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King Abdullah Petroleum Studies and Research Center

Policy options for reducing water for agriculture in Saudi Arabia

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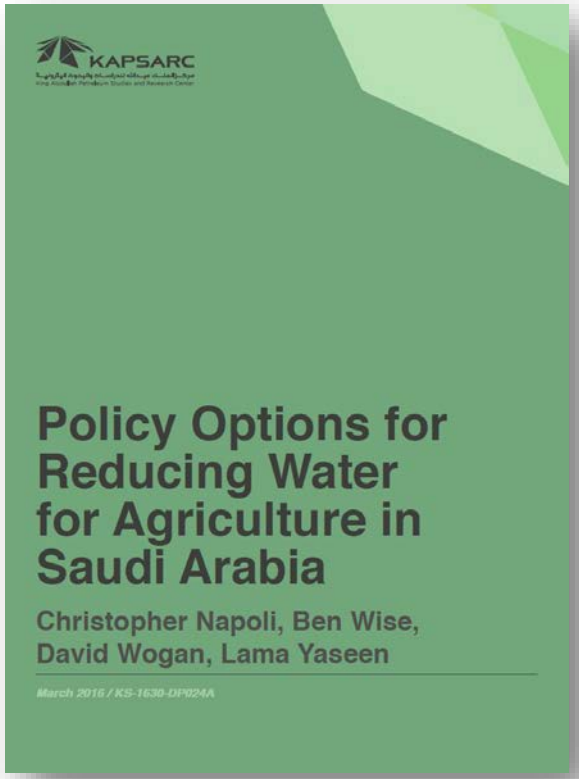
Study overview

- Our study illustrates how short-term gains in water reduction can be achieved through crop switching
- We apply a linear programing (LP) model to determine an optimal crop portfolio to minimize water consumption
- We use a collective decision-making model to evaluate the feasibility of the options
- The study is an example of how model-based outputs can be integrated into a KTAB bargaining analysis



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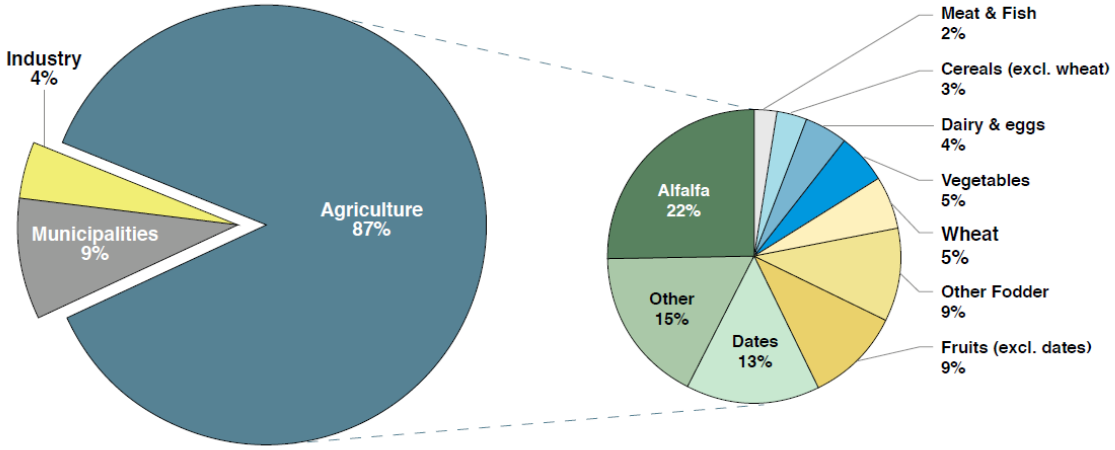
Motivation: Saudi Arabia is a severely water scarce country

- Total water withdrawals increased by a factor of 14 over three decades
  - 1975: 1.75 km^3
  - 2006: 25.4 km^3
- Drivers
  - Population growth (7.4 million to 25.4 million)
  - Economic expansion of domestic sectors, most notably agriculture
- Agriculture supports self-sufficiency (food security) and economic development goals
- However, agriculture consumes 87% of all extracted water



Note: as of 2016, wheat and alfalfa are no longer produced in-Kingdom

Policy responses

- Policymakers have acted to improve water sustainability
  - 2016 – Phased out wheat production
  - Purchasing farmland in other countries to produce alfalfa
  - Abolished tariff on imported agricultural goods
    - Cereal
    - Animal feed
    - Wheat flour
- **Policy target: 30% water reduction by 2030**
- **Aspiration: 50% water reduction by 2030**

Crop circles north of Riyadh, KSA

Date palms south of Riyadh, KSA

Methodology

Hypothesis: Saudi Arabia can reduce water use in the short-term through crop switching (without introducing new farming techniques or technology)

1. Optimization analysis – what is *technically* feasible?
2. Collective choice analysis – what is *socially* feasible?

1. Optimization analysis

- We created a stylized model of the Saudi agriculture sector based on the availability of the following datasets for 37 crops and livestock products (alfalfa, melons, goat meat, etc)
  - Revenue (USD/ton)
  - Production (tons)
  - Water consumption (m^3/ton)
- The model adjusts the production level of 37 crops and settles on a portfolio that consumes the smallest volume of water given the following constraints:
  - Aggregate farmer revenue must be greater than or equal to the amount in the base case (proxy for farmer welfare – cannot decrease because of reform)
  - Aggregate tonnage of crops and livestock must be greater than or equal to the base case (proxy for food security / self-sufficiency – cannot be compromised because of reform)
- Livestock consume alfalfa and other fodder, therefore a ratio of fodder to livestock was included

Scenarios

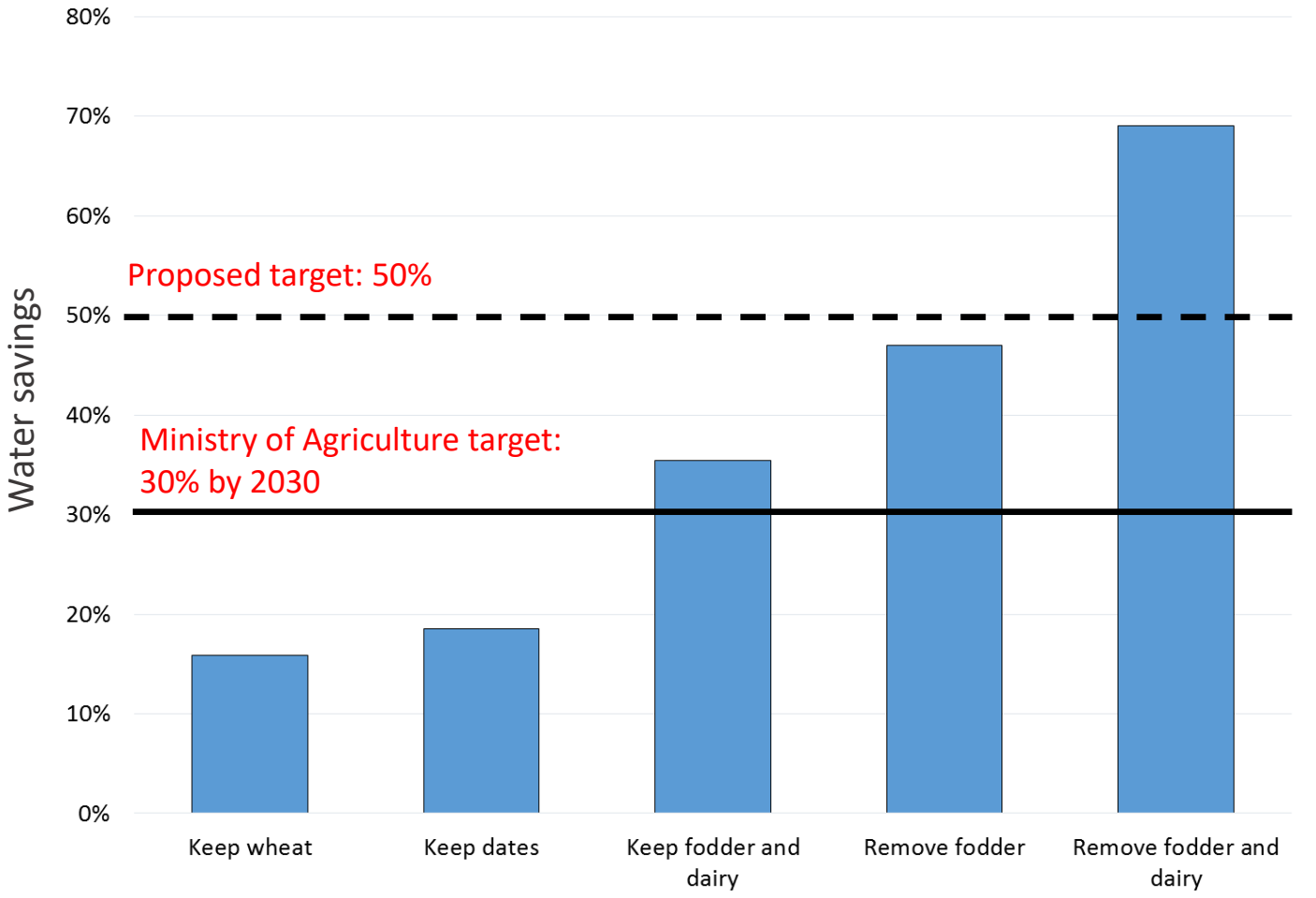
- Limits were set on how much crop-specific production could increase or decrease (percentage)
  - This provides flexibility to design scenarios
  - Can be used to preserve culturally significant crops (dates) or test extreme scenarios where crops are removed completely (e.g., dairy products)
  - 28 scenarios were considered, of which we present five illustrative ones

Description	Other crops can decrease or increase by
Keep wheat	25% (decrease) or 100% (increase)
Keep dates	25% or 100%
Remove fodder and dairy	75% or 200%
Remove fodder	25% or 100%
Remove fodder and dairy	95% or 300%

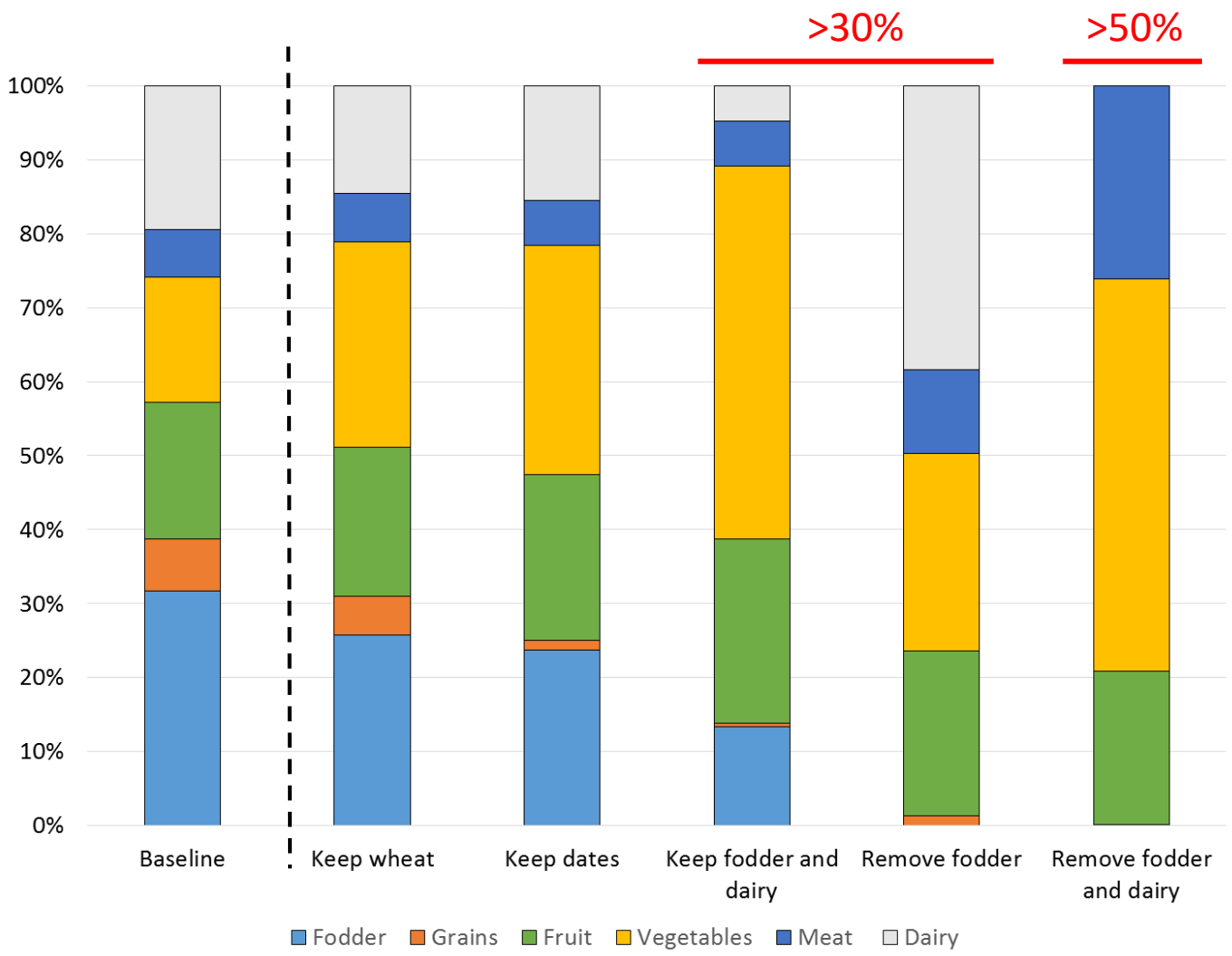
Note: Wheat is eliminated for all other scenarios per policy

Results – water savings

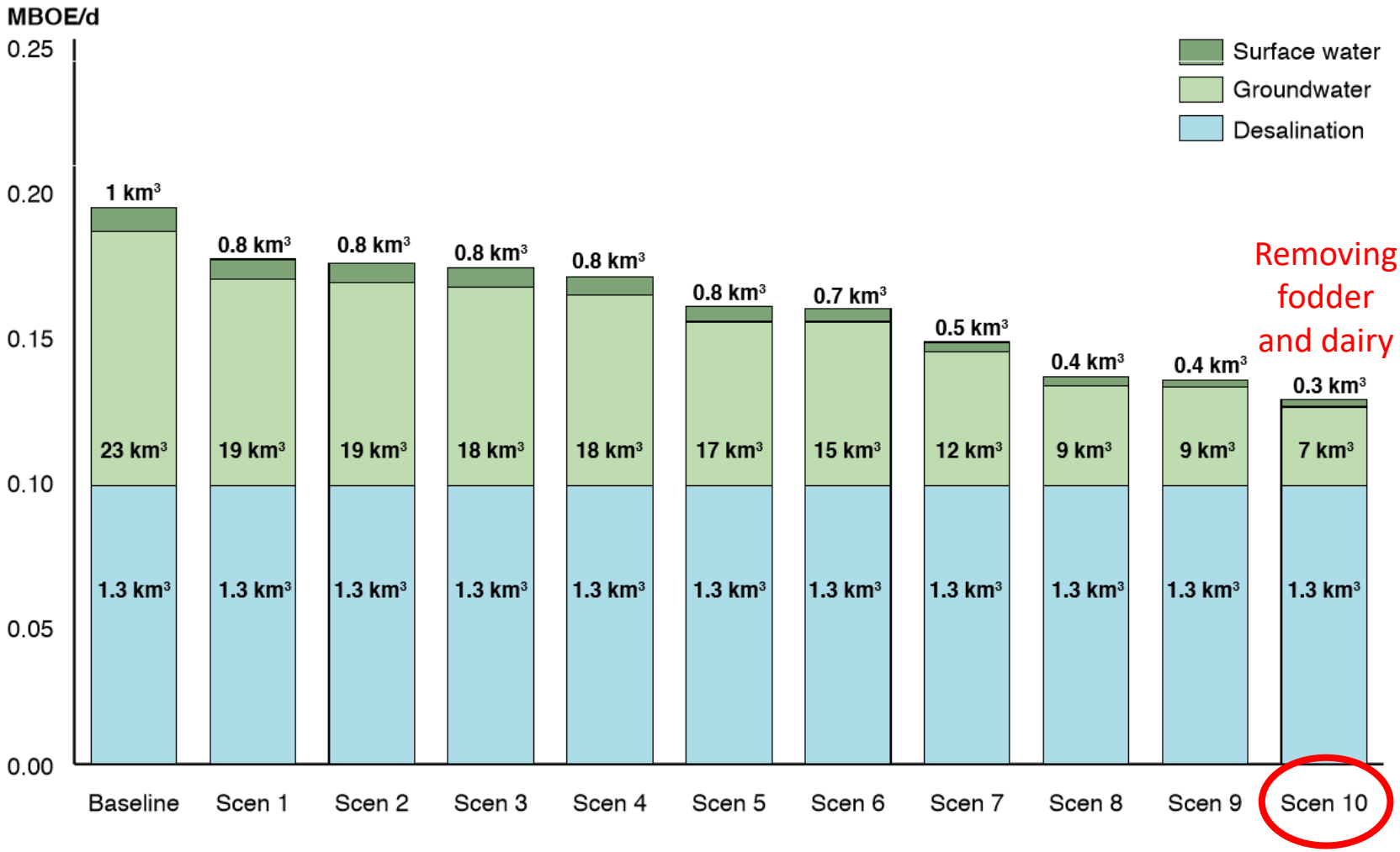
- Crop switching can reduce agricultural water consumption by up to 70%



Results – crop portfolio



Results – energy consumption

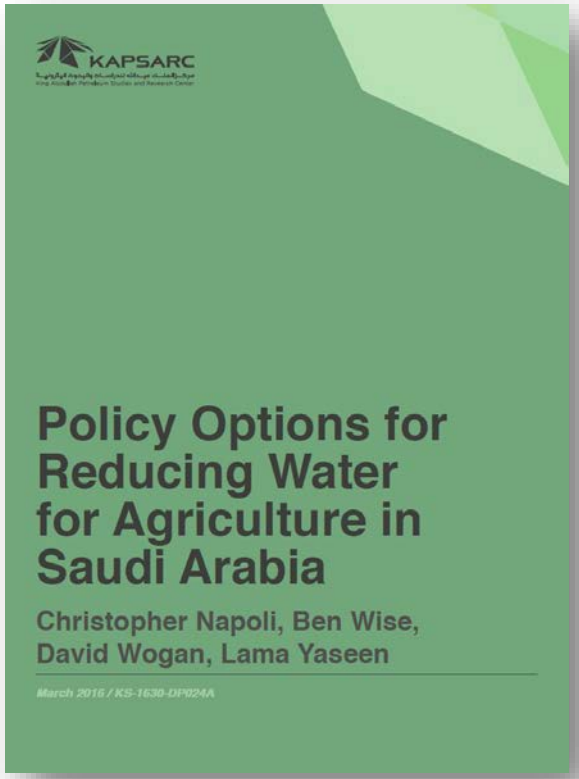


Interpreting the results

- First, we find that significant water savings can be gained by relatively small changes in crop production
  - When retaining dates (or wheat) and allowing other crops to decrease by 25% or double in production
- Second, reaching the 30% target requires a more ambitious approach by allowing a drastic change in production
  - When retain fodder and dairy, but allowing a large swing in production levels
  - Or by removing a water-intensive crop like fodder
- Finally, the 50% target is only possible with *both* substantial changes in crop production and the elimination of water-intensive crops like fodder and dairy
- Our hypothesis was that a scenario with minimal impact (and thus water savings) would be most favorable

Key results

- Our study illustrates how short-term gains in water reduction can be achieved through crop switching
- Water for agriculture can be reduced by 47% without compromising food security or aggregate farmer revenues
- **Eliminating the most water-intensive, low-value added crop is less disruptive than moderate reductions across many crops**
- Water for agriculture could be reduced by 70%, but at the expense of losing the dairy, fodder, and grains sectors



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Thank you

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Lessons learned

- The team considered a more sophisticated model that would make production decisions based on economics of agriculture
- A model of this structure would involve obtaining data on
  - Cost of production
  - Transportation costs from farm to final demand center
  - Cost of water extraction and delivery
  - Energy inputs for farming and livestock
  - Emissions and other environmental attributes
  - Price controls or subsidies for inputs and final goods
- The model would then meet demand by (a) minimizing cost or (b) maximizing profit through an optimal crop portfolio
- Water consumption would be an output of the model and inspected to assess the effectiveness of potential policies
- However, a relatively lightweight and straightforward model like the one presented can yield insight