How Narratives Influence Water Policy in the Saskatchewan River Basin

Hayley Carlson, Murray Fulton, Graham Strickert, Elmira Hassanzadeh

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Emerging trends in global freshwater availability

M. Rodell[1*], J. S. Famiglietti[2,5], D. N. Wiese[2], J. T. Reager[2], H. K. Beaudoing[1,3], F. W. Landerer[2] & M.-H. Lo[4]

Freshwater availability is changing worldwide. Here we quantify 34 trends in terrestrial water storage observed by the Gravity Recovery and Climate Experiment (GRACE) satellites during 2002–2016 and categorize their drivers as natural interannual variability, unsustainable groundwater consumption, climate change or combinations thereof. Several of these trends had been lacking thorough investigation and attribution, including massive changes in northwestern China and the Okavango Delta. Others are consistent with climate model predictions. This observation-based assessment of how the world's water landscape is responding to human impacts and climate variations provides a blueprint for evaluating and predicting emerging threats to water and food security.

Groundwater, soil moisture, surface waters, snow and ice are dynamic components of the terrestrial water cycle[1–3]. Although they are not static on an annual basis (as early water-budget analyses supposed), in the absence of hydroclimatic shifts or substantial anthropogenic stresses they typically remain range-bound. Recent studies have identified locations where terrestrial water storage (TWS; the sum of these five components) appears to be trending below previous ranges, notably where ice sheets or glaciers are diminishing in response to climate change[4,5] and where groundwater is being withdrawn at an unsustainable rate[6–8]. attribution of the TWS changes requires comprehensive examination of all available auxiliary information and data, which has never before been performed at the global scale.

Here we map TWS change rates around the globe based on 14 years (April 2002 – March 2016) of GRACE observations (Fig. 1). The GRACE data were processed using an advanced mass concentration[20] ('mascon') approach that enables improved signal resolution relative to the standard spherical-harmonic technique[21]. Best-fit linear rates of change after removing the seasonal cycle (referred to herein as 'apparent trends') are

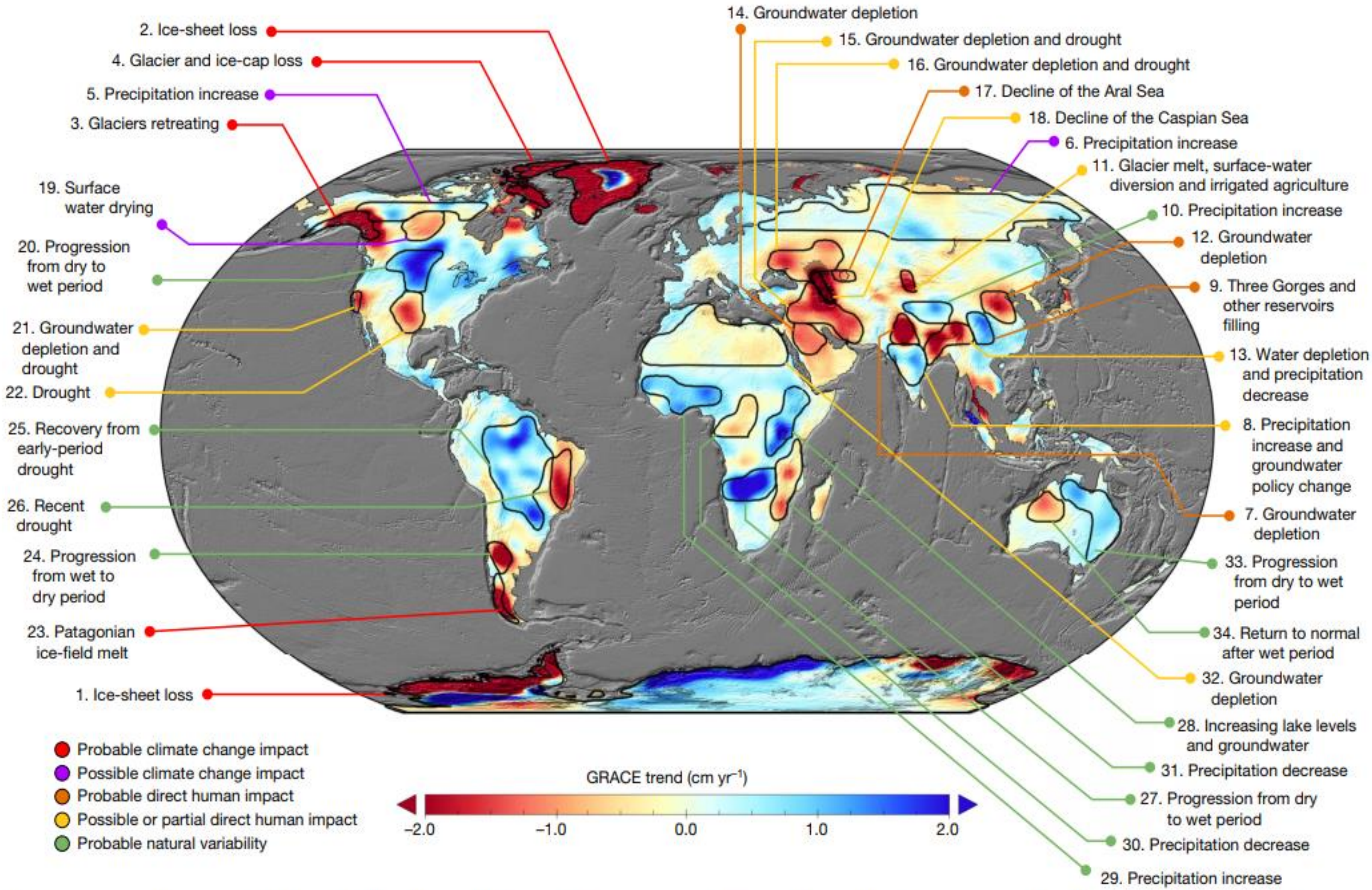

Fig. 1 | Annotated map of TWS trends. Trends in TWS (in centimetres per year) obtained on the basis of GRACE observations from April 2002 to March 2016. The cause of the trend in each outlined study region is briefly explained and colour-coded by category. The trend map was smoothed with a 150-km-radius Gaussian filter for the purpose of visualization; however, all calculations were performed at the native 3° resolution of the data product.

"GRACE has revealed considerable changes in freshwater resources occurring across the globe and has allowed them to be quantified at regional scales, unimpeded by sparse measurements or restrictive data-access policies… **provid[ing] motivation for multilateral cooperation** among nations, states and stakeholders…In the face of aquifer depletion, population growth and climate change, water and food security will depend upon water-saving technologies and **improved management and governance.**" (p.6-7)

➡ We need to get better at managing water given the unprecedented changes we observing and predicting.

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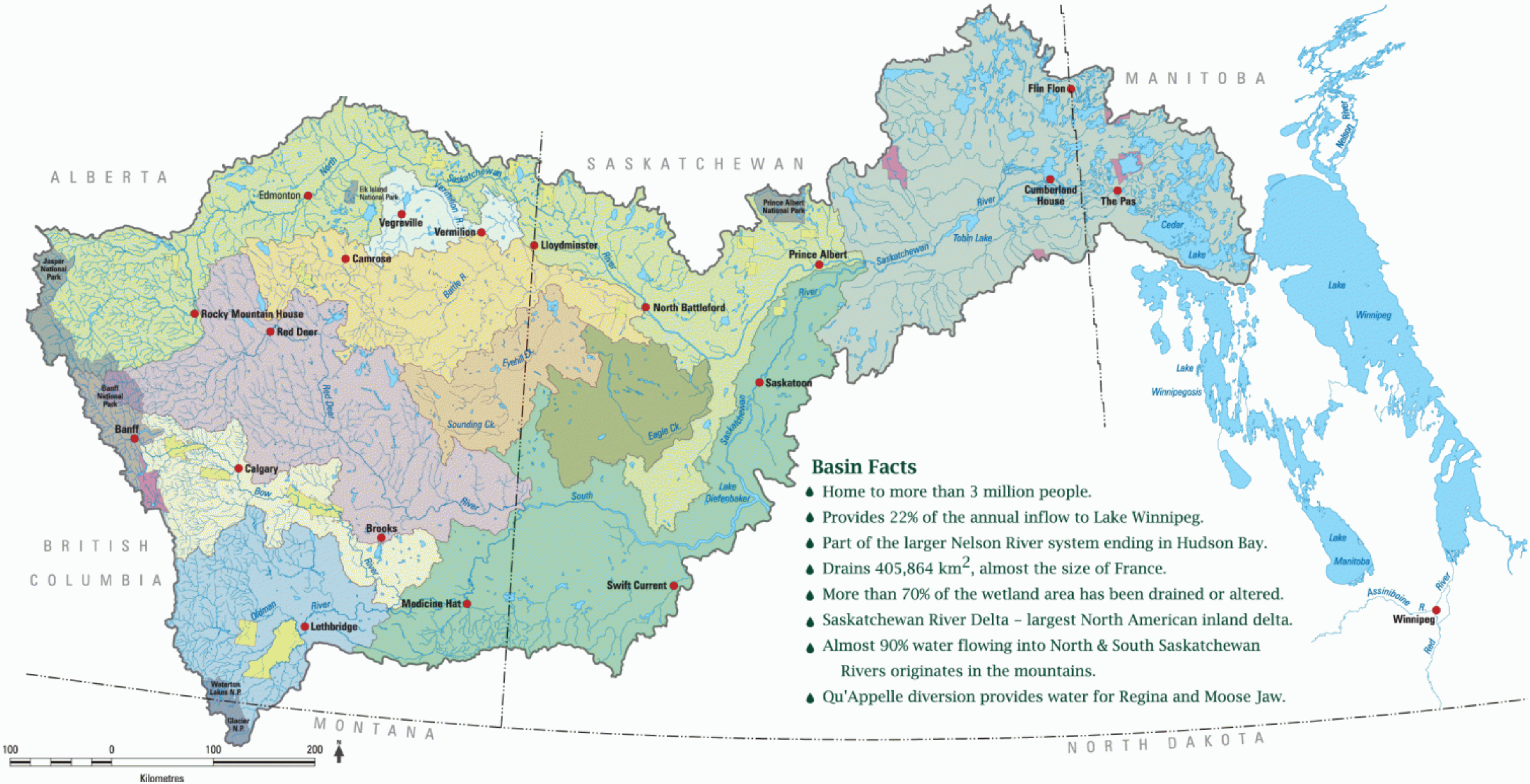
Based upon Rittel and Webber (1973)



Basin Facts

- Home to more than 3 million people.
- Provides 22% of the annual inflow to Lake Winnipeg.
- Part of the larger Nelson River system ending in Hudson Bay.
- Drains 405,864 km^2, almost the size of France.
- More than 70% of the wetland area has been drained or altered.
- Saskatchewan River Delta – largest North American inland delta.
- Almost 90% water flowing into North & South Saskatchewan Rivers originates in the mountains.
- Qu'Appelle diversion provides water for Regina and Moose Jaw.

Image courtesy of PSRB

Partners FOR the Saskatchewan River Basin

Canada's Rivers at Risk

There is more than enough water, and we are letting it all go to waste. Look at how much Alberta has profited from their water-based development.

The South Saskatchewan River runs dry

Heavy exploitation and an arid climate have made the South Saskatchewan River Canada's most threatened river in terms of environmental flows. In some areas, more water is allocated for use than is available and the river almost runs dry.

Hope for the Saskatchewan River Delta?

Saskatchewan has water; Saskatchewan has choices.

Lake Diefenbaker's Unfinished Business

The Time Has Come to Irrigate!

Saskatchewan is facing very severe water security concerns. Look at the scarcity issues Alberta is facing because of their water-based development.

KEEPING THE PROMISE!

COMPLETING THE IRRIGATION AGENDA!

Cognition

People make decisions based on patterns they interpret from their environment (Kahneman, 2011).

Decisions are a result of 'contests' between different frameworks of interpretation (Stone, 2002; Kaplan, 2008)

Cognition plays a larger role in uncertain and complex contexts (Kaplan, 2002; Stone, 2002)

Power

Power results in institutional contexts that define landscape in which management decisions are made, and result in unequal benefits across groups (Moe, 2015; Moe 2005)

Powerful actors have more capacity to defend institutions that work in favor of their agenda (Moe, 2015)

Power = money, votes position + strategic use of ideas (Stone, 2002)

Narratives

- Stories that connect ideas (Roe, 1994)
- Contain setting, characters, causal mechanisms, morals (Jones and McBeth, 2010; Ganz, 2011)
- Relay what will happen if story events unfold (Roe, 1994)
- Employ strategic techniques (numbers, metaphors, synecdoche) to influence audience (Stone, 2002)

Narrative (Content) Analysis

134 document catalogue spanning 11 SRB stakeholder groups. Materials included annual reports, studies, website materials, published interviews, media, videos.

Coding Guide

The coding guide is composed of series of questions designed to identify key features that define each water management policy existing in the Saskatchewan portion of the Saskatchewan River Basin. Of interest during the content analysis (Phase 1) is the narrative, and the unit of analysis is words, phrases, symbols and numbers.

Question 1: Does the material include a temporal sequence of events (or otherwise, a 'plot')? **Describe** them (Jones, 2010; Stone, 2002).

- In a temporal sequence of events there will be a beginning, middle and end. You must be able to identify clearly each.
- A plot indicates that the events will relate to each other: in a pattern, through cause and effect, or through coincidence. You must be able to identify the 'plot'.

Question 2: Does the material have a moral (Jones, 2010)? **Describe**.

- Right and wrong behaviour or decisions (a lesson) will be indicated.
- Proper conduct will be outlined.
- The moral must be able to be simply named and described.

Question 3: Does the material have 'dramatic moments' (Jones, 2010). **Describe** them.

- A dramatic event will be - striking, effective, emotional, startling, surprising, over the top, emphasized - in some way. Must be able to outline why it is dramatic (may depend on context).

Question 4: Does the material have 'characters' – heroes, victims, villians? **Categorize**.

- Identify the protagonist and antagonist if possible. Note, these 'characters' can be inanimate objects or systems of thinking.
- A villain/antagonist is whatever is harming victims or is at odds with the heroes.

Question 5: Does the material have symbols - stories, synecdoches, metaphors or ambiguity (Stone, 2002)? **Categorize**.

- Chapter 6 of Policy Paradox describes all of these elements in detail and the qualifications for correct categorization.
- Note that stories are similar to temporal sequence of events but Stone (2002) outlines 8 specific stories within which each narrative can be categorized.

Question 6: What numbers does the material include? Identify how they are used (Stone, 2002)? **Identify**.

- Stone (2002) outlines a number of ways in which numbers can be used in narratives including boundaries, stories, reducing complexity, norms, bolstering authority, creating communities, aiding negotiation/compromise. Categorizing numbers used in the narrative in one of these categories depends on context – could be different between coders.
- Categories are not mutually exclusive.

Nodes

Name

- Blame
  - Calculated Risk
  - Complex System
  - Conspiracy
  - Teleological
- Cause
  - Complex
  - Simple
- Characters
  - Hero
  - Victim
  - Villian
- Decision
  - Inducements
  - Powers
  - Rational Planning
  - Rights
  - Rules
- Dramatic Moment
- Facts
- Interests
  - Alliances
  - Competing interests
  - Representative - Delta community
  - Stakes
- Moral
- Numbers
- SIPA Modeling Numbers
- Symbols
  - Ambiguity
  - Metaphor
  - Story
  - Synechdote
- Temporal Sequence of Events

Table 5.3. Coding frequencies for the main narrative elements, arranged by the four SRB stakeholder groups selected for modelling.

Main Story Elements		Irrigation Agriculture	Aboriginal	Industry	Environment
Story	Decline: Environmental	0	40 to 75	0	15 to 39
	Decline: Stymied Progress	40 to 75	0	0	0
	Conspiracy Stories	0	<15	0	40 to 75
	Change-is-only-an-illusion	0	0	40 to 75	<15
Characters	Hero	15 to 39	0	>75	0
	Victim	0	40 to 75	0	15 to 39
	Villian	15 to 39	40 to 75	0	40 to 75
Cause	Unintentional	<15	0	<15	<15
	Natural	<15	0	<15	<15
	Mechanical	15 to 39	15 to 39	40 to 75	15 to 39
	Intentional	15 to 39	>75	<15	40 to 75
	Complex	<15	0	0	0
Blame	Calculated Risk	0	0	40 to 75	0
	Complex System	<15	0	0	0
	Conspiracy	0	0	0	40 to 75
	Teleological	15 to 39	>75	0	15 to 39
Solutions	Inducements	40 to 75	0	40 to 75	15 to 39
	Powers	<15	40 to 75	<15	0
	Rational Planning	15 to 39	<15	40 to 75	15 to 39
	Rights	0	<15	0	0
	Rules	15 to 39	<15	40 to 75	15 to 39

(%)
0
<15
15 to 39
40 to 75
>75

Note: coding frequencies refer to number of documents coded for this narrative element

Story Elements	Groups: Indigenous	Irrigation Agriculture	Industry	Environment
Story	*Environmental Decline* *Cultural Decline* *Conspiracy*	*Stymied Irrigation Progress*	*Development Change, is-an-illusion*	*Development Conspiracy*
Characters	Villain-Victim story	Villain-Hero story	Hero-story	Villain-Victim story
Cause	Intentional Mechanical	Intentional Mechanical Unintentional/Natural Institutional	Mechanical Unintentional Natural and Intentional	Intentional Natural Mechanical and Unintentional
Blame	Teleological*	Teleological*	Calculated Risk	Conspiracy Teleological*
Solutions	Powers Rights Rational Planning	Inducements Rational Planning Rules and Powers	Rules Rational Planning Inducements	Rules Rational Planning Inducements

*Assumes the unfavorable effects of the action taken were the intended effects of the actor.
Note: Larger text size indicates this element plays a more dominant role in the narrative based on coding frequencies.

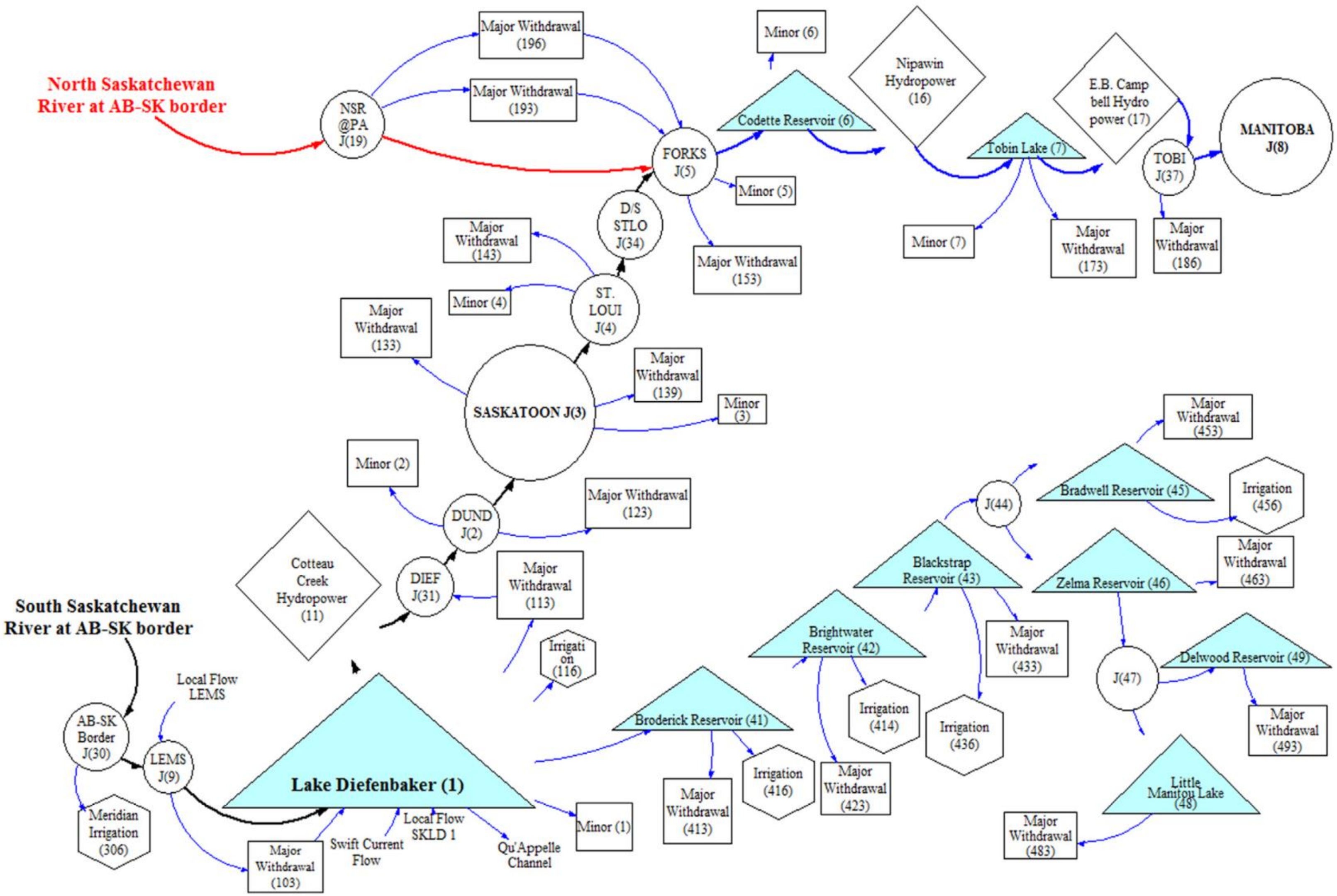


Figure 4.3. Simplified schematic of the SWAMP$_{SK}$ water resources system from Hassanzadeh *et al.*, (2014). The main flow of the SRB system (SSR, NSR and SR) follows the path of the thick black lines.

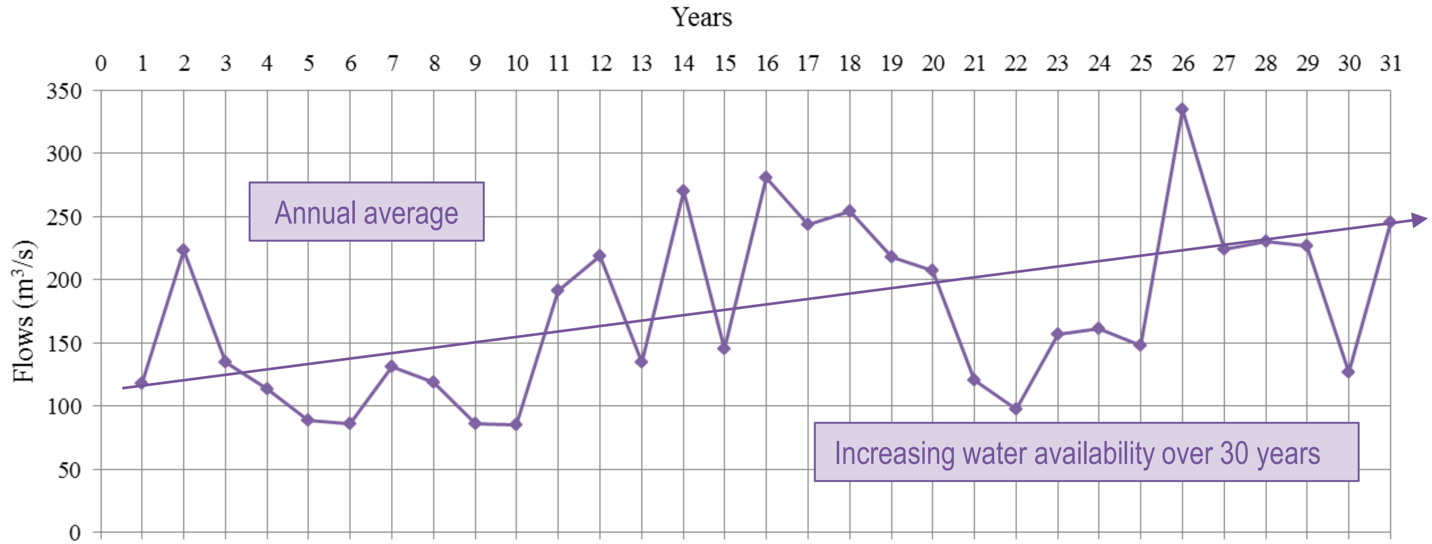
Table 4.3 Baseline and future scenarios employed during narrative modelling.

Scenario	Characteristics
S0 *No Change*	Historical flows SSR and NSR (1980 to 2010) 21,400 ha of irrigation
S2 *Irrigation Expansion*	Historical SSR and NSR flows (1980-2010) 107,000 ha of irrigation (expanded from 21,400 ha)
S3 *Irrigation Expansion and Climate Change*	Historical flows SSR and NSR (1980 to 2010) 107,000 ha of irrigation (expanded from 21,400 ha) 5% drop in historical flows for the NSR 8.5% drop in flows for the SSR

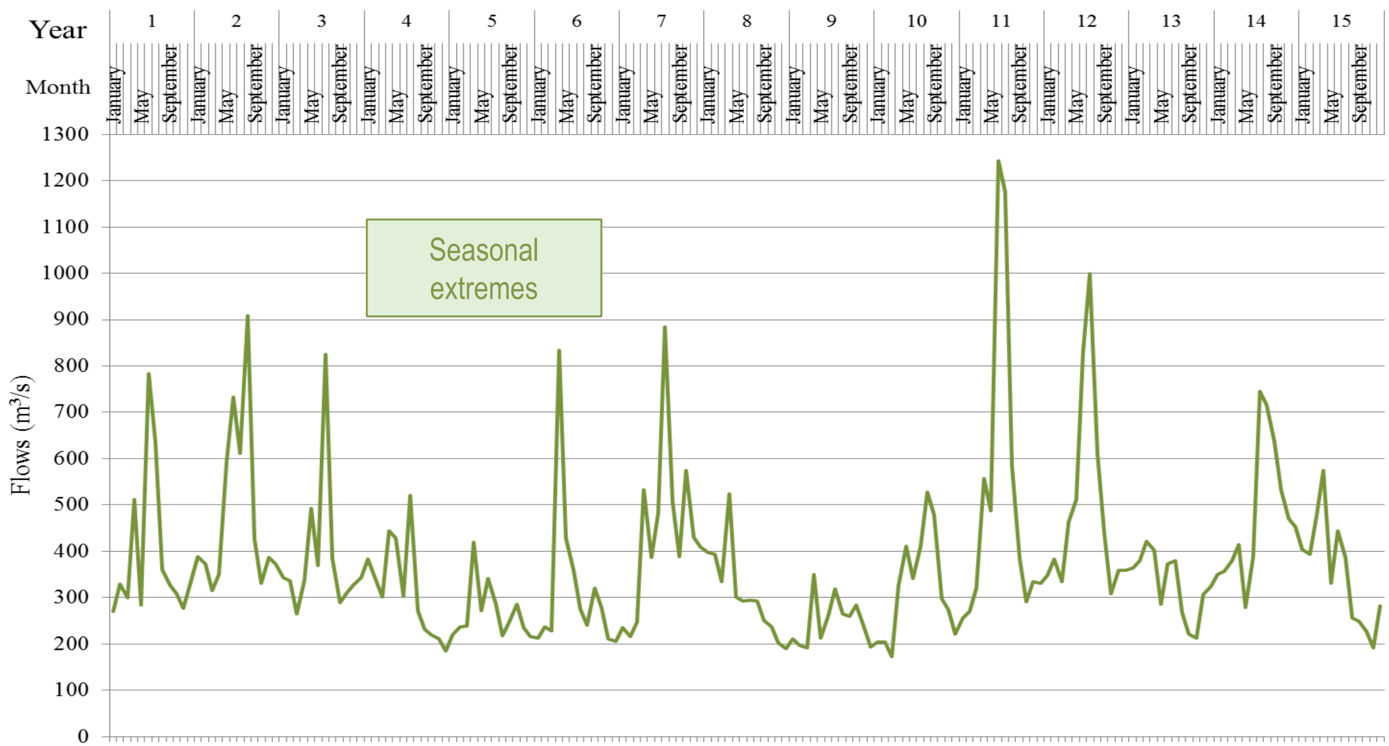
Variable Type	Variables	
	Stymied Irrigation Progress	*Environmental Decline*
Stochastic Variables	Apportioned South Saskatchewan River and North Saskatchewan River flows (monthly and annual from 1980 to 2010) Precipitation Temperature Evapotranspiration rates	
Market and Policy Parameters	Industrial and Municipal water demands Agricultural area (irrigated acres) Lake Diefenbaker operating policies 2012 prices and costs associated with hydropower generation Revenues and costs associated with potash mining (in 2012)	
Narrative Variables	**Annual average**: Annual historical flows from 1980-2010 (m^3/s)	**Seasonal variation**: Monthly historical flows from 1980-2010 (m^3/s)
	Irrigation focus: Flows values (SSR) reported before Saskatoon	**River Delta focus**: Flow values (SR) reported into the SRD
	Direct **on-farm economic benefit**: Profit of $186.34 per irrigated acre	Impact to **habitat:** Surface water coverage area (km^2) $=1.76x^{0.63}$ where x is discharge at the entry to the SRD
	Direct, Indirect and Induced **societal economic benefit**: $851.2 in sales, $485.7 to GDP, $307.4 in income per irrigated acre	Impact to **wildlife:** Habitat Quality for moose (between 5 and 10 % surface water coverage)
	Direct **employment benefit**: 9.1persons employed per 1000 irrigated acres.	Impact by **human development:** Flows with and without the E.B. Campbell Dam in an 'environmental flow gap'

Flows **in a future like the present** from the perspective of…

Stymied Irrigation Progress

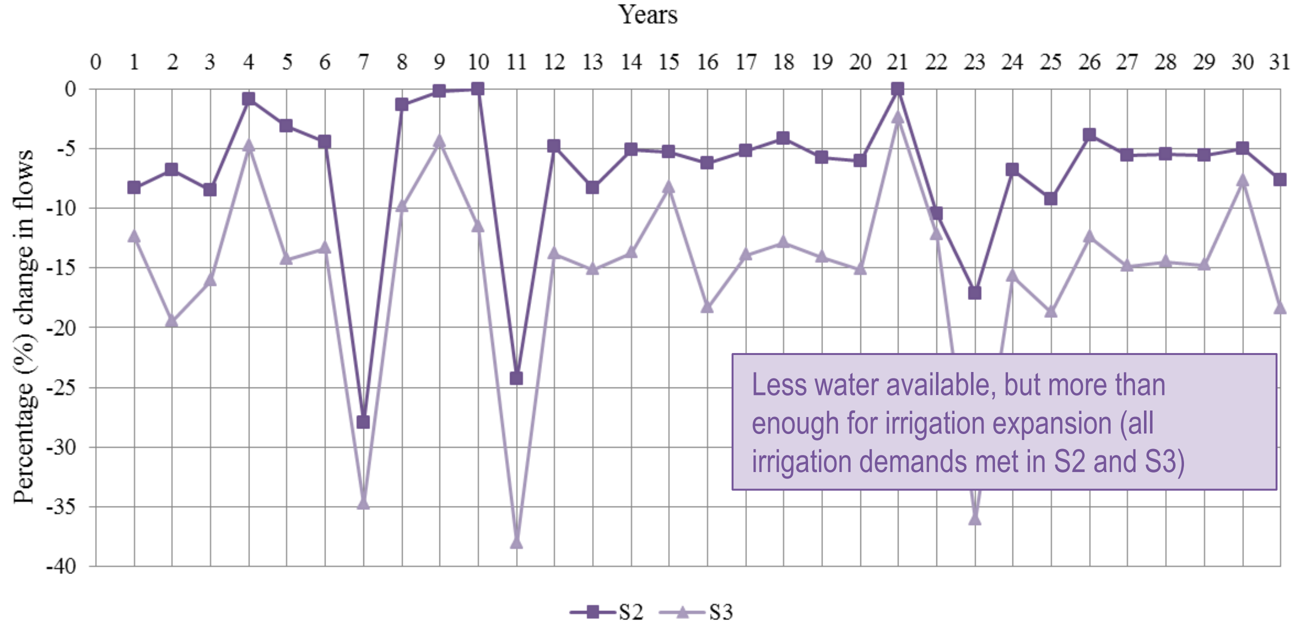


Environmental Decline

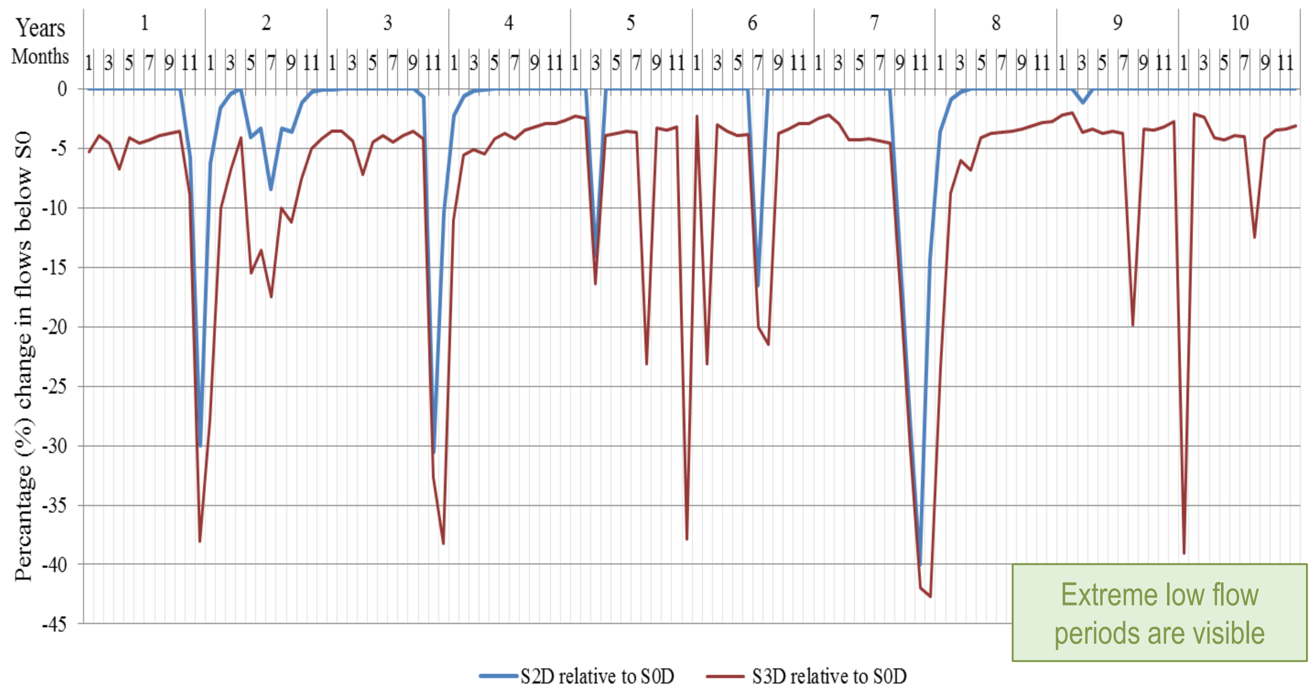


Flows in a future with an **irrigation expansion** and an **irrigation expansion + climate change impacts** from the perspective of….

Stymied Irrigation Progress



Environmental Decline



“Environmental Flow Gap” or the difference in flows with and without the E.B. Campbell Dam = $\alpha + \beta 1January_T + \beta 2Feburary_T + \beta 3March_T + \beta 4April_T + \beta 5May_T + \beta 6June_T + \beta 7August_T + \beta 8September_T + \beta 9October_T + \beta 7November_T + \beta 8December_T + \mu$

Table 6.2. ‘Environmental flow gap’ regression results in three future scenarios

	Dependent Variable: Difference between flows with and without the E.B. Campbell Dam		
Variables	**S0** (S0D-S0N)	**S2** (S2D-S2N)	**S3** (S3D-S3N)
(Intercept)	0.21*	1.0*	0.6*
	(-0.21)	(-1.05)	-0.8
January	6.5*	5.7*	6.2*
	(-4.61)	(-4.06)	(-6.54)
February	34.3*	33.5*	33.0*
	(-24.24)	(-23.86)	(-35.94)
March	7.1*	6.2*	6.7*
	(-4.98)	(-4.44)	(-7.1)
April	-12.2*	-13.0*	-10.6*
	(-8.59)	(-9.26)	(-11.19)
May	-21.7*	-22.5*	-23.9*
	(-15.31)	(-16.03)	(-25.28)
June	-7.4*	-8.2*	-7.1*
	(-5.20)	(-5.81)	(-7.51)
August	3.1*	1.3	1.8
	(-2.18)	(-0.96)	(-1.91)
September	8.2*	7.3*	7.8*
	(-5.78)	(-5.26)	(-8.28)
October	10.3*	9.5*	10.0*
	(-7.28)	(-6.77)	(-10.55)
November	4.5*	3.7*	4.2*
	(-3.21)	(-2.66)	(-4.45)
December	-23.5*	-24.4*	-23.9*
	(-16.61)	(-17.34)	(-25.27)
R^2	0.88	0.88	0.88
N	372	372	372

*Coefficients statistically significant at 95% confidence (t=1.96; p=0.05)
Note: Numbers in brackets are estimated t-statistics

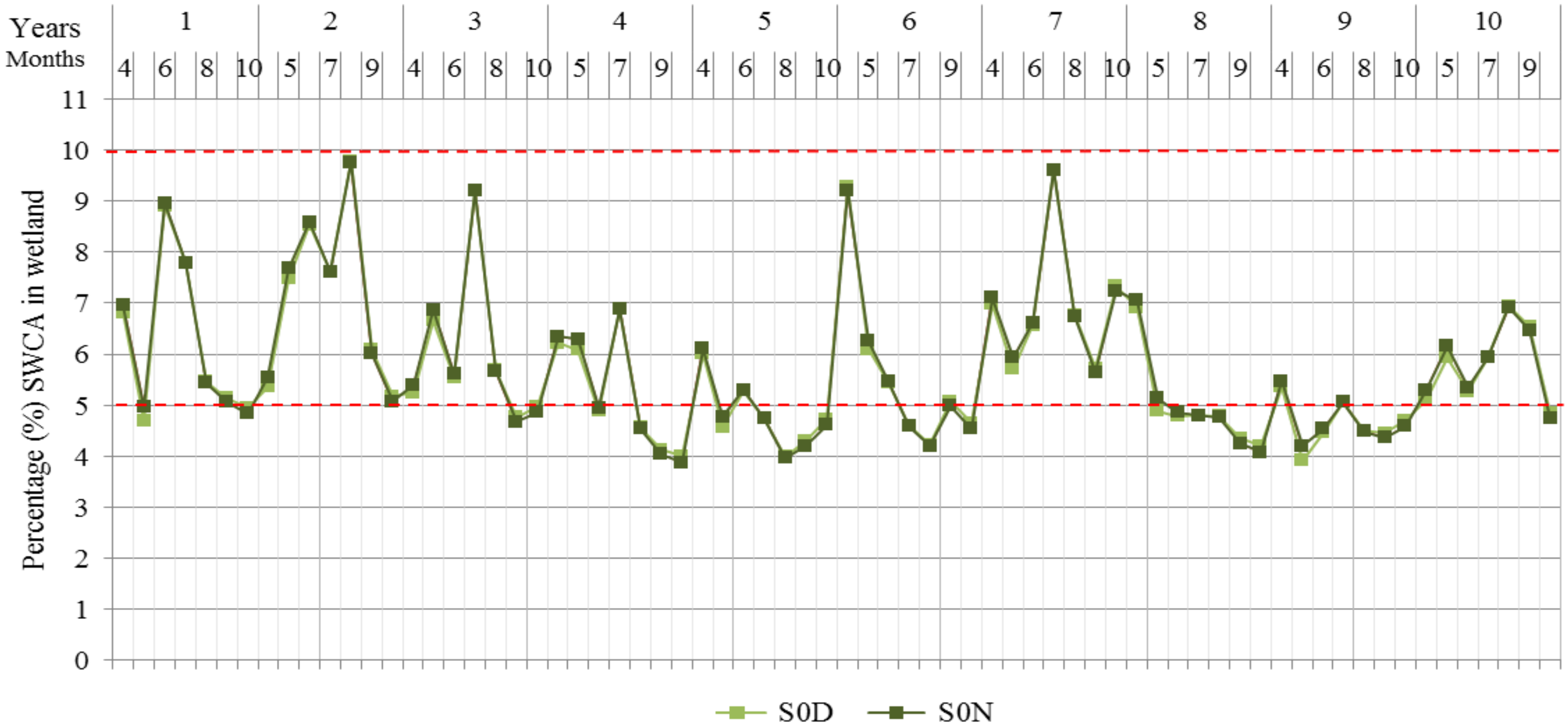


Figure 6.8. Wildlife habitat suitability with (light green) and without (dark green) the impact of human development in the *Environmental Decline* future scenarios S0D and S0N. Values show the percentage of SWCA over the total study area (1315km^2).

	S0		S2		S3	
	D	*N*	*D*	*N*	*D*	*N*
Number of months percentage of SWCA falls below 5%	68	67	73	71	86	84
Number of months percentage of SWCA falls above 10%	12	12	11	10	7	6
Total months unsuitable (%)	80 (37%)	79 (36%)	84 (39%)	81 (37%)	93 (43%)	90 (41%)

Notes: SWCA is calculated as a percentage of wetland areas (a representative study area of 1315 km^2 is used) for the ice-free season (April to October) for 31 years (N=217). Percentages over 10% and below 5% are considered less suitable for moose.

Table 6.3. Impact to wildlife in Environmental Decline S0, S2 and S3 simulations.

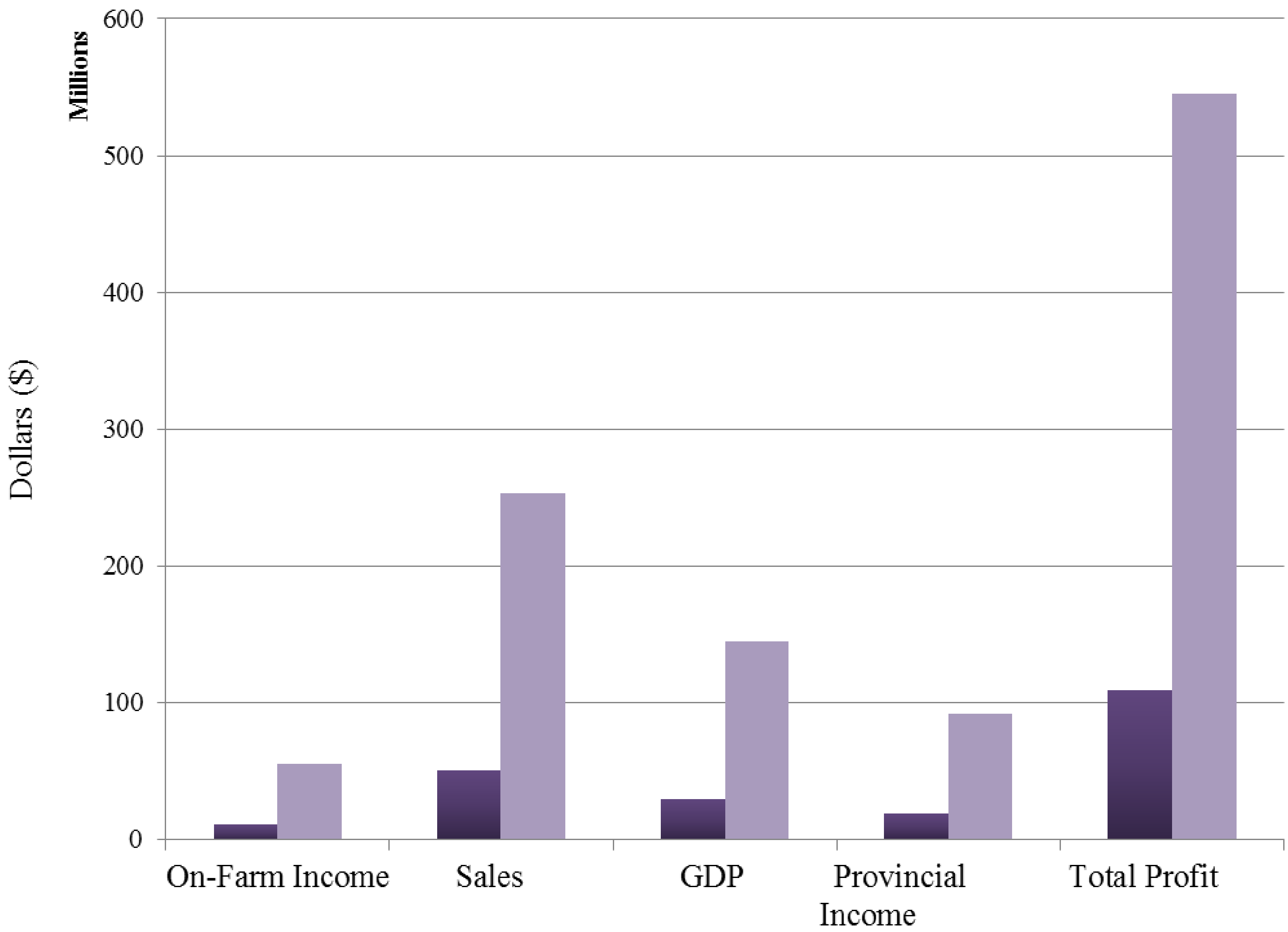
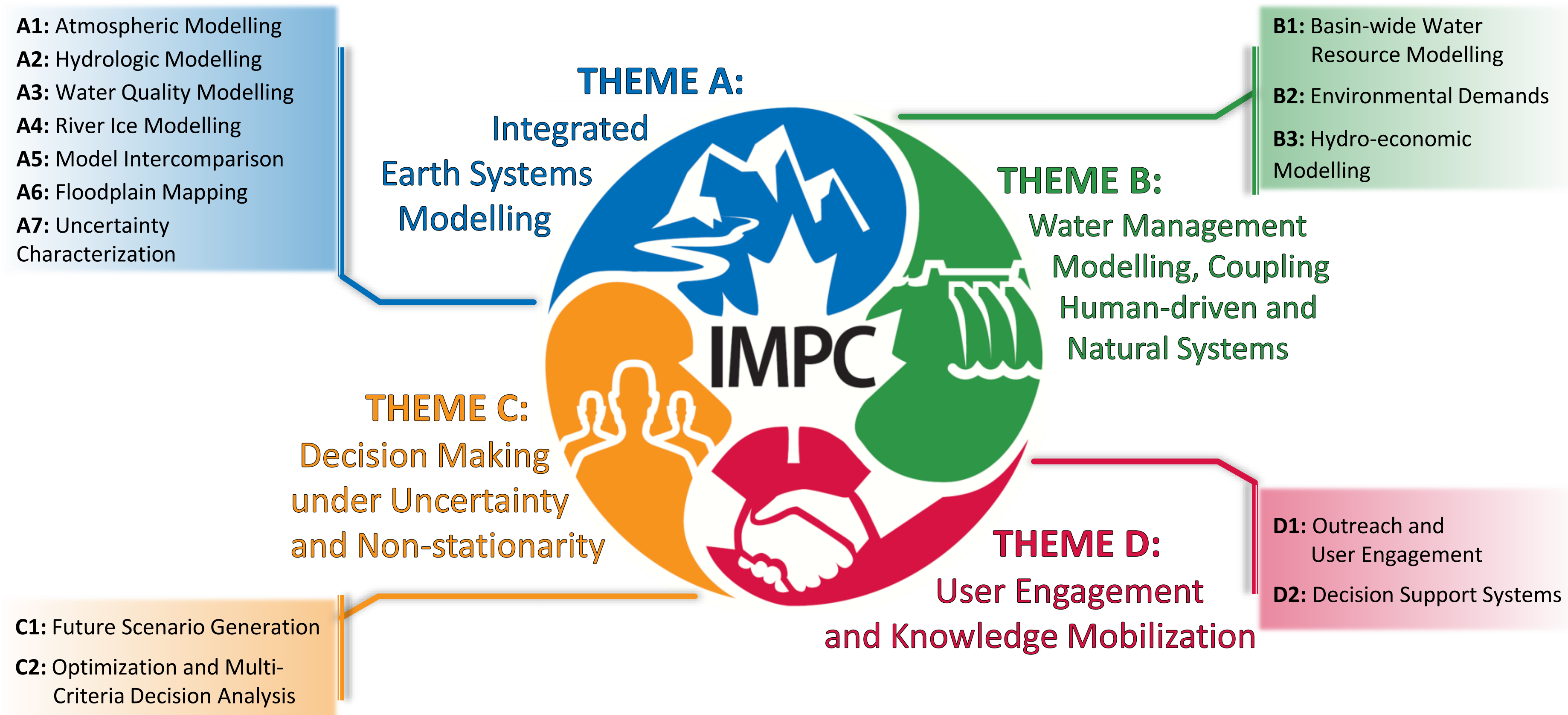


Figure 6.13 Direct and societal irrigation economic benefits in the *Stymied Irrigation Progress* S0, S2 and S3 simulations. Benefits are depicted on an annual basis for 59, 552 acres in S0 (dark purple) and 297, 761 acres for S2 and S3 (light purple), combined in this graphic.

Conclusion

- Several distinct stories about SRB water management exist in Saskatchewan.
  - Discussion around water planning becomes difficult because advocacy for one policy outcome is associated with the baggage of assumptions represented by the narrative variables.
- Divergent views matter for water policy and planning.
  - Decision-makers are exposed to real differences in how the future will unfold and what is at stake.
  - Results also suggest there are real costs in the case where one narrative successfully influences the policy outcome but a competing frame comes to more accurately represent reality.

Is the current interpretive framework guiding our decision-making in Saskatchewan going to prepare us well for the future?


A1: Atmospheric Modelling
A2: Hydrologic Modelling
A3: Water Quality Modelling
A4: River Ice Modelling
A5: Model Intercomparison
A6: Floodplain Mapping
A7: Uncertainty Characterization
THEME A:
Integrated Earth Systems Modelling
B1: Basin-wide Water Resource Modelling
B2: Environmental Demands
B3: Hydro-economic Modelling
THEME B:
Water Management Modelling, Coupling Human-driven and Natural Systems
IMPC
THEME C:
Decision Making under Uncertainty and Non-stationarity
C1: Future Scenario Generation
C2: Optimization and Multi-Criteria Decision Analysis
THEME D:
User Engagement and Knowledge Mobilization
D1: Outreach and User Engagement
D2: Decision Support Systems

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