simulation Examples

water rationing on irrigated land_normal



Crop yield comparison for canola under dry, normal, and wet condition 2020-2030

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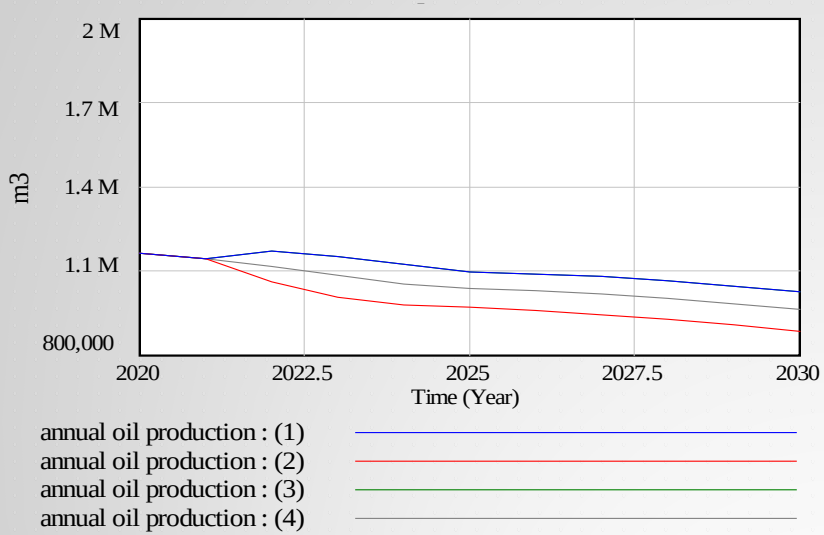
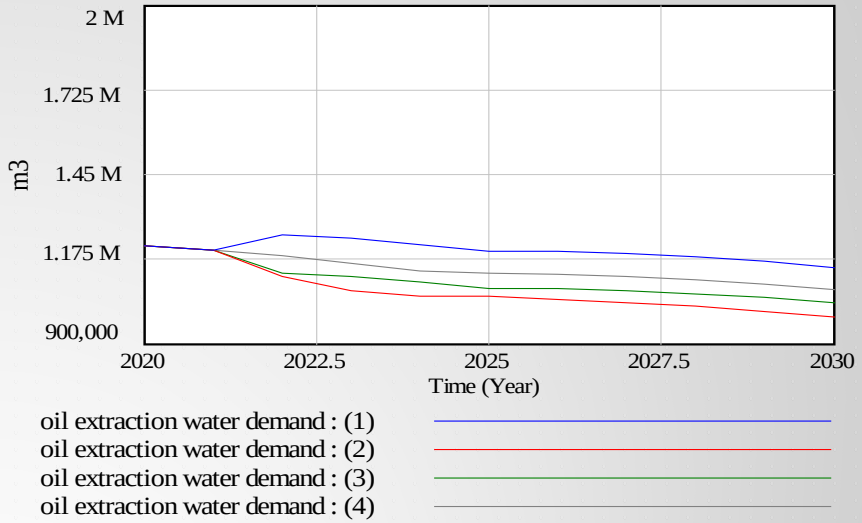
- Simulation Examples





Annual oil production & extraction water demand based on different policy combinations

NEXT STEPS

- Develop model structures
- Validate the model for Bow River Basin
- Test the model