Climate Change and Water: Adaptation

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Outline

• Challenge of managing for multiple objectives within a scenario of climate change
• Opportunity for participatory approaches
• Climate change adaptation case studies:
  – Colorado Basin
  – Okanagan Basin
• Conclusions
Water Resources in the Columbia River Basin

System objectives affected by winter flows
Winter hydropower production (PNW demand)

System objectives affected by summer flows
Flood control
Summer hydropower production (California demand)
Irrigation
Instream flow for fish
Recreation

Source: Alan Hamlet
University of Washington
Columbia Basin

*Impacts of Climate Change on Streamflow*

- Less snow, earlier melt means less water in summer
  - irrigation
  - urban uses
  - fisheries protection
  - energy production
- More water in winter
  - energy production
  - flooding

*Natural Columbia River flow at the Dalles, Oregon*

Source: P. Mote, University of Washington
Climate change adaptation may involve complex tradeoffs between competing system objectives.

Source: Barnett et al., 2005 (Nature).
The Leaky Boat & the Juggling Act

I’m sure glad the hole isn’t in our end . . .
Participatory approach can help to build the science-policy bridge

- Role of local experts (practitioners, stakeholders) in climate change impacts-adaptation research
  - Local context (planning, decision-making)
  - Data, operational perspectives
  - Professional networks
  - Local governments

- Experts become extension agents for local adaptation
  - Role of research community changes from initiator of studies to resource for community-based assessments
  - Broadens base of investments in impacts-adaptation research
  - Potential for increased support for monitoring
Climate change information flow to stakeholders?

**Climate Information**
- Forecasts
- Trends
- Scenarios

**Stakeholder Interest**
- Regional development
- Jobs
- Liability
- Quality of life

outreach
Climate Change: The Medium is the Message

Climate information
- Forecasts
- Trends
- Scenarios

Filter/medium
- Hydrograph
- Crop model
- Malaria risk model
- Decision support tool

Practitioner interest
- Risk assessment
- Design standards
- Operating rules
- Allocations

......translation from climate science to practitioner interest
Participatory approach...link with practitioners (Cohen and Waddell, in press)

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delivery
translation
extension
policy
Building the science-policy bridge…

- Dialogue with local experts/practitioners as part of integration; beyond serving as an information source and outreach process

Okanagan climate change study team visit to Penticton Dam, June 2002
Colorado Basin

- Supplies water for 25 million people
- By 2020, will need to support 38 million
- Natural inflows have been below average in 7 of the last 9 years
Drought in the Colorado Basin: recent impacts and future scenarios

• Below average runoff since 2000, accompanied by 0.8 °C rise in temperature since 1950s
  – Increasing losses in snowpack, reduced soil moisture, increasing water demands
  – Initial allocations made during 1905-1925, a relatively wet period; this continues to influence management decisions

• Projected runoff decrease by 20% by 2050s, and 30% by end of 21st century (Milly et al., 2005)

• Requirements of Colorado River Compact would be met only 60-75% by 2025 (Christensen et al., 2004)
Inclusion of stakeholders in the Colorado Basin water management has become the norm

- National Integrated Drought Information System (NIDIS) created in 2006; result of ongoing drought conditions in Colorado Basin (www.drought.gov).
  - Coordinates information providers, users, monitoring, forecasting, risk and impact assessments, preparedness planning, and communication
Cross-scale issues in the integrated water management of the Colorado River Basin  
(*Pulwarty and Melis 2001*)

<table>
<thead>
<tr>
<th>Temporal Scale</th>
<th>Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indeterminate</td>
<td>Flow necessary to protect endangered species</td>
</tr>
<tr>
<td>Long-term</td>
<td>Inter-basin allocation and allocation among basin states</td>
</tr>
<tr>
<td>Decade</td>
<td>Upper basin delivery obligation</td>
</tr>
<tr>
<td>Year</td>
<td>Coordinated Lake Powell -Lake Mead storage requirements</td>
</tr>
<tr>
<td>Seasonal</td>
<td>Peak heating and cooling months</td>
</tr>
<tr>
<td>Daily-monthly</td>
<td>Flood control operations</td>
</tr>
<tr>
<td>Hourly</td>
<td>Western Area Power Administration’s power generation</td>
</tr>
</tbody>
</table>

| Spatial Scale   |                                                                             |
|-----------------|                                                                             |
| Global          | Climate influences, Grand Canyon National Park                            |
| Regional        | Prior appropriation (e.g. Upper Colorado River Commission)                |
| State           | Different agreements on water marketing within and out of state water district |
| Municipal and Communities | Watering schedules, treatment, domestic use                      |
Okanagan Basin – snowmelt watershed with semi-arid climate

Supply depends on storage in
• upland reservoirs
• mainstem lakes
• ground water (limited)

Photos: upper left—Kelowna and Okanagan Lake, lower left—Osoyoos and Osoyoos Lake (Denise Neilsen); right—installation of intake at Penticton, Okanagan Lake (Bob Hrasko)
Water Resources in the Okanagan Basin

Part of the Columbia Basin, British Columbia

- Area = 8200 km²
- Okanagan Valley = 160 km in length
- Population = 310,000 (1999 approx.); 13 municipalities, 3 regional districts, 4 First Nation communities, 59 “improvement districts”
- Agriculture: fruit, vineyards, pasture; 40% irrigated lands; 3% decrease since 1976 due to urbanization

Source: Cohen and Kulkarni (2001); map from Alan Hamlet (U. Washington)
Okanagan Basin, British Columbia

- Rapid population growth
- 80% of streams fully recorded
The 2003 Okanagan drought & fire
Responding to future climate change & population growth?
Agricultural land use in the Okanagan Basin (photos from Denise Neilsen)
Risks associated with water supply and demand in response to climate change (Neilsen et al., 2004)

Maximum allowable demand – 2002 use

Local defined drought – 30% average annual flow
Domestic Demand Side Management
Oliver, CGCM2 A2, Medium Population Growth
(Neale et al, 2007)

Year

Water Demand (ML)

2001 Baseline
Current DSM
Education
Metering CUC
Metering IBR
Xeriscaping
High Eff Retrofit
Combined
Okanagan adaptation costs, based on recent & proposed water projects *(source: McNeill & Hrasko, 2006)*

<table>
<thead>
<tr>
<th>#</th>
<th>PROJECTS (Listed by $ / ML)</th>
<th>Component</th>
<th>Annual ML Developed</th>
<th>TOTAL COST</th>
<th>$ / ML</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>City of Penticton - Okanagan Lake Intake Pipe</td>
<td>Mainstem</td>
<td>8300</td>
<td>$947,381</td>
<td>$114</td>
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<tr>
<td>13</td>
<td>Glenmore-Ellison Improvement District - Airport Well No. 2</td>
<td>GW</td>
<td>1250</td>
<td>$258,060</td>
<td>$206</td>
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<td>9</td>
<td>District of Salmon Arm - Canoe Lake Intake Pipe</td>
<td>Mainstem</td>
<td>3000</td>
<td>$755,798</td>
<td>$252</td>
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<tr>
<td>14</td>
<td>City of Kelowna - UV Disinfection</td>
<td>WT</td>
<td>12775</td>
<td>$3,780,000</td>
<td>$296</td>
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<tr>
<td>3</td>
<td>Black Mountain Irrigation District - Mission Lake Reservoir (proposed)</td>
<td>Watershed</td>
<td>1850</td>
<td>$773,548</td>
<td>$418</td>
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<td>15</td>
<td>Black Mountain Irrigation District - WTP Clarification Only</td>
<td>WT</td>
<td>12775</td>
<td>$5,541,618</td>
<td>$434</td>
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<tr>
<td>10a</td>
<td>South East Kelowna Irrigation District - Irrigation Metering Program</td>
<td>Conserv.</td>
<td>2925</td>
<td>$1,318,362</td>
<td>$451</td>
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<td>11</td>
<td>Black Mountain Irrigation District - Irrigation Metering Program (proposed)</td>
<td>Conserv.</td>
<td>1760</td>
<td>$1,050,155</td>
<td>$597</td>
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<td>2</td>
<td>South East Kelowna Irrigation District - Turtle Lake Expansion (proposed)</td>
<td>Watershed</td>
<td>2096</td>
<td>$1,944,000</td>
<td>$927</td>
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<tr>
<td>1b</td>
<td>Lakeview Irrigation District - 1993 Big Horn Dam (to full pool in 1993)</td>
<td>Watershed</td>
<td>3400</td>
<td>$3,141,882</td>
<td>$924</td>
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<td>7</td>
<td>Glenmore-Ellison Improvement District - Okanagan Lake Supply (proposed)</td>
<td>Mainstem</td>
<td>6400</td>
<td>$6,268,388</td>
<td>$1,027</td>
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<tr>
<td>1a</td>
<td>Lakeview Irrigation District - 1993 Big Horn Dam (existing)</td>
<td>Watershed</td>
<td>2295</td>
<td>$2,356,412</td>
<td>$1,027</td>
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<tr>
<td>6</td>
<td>District of Summerland - Trout Creek Pump Station (proposed)</td>
<td>Mainstem</td>
<td>3494</td>
<td>$4,802,816</td>
<td>$1,375</td>
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<td>1c</td>
<td>Lakeview Irrigation District - 2005 Big Horn Dam expansion</td>
<td>Watershed</td>
<td>1105</td>
<td>$1,643,532</td>
<td>$1,487</td>
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<tr>
<td>12</td>
<td>City of Kelowna - Domestic Metering Program</td>
<td>Conserv.</td>
<td>2900</td>
<td>$5,822,097</td>
<td>$2,008</td>
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<tr>
<td>5</td>
<td>Lakeview Irrigation District - Lambly Creek Dam (proposed)</td>
<td>Moderate</td>
<td>8100</td>
<td>$17,743,839</td>
<td>$2,191</td>
</tr>
<tr>
<td>10b</td>
<td>South East Kelowna Irrigation District - Domestic Metering (proposed)</td>
<td>Conserv.</td>
<td>266</td>
<td>$665,451</td>
<td>$2,502</td>
</tr>
<tr>
<td>16</td>
<td>City of Penticton - WTP Conventional Filtration</td>
<td>WT</td>
<td>7300</td>
<td>$20,389,687</td>
<td>$2,793</td>
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<tr>
<td>17</td>
<td>Westbank Irrigation District - Infiltr DAF</td>
<td>WT</td>
<td>6570</td>
<td>$18,600,000</td>
<td>$2,831</td>
</tr>
<tr>
<td>18</td>
<td>City of Kamloops - Membrane Filtration</td>
<td>WT</td>
<td>19467</td>
<td>$58,060,800</td>
<td>$2,983</td>
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<tr>
<td>19</td>
<td>Lakeview Irrigation District - DAF Filtration WTP (proposed)</td>
<td>WT</td>
<td>5475</td>
<td>$17,015,806</td>
<td>$3,108</td>
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<td>20</td>
<td>Lakeview Irrigation District - Actiflo Filtration WTP (proposed)</td>
<td>WT</td>
<td>5475</td>
<td>$18,006,311</td>
<td>$3,289</td>
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<td>21</td>
<td>Lakeview Irrigation District - Conventional WTP (proposed)</td>
<td>WT</td>
<td>5475</td>
<td>$18,173,030</td>
<td>$3,319</td>
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<td>4</td>
<td>Black Mountain Irrigation District - Black Mountain Reservoir (proposed)</td>
<td>Watershed</td>
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<td>$22,944,641</td>
<td>$4,988</td>
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<td>22</td>
<td>Lakeview Irrigation District - Membrane Filtration WTP (proposed)</td>
<td>WT</td>
<td>5475</td>
<td>$30,966,849</td>
<td>$5,656</td>
</tr>
</tbody>
</table>

*GW = groundwater

*Watershed = supply expansion

*WT = water treatment

*Conserv. = manage demand
Impact on Okanagan Water Management

- Incorporation of climate change into Trepanier Landscape Unit Water Management Plan
  - Recommends demand management as first priority, along with supply augmentation, by 2050 if no climate change assumed, and by 2020 if climate change is assumed
Moving Beyond The Damage Report

an opportunity for participatory integrated assessment (PIA) & decision support....

![Image showing the concept of combining Technical Info & Data with Experience Based Knowledge & Values to create a Decision Support Model.]

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The image shows a visual representation of the process described in the text. It illustrates the idea of combining technical information and data with experience-based knowledge and values to create a decision support model. The images depict people in a participatory setting, which aligns with the concept of participatory integrated assessment (PIA).
Preliminary sketch of decision model

(\textit{Langsdale et al., 2006, 2007})
Input from some participants at Okanagan study model building workshop, April 2005 (Cohen & Neale, 2007)
2040-2069 case; Upland agriculture supply-demand balance, (1) No adaptation; (2) adaptation DSM & densification implemented.
2040-2069 case; Agriculture supply-demand balance; (1) No adaptation; (2) supplement with Okanagan Lake; no other adaptation
Consequences: OK Lake Outflow for Sockeye Habitat and Instream Flows for Upland Streams

2040-2069 climate change & high population growth; Uplands instream allocation target,
(2) supplement with Okanagan Lake; no other adaptation
(1) No adaptation; (2) supplement with Okanagan Lake; no other adaptation
2040-2069 case; Okanagan Lake stage; (1) No adaptation; (2) supplement with Okanagan Lake; no other adaptation
2040-2069 case; Okanagan Lake stage;
(1) No adaptation;
(2) agriculture & residential DSM adaptation, plus supplement with Okanagan Lake; no sockeye management
Okanagan Inflows vs. Water Demands, HadCM3-A2
(source: Langsdale et al., 2006; in Cohen and Neale 2006)

Note: assumes no change in instream demands to support ecosystems, and reduction in agricultural demand in dry years
Years (out of 30) when water demand exceeds supply in the Okanagan Basin, medium population growth scenario (Langsdale et al., 2007)

<table>
<thead>
<tr>
<th>SCENARIO</th>
<th>Historic</th>
<th>2020’s</th>
<th>2050’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>No climate change (population growth only)</td>
<td>3</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>HadCM3 – A2</td>
<td>--</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>HadCM3 – A2 Moderate Adaptation</td>
<td>--</td>
<td>9</td>
<td>19</td>
</tr>
<tr>
<td>CGCM2 – B2</td>
<td>--</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>CSIRO Mk2 – B2</td>
<td>--</td>
<td>14</td>
<td>21</td>
</tr>
</tbody>
</table>

Moderate adaptation = demand management portfolio: metering, IBR prices, education, agricultural efficiency improvement
Conclusions

- Policy context, a dynamic dialogue process, and framework for collaboration, together, can make climate change adaptation happen.
- Success of participatory integration depends on the ability of practitioners (and related governance bodies) to compare scientific claims to their own knowledge.
  - This is needed to maintain trust in the process.
Practical implications

- Need mechanisms for anticipatory coordination within development plans
- Develop climate risk management triggers (thresholds) for early warning of potential conflicts among water users
- Develop and employ water efficient technologies
- Engage communities and states in “mainstreaming” climate information into practice through participatory mechanisms (including co-development of scenarios)
- Invest in career opportunities for climate change adaptation within local governments and water-based utilities, integrated within long-term planning for sustainability
Future Needs

• Need greater exploration of alternate integration models AND overlying policy structures to facilitate and sustain shared learning
  – From individual projects to a long-term service
• Need to support dynamic dialogue between researchers and practitioners on:
  – Knowledge of local changes in the climate system
  – Evaluation of acceptability of adaptation technology & practice,
  – Improving understanding of communication for cross-scale adaptation decisions
    • Within one level of government
    • Multi-levels of government
    • Watershed scale; mix of governments, utilities and water user groups
Thank You

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