Ending Overdraft in California under Climate Change

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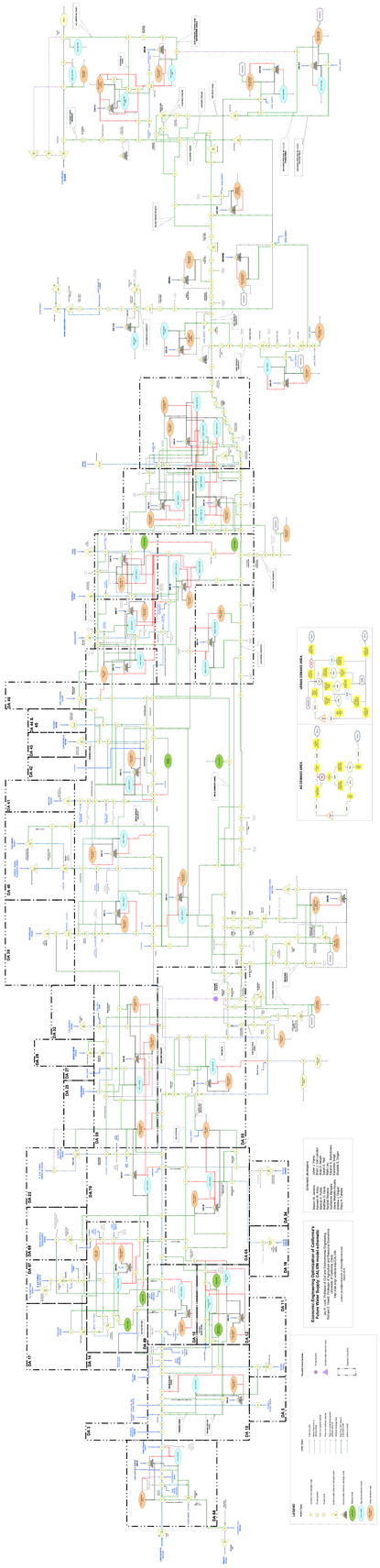

1 Study area: Central Valley

- Productive agricultural land.
- Sacramento and San Joaquin R. drain Central Valley's water to the San Francisco Bay, creating the Delta.
- More pressure from population growth, economic development, and increased irrigation demand
- Sustainable Groundwater Management Act (SGMA) aims to better manage groundwater and end overdraft

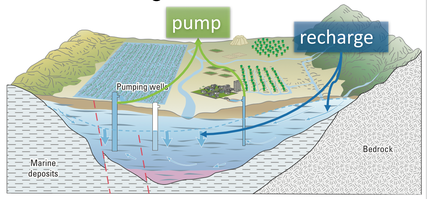

Figure 1. Groundwater representation of the valley (Faunt et al., 2009)

2 Groundwater overdraft in the Central Valley

Overdraft:

- Groundwater extraction through pumping exceeds aquifer recharge over a long period
- Unsustainable use of groundwater

Overdraft in the valley:

- Tulare Basin has long been suffering from overdraft

Climate change (warm&dry):

- less surface water, more groundwater pumping

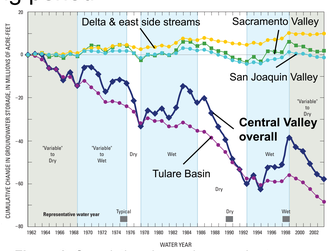

Figure 2. Cumulative change in groundwater storage of the valley, 1962-2003 (Faunt et al., 2009)

3 Method: Hydroeconomic evaluation of ending overdraft

Economic response to ending groundwater overdraft with adaptation is evaluated with CALVIN, a hydroeconomic optimization model for California's water supply system

CALVIN:

- California's entire intertied water infrastructure
- Integrated model: surface and groundwater
- Economic representation of agricultural and urban demands
- Optimize water allocation to users
- Provides insights into water policy, planning and management

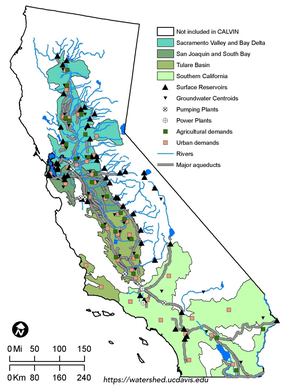

Figure 3. CALVIN model coverage and California's major water infrastructure

4 Management scenarios & basic Delta water balance

	8 Hypothetical "No Overdraft" Scenarios
Historical	No overdraft
Historical	No overdraft & No reduction in Delta outflow
Climate change	No overdraft & No additional Delta exports
Climate change	No overdraft & No Delta exports

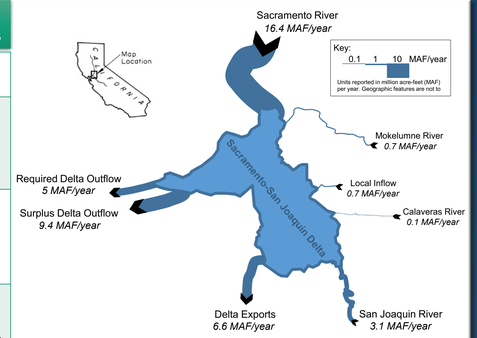

Figure 4. Major water contributions to the Delta, outflow and water exports to south of Delta (Buck, 2016)

5 Annual average water scarcity & scarcity cost

- Agricultural and urban water scarcities and costs increase with climate change and no overdraft policy
- Ending overdraft with adaptations is more desirable

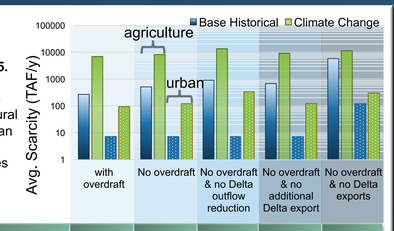

Figure 5. Annual average agricultural and urban water scarcities

Scarcity Cost (M$/y)		with overdraft	No overdraft	No overdraft & no Delta outflow reduction	No overdraft & no additional Delta export	No overdraft & no Delta exports
ag	Base Historical	20	41	66	57	2671
ag	Climate Change	2,324	3,048	6,190	3,535	7,589
urban	Base Historical	14	14	14	14	148
urban	Climate Change	87	107	374	111	378

Table 1. Annual average agricultural and urban water scarcity costs

6 Groundwater storage without overdraft

- Short-term overdraft is useful for reducing cost and conjunctive use
- No overdraft policy under climate change reduces groundwater pumping

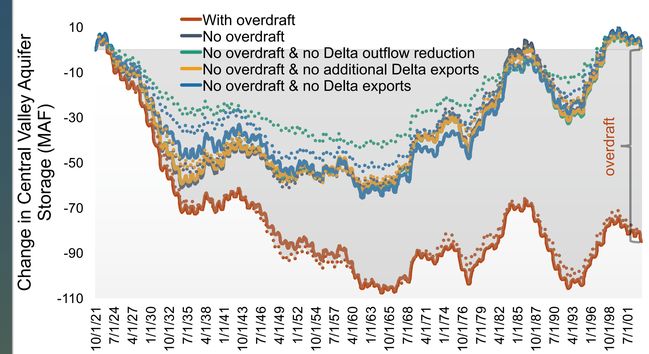

Figure 6. Projected monthly cumulative change in Central Valley aquifer storage from Oct. 1921 to Sep. 2003 with no overdraft policies and climate change

7 Delta exports from California aqueduct & Delta-Mendota canal

- Delta exports increase when overdraft is terminated
- Climate change reduces reliability of exports
- Delta outflow and water trades from north of Delta are exported

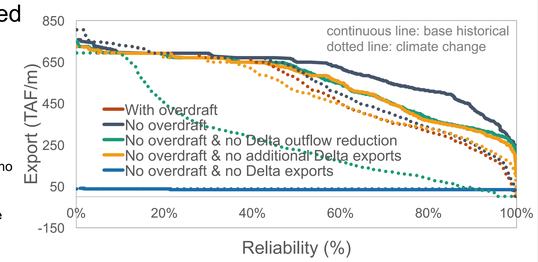

Figure 7. Delivery-reliabilities of monthly Delta exports under no overdraft scenarios and climate change

8 Delta outflow: drainage from Central Valley into S. F. Bay

- No overdraft policy diverts more water from Delta outflow
- Climate change considerably reduces the outflow and shifts the peak

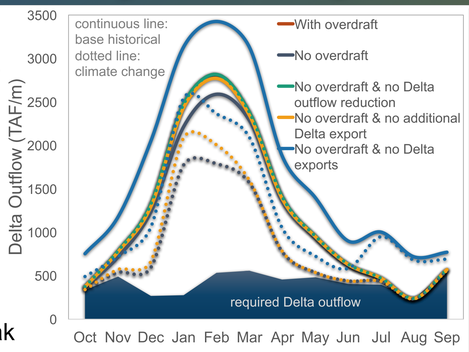

Figure 8. Monthly average and required Delta outflow

9 Conclusions

- Adaptations make ending overdraft less costly
- Agricultural users are most affected from ending overdraft
- Diversions from surplus Delta outflow are important especially under climate change

Useful adaptations:

- Diversions from Delta outflow
- Additional Delta exports
- Conjunctive use
- Water trades
- Water conservation

References & more results:

- Faunt, C.C., ed., 2009, Groundwater Availability of the Central Valley Aquifer, California: U.S. Geological Survey Professional Paper 1766, 225 p.
- Dogan, M. S. (2015). *Integrated water operations in California: Hydropower, overdraft, and climate change*. MS Thesis, University of California, Davis
- Buck, I. (2016). *Managing to End Groundwater Overdraft in California's Central Valley with Climate Change*. MS Thesis, University of California Davis