MCC Jordan Compact – Water Sector

Impact Evaluation (IE) Design

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MCC's Evaluation Catalog:
http://data.mcc.gov/evaluations/index.php/catalog/103/related_materials

Overview

1) Introduction to the Jordan Compact Evaluation Logic

2) Design of the impact evaluation (IE)
   a. Basic principles and contribution
   b. Operationalization

3) Questions / Discussion

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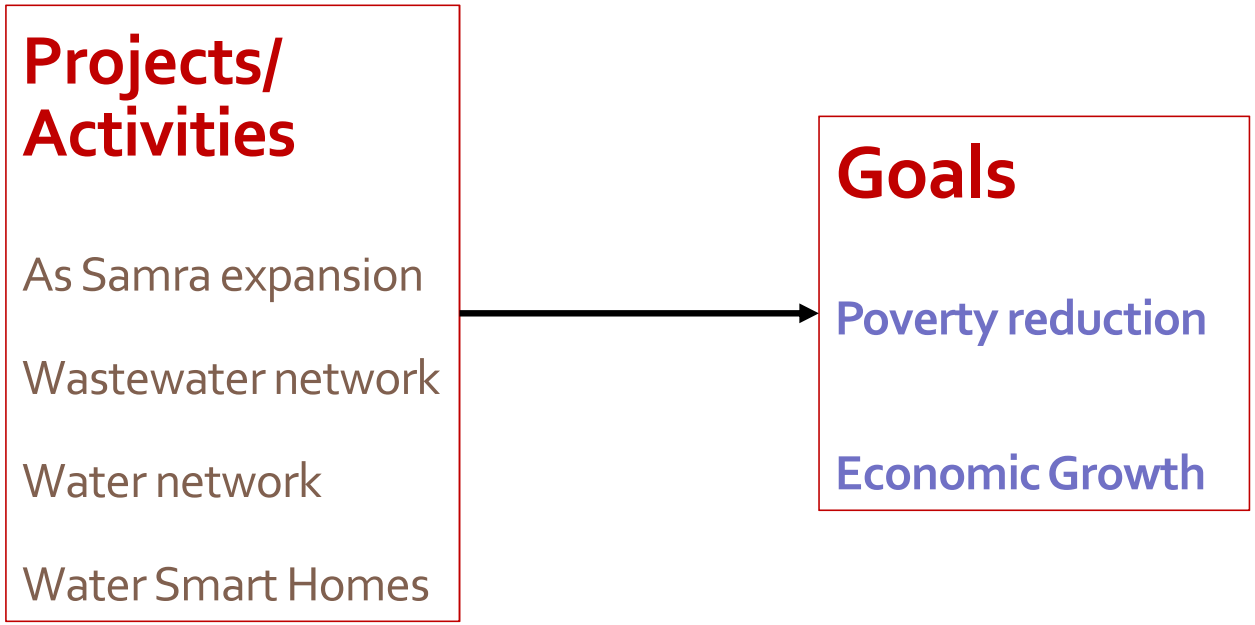
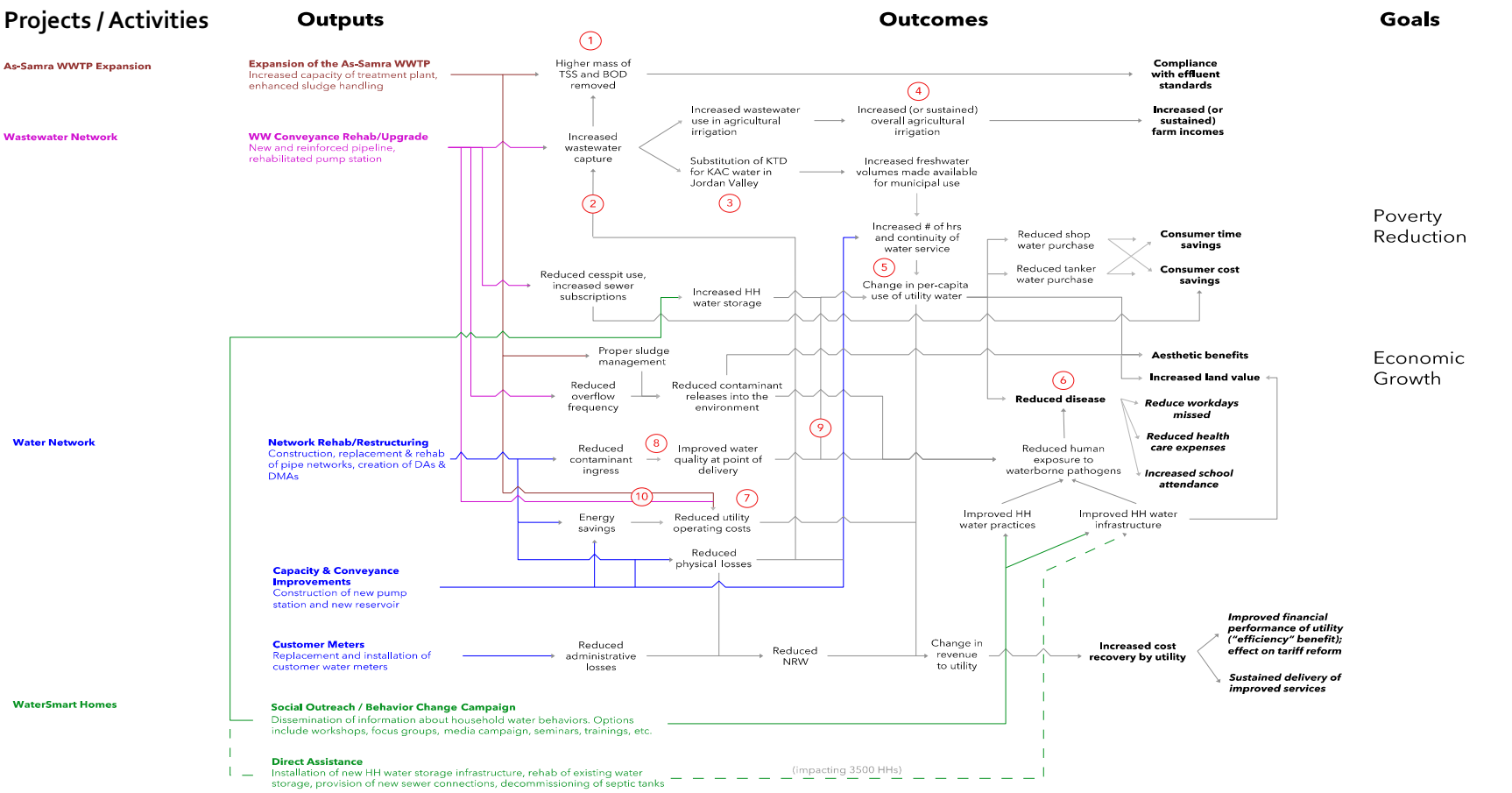
Impact Logic



Impact Logic

Bottom line: Very complex web moving from projects to goals



Key:
- Colors correspond to Activity
- Normal text corresponds to intermediate outcomes
- **Bold** corresponds to longer term outcomes
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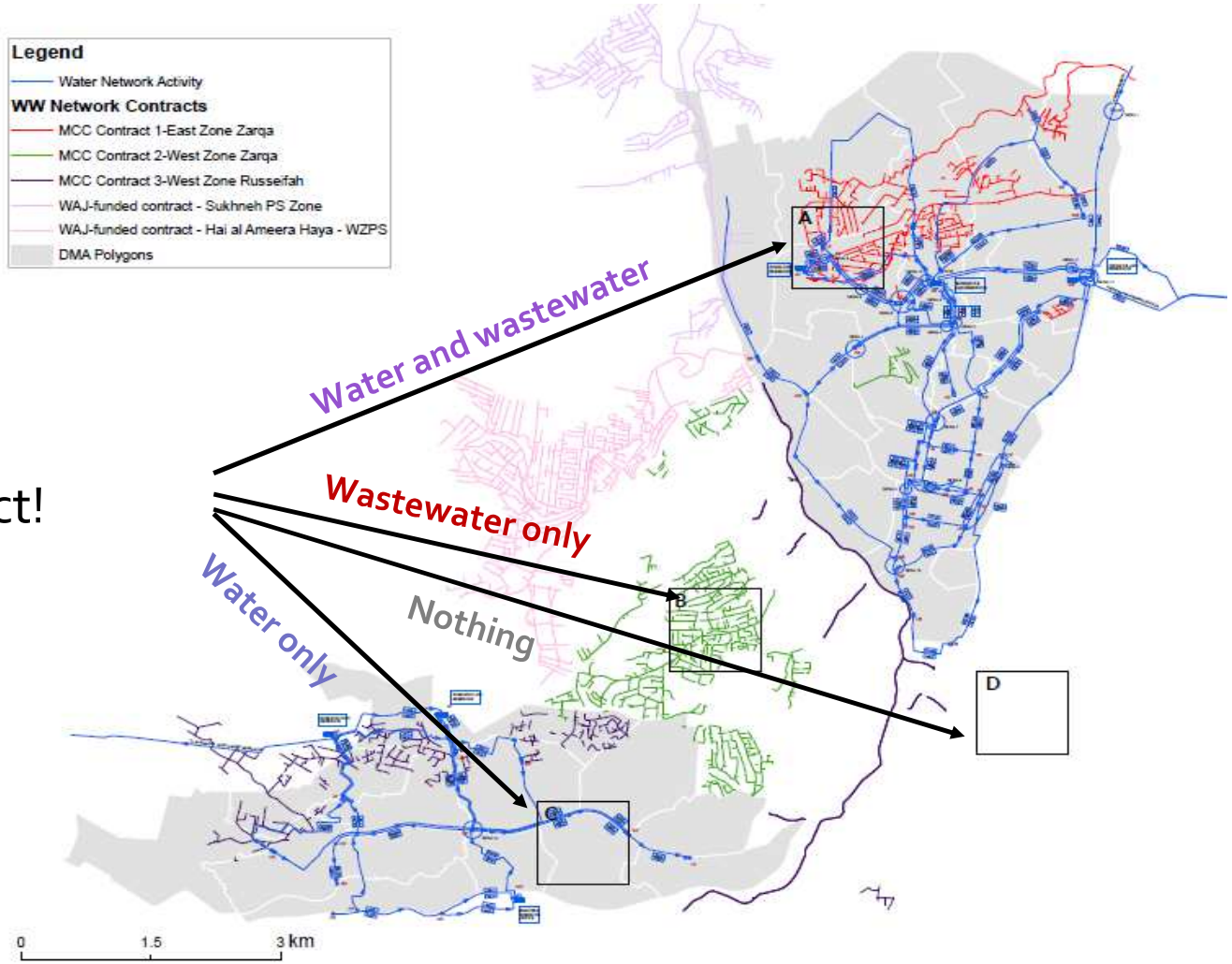
Implementation Map

Areas are differentially exposed to the Compact!



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Primary IE Objective

Primary objective: Did the interventions of the Jordan Compact lead to reduced poverty and higher income in Zarqa governorate? What are the other economic impacts of these investments (on enterprises, farmers, utility performance, others outside Zarqa, etc.)

Goes well beyond traditional monitoring, with its focus on ***outputs***, to consider ***outcomes***

Goal is:

- To learn about value of investment
- To inform future planning

The central element of impact evaluation is the inclusion of a plausible **"counterfactual"** for treated units – also known as a "comparison" or "control" group – that is identical in all ways save for exposure to the intervention

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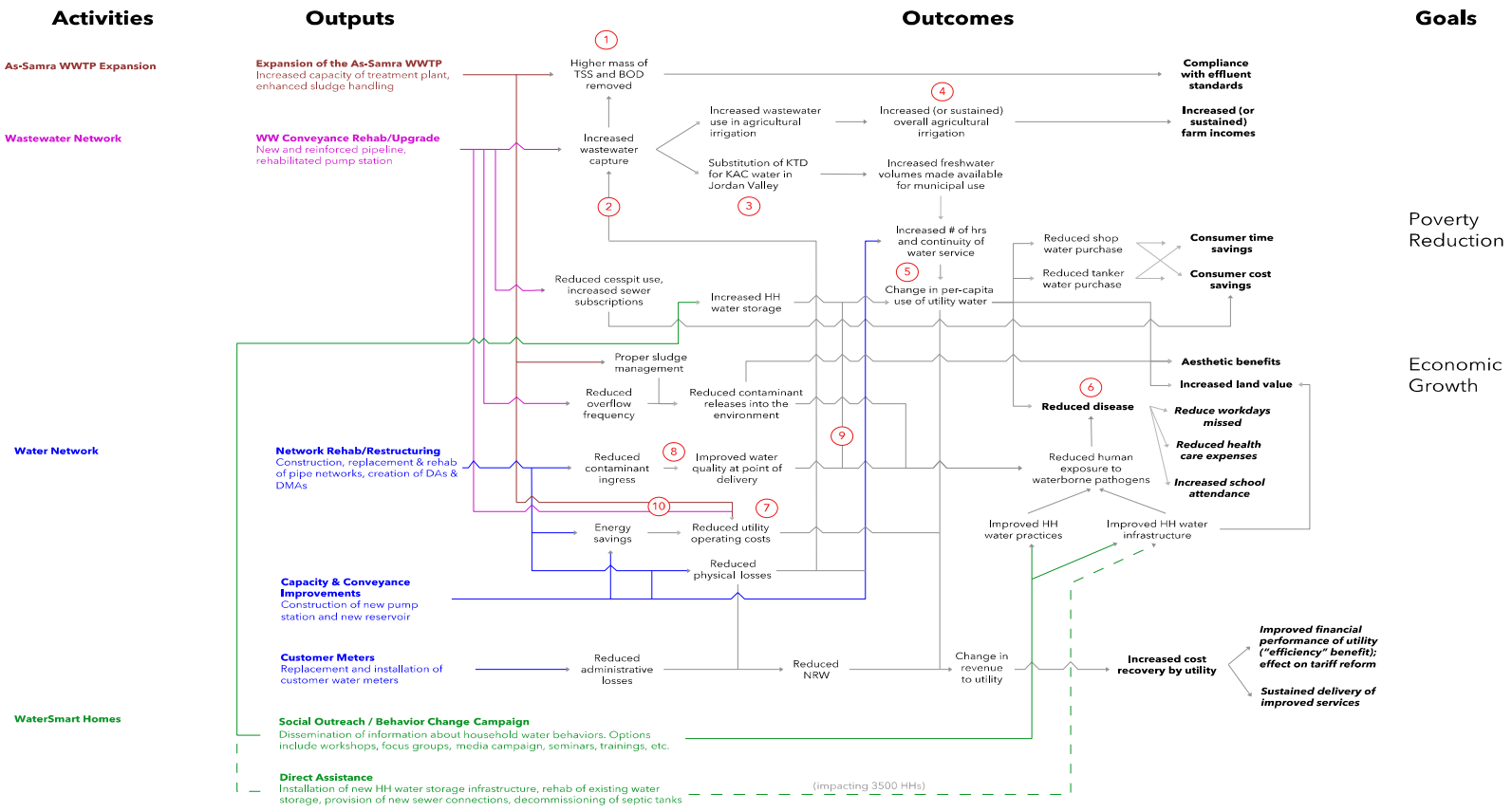
Main challenges to evaluation objectives:

1. Overlapping causal links (Remember the IE Logic)

IE Logic



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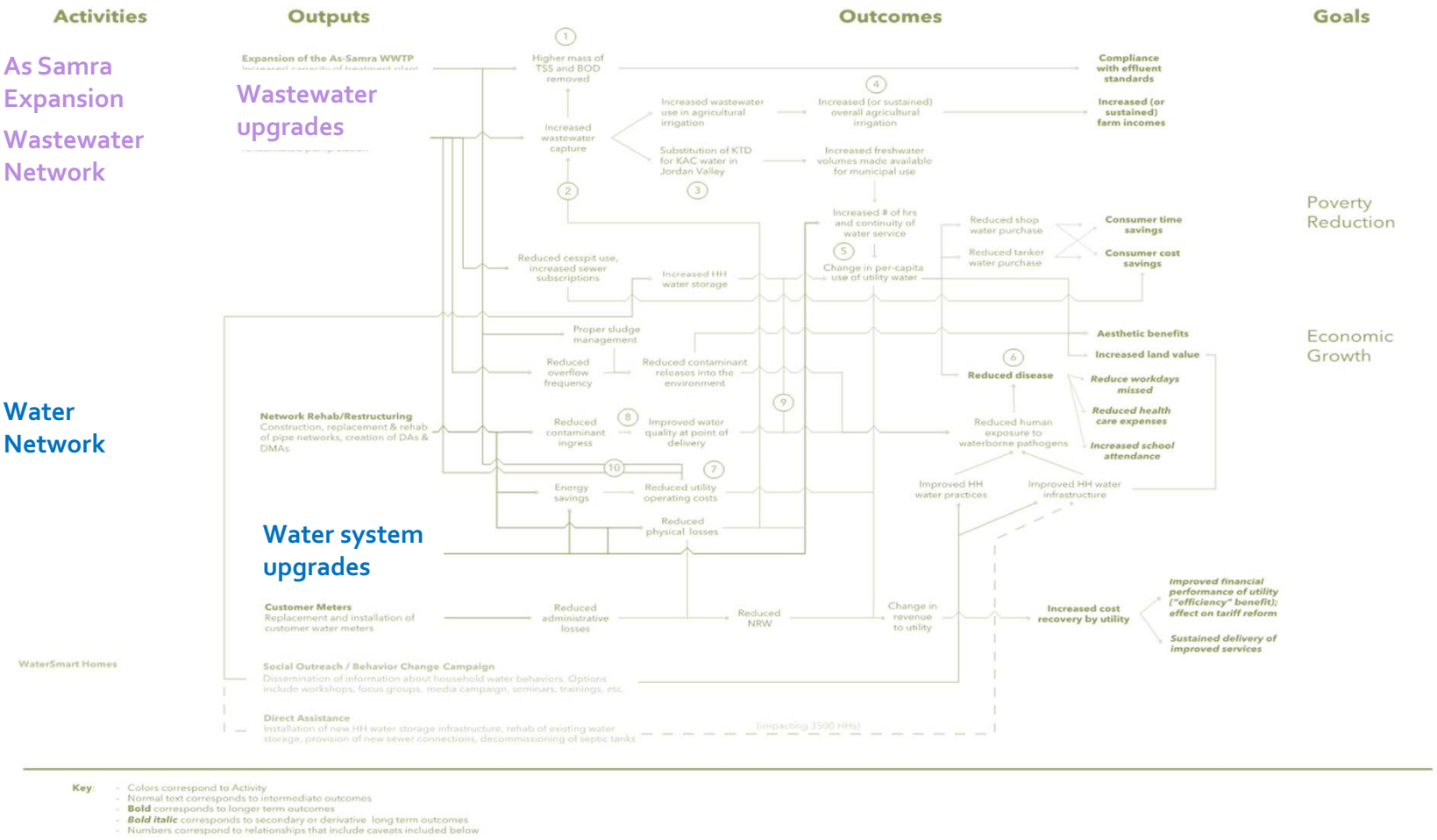
Activities
Outputs
Outcomes
Goals
As Samra Expansion
Wastewater Network
Water Network
Expansion of the As-Samra WWTP
Wastewater upgrades
Higher mass of TSS and BOD removed
Compliance with effluent standards
Increased wastewater capture
Increased wastewater use in agricultural irrigation
Increased (or sustained) overall agricultural irrigation
Increased (or sustained) farm incomes
Substitution of KTD for KAC water in Jordan Valley
Increased freshwater volumes made available for municipal use
Increased # of hrs and continuity of water service
Reduced shop water purchase
Consumer time savings
Reduced tanker water purchase
Consumer cost savings
Reduced cesspit use, increased sewer subscriptions
Increased HH water storage
Change in per-capita use of utility water
Poverty Reduction
Proper sludge management
Aesthetic benefits
Increased land value
Reduced overflow frequency
Reduced contaminant releases into the environment
Reduced disease
Reduce workdays missed
Reduced health care expenses
Increased school attendance
Economic Growth
Network Rehab/Restructuring
Construction, replacement & rehab of pipe networks, creation of DAs & DMAs
Reduced contaminant ingress
Improved water quality at point of delivery
Reduced human exposure to waterborne pathogens
Energy savings
Reduced utility operating costs
Improved HH water practices
Improved HH water infrastructure
Reduced physical losses
Water system upgrades
Customer Meters
Replacement and installation of customer water meters
Reduced administrative losses
Reduced NRW
Change in revenue to utility
Increased cost recovery by utility
Improved financial performance of utility ("efficiency" benefit); effect on tariff reform
Sustained delivery of improved services
WaterSmart Homes
Social Outreach / Behavior Change Campaign
Dissemination of information about household water behaviors. Options include workshops, focus groups, media campaign, seminars, trainings, etc.
Direct Assistance
Installation of new HH water storage infrastructure, rehab of existing water storage, provision of new sewer connections, decommissioning of septic tanks
(impacting 3500 HHs)
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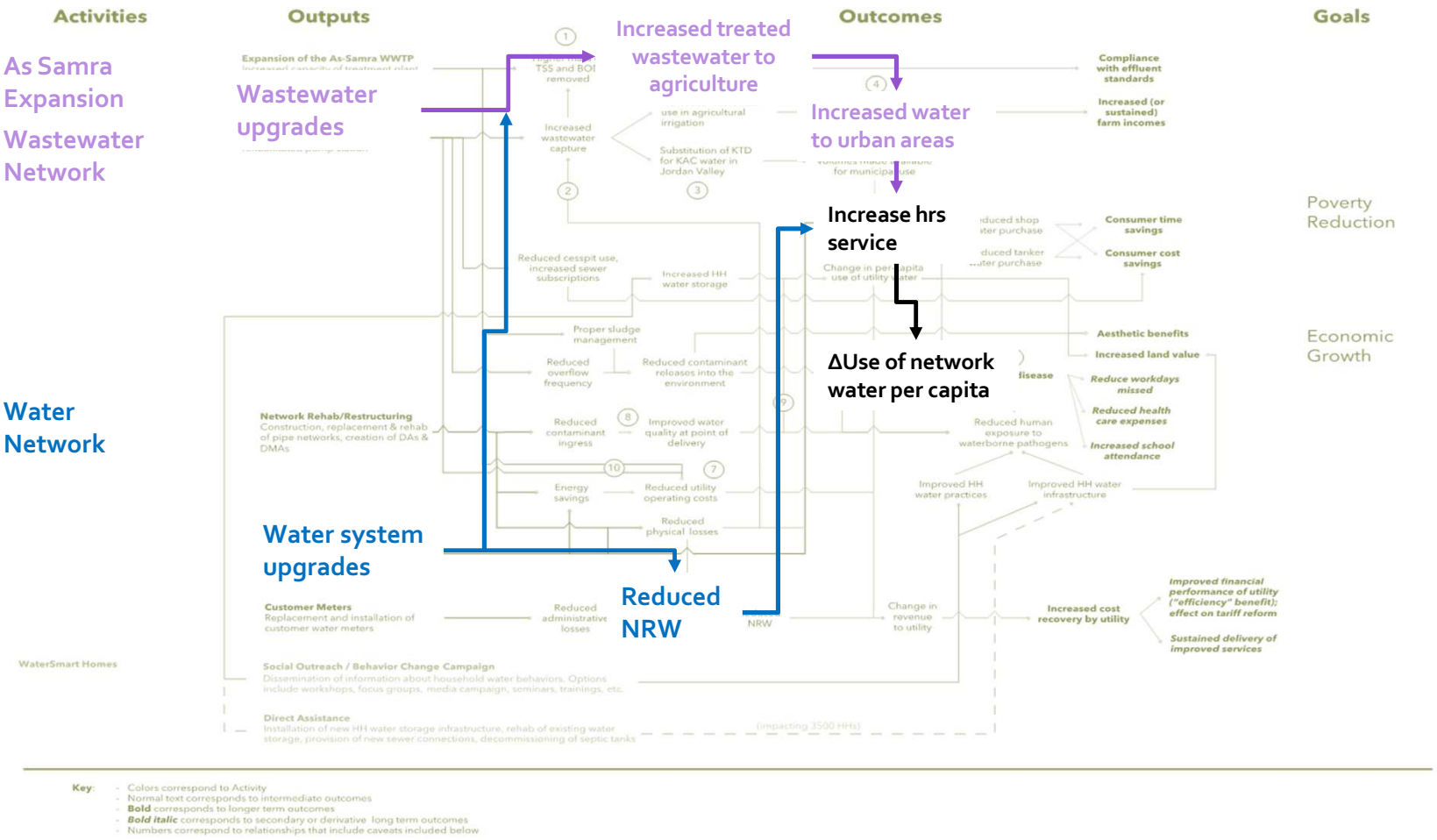
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Increased treated wastewater to agriculture
Increased water to urban areas
Increase hrs service
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Compliance with effluent standards
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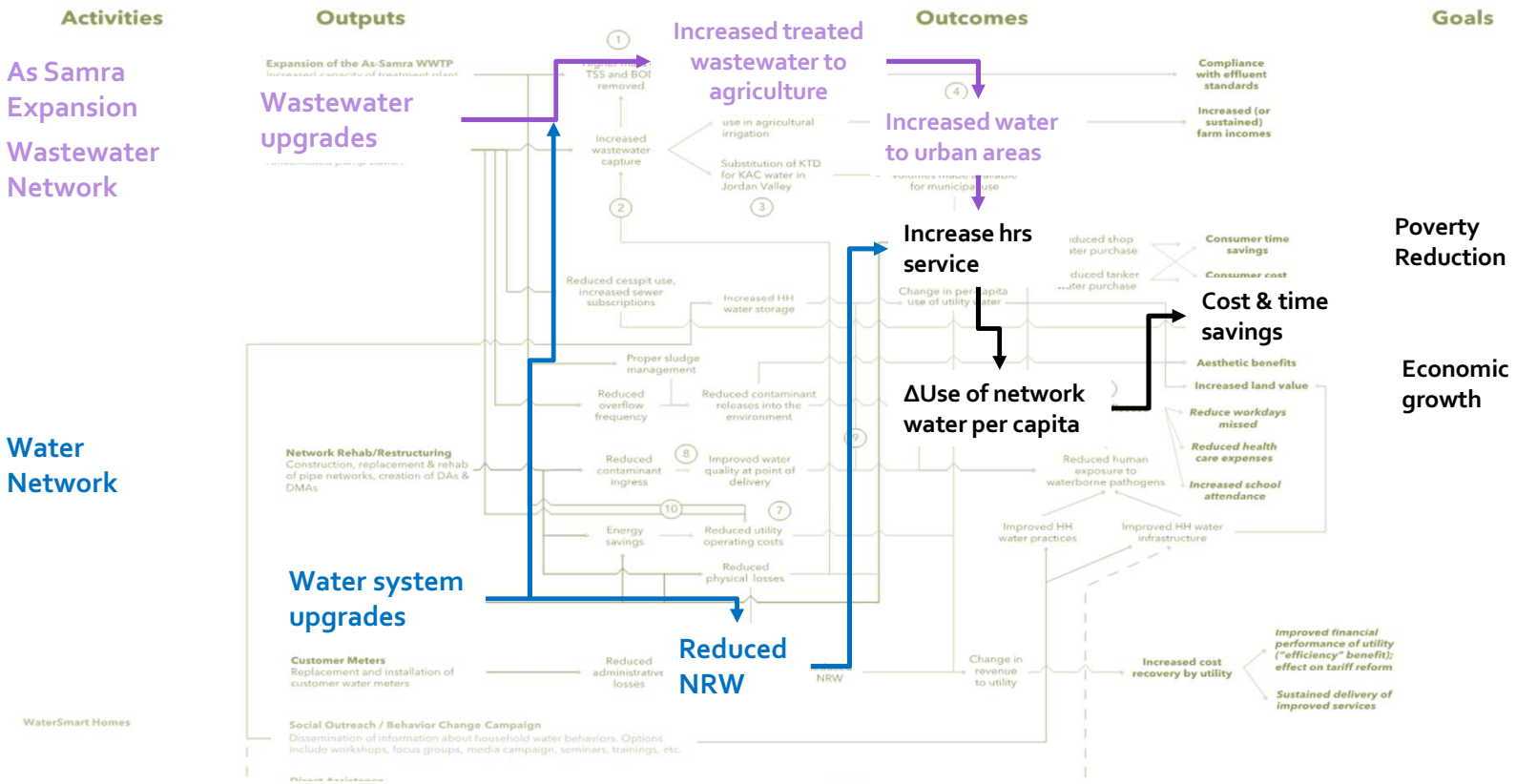

First critical substitution: More efficient conveyance increases wastewater capture; this can be productively reused and increase system water availability

Second critical substitution: More system water allows households to switch away from expensive alternatives (e.g., shop or tanker water)

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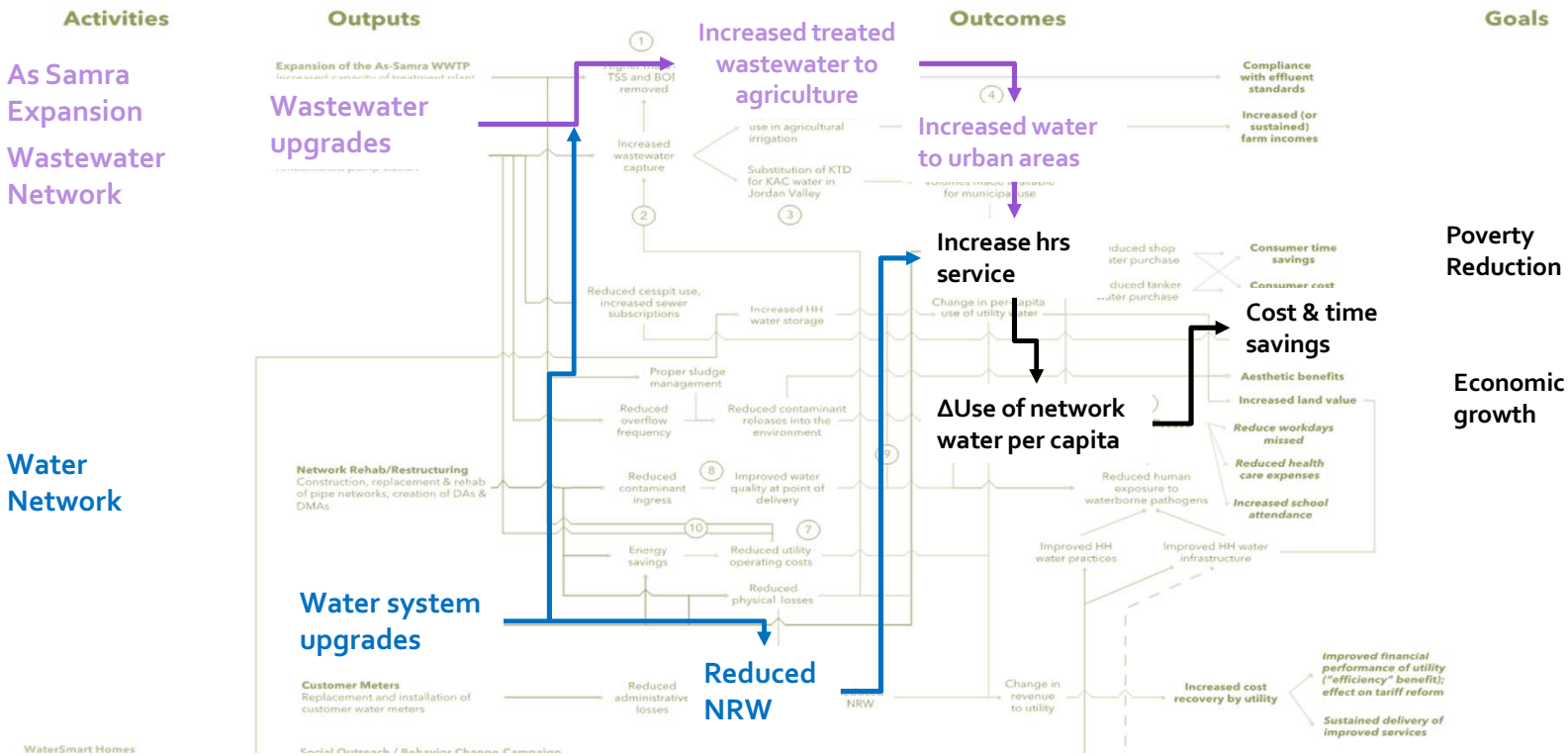

First critical substitution: More efficient conveyance increases wastewater capture; this can be productively reused and increase system water availability

Second critical substitution: More system water allows households to switch away from expensive alternatives (e.g., shop or tanker water)

But also many other potential impacts!

Major evaluation outcomes

Impact category	Intermediate / final?	Indicators	Data collection strategy
Increased water service	Intermediate	Hrs/wk; complaints & interruptions	Surveys, utility records
Improved sewer service	Intermediate	# connections; ww volumes; complaints	Surveys, utility records
Improved urban water quality	Intermediate	Perceptions; e. coli & coliform counts	Surveys; testing
Increased water consumption	Intermediate	Consumption (meters); use of other sources	Surveys, utility records
Reduced Non-Revenue Water	Intermediate	Un-metered consumption	Utility records
Water substitution	Intermediate	Water flows to various users; hydrological measurements	Water balance analysis (using secondary data)
Δ Agricultural water quality	Intermediate	Quality of treated ww; quality of JV water	Use secondary data
Δ Farm water use	Intermediate	Water use; irrigated area	Surveys, admin records

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Improved utility cost recovery	Final	Revenues; costs; billing efficiency	Utility records
Consumer time & cost savings	Final	Expenditures (+ time) on water & sewer	Surveys
Increased productivity	Final	HH time savings; income; firm & farm output	Surveys
Quality of life benefits	Final	Satisfaction; hygiene; total water demand	Surveys
Reduced burden of disease	Final	Diarrhea incidence; cost-of-illness	Surveys

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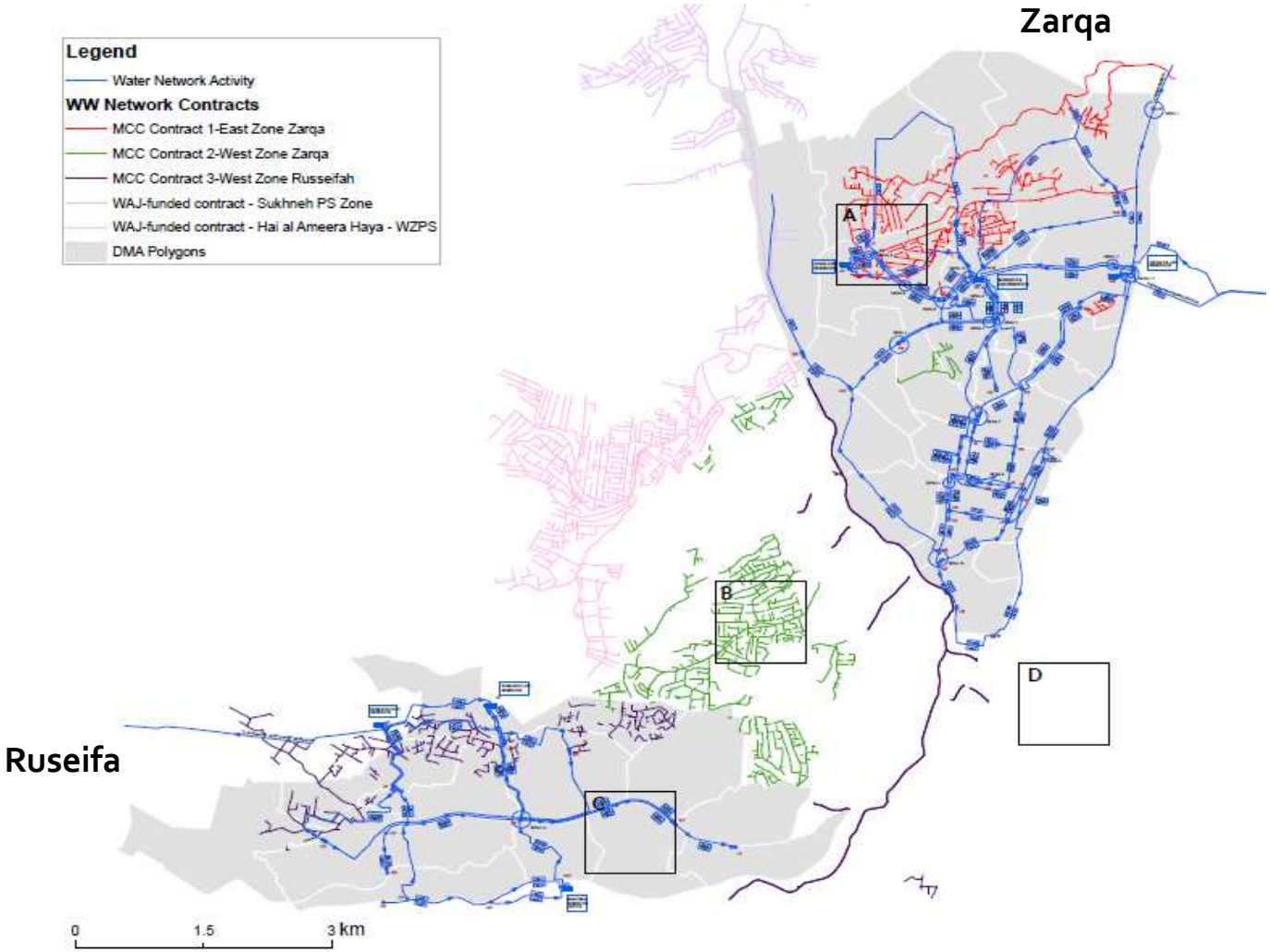
Main challenges to evaluation objectives:

1. Overlapping causal links (IE Logic)
2. Overlapping geographical areas (Implementation Map)

Implementation Map



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1. Overlapping causal links (IE Logic)
2. Overlapping geographical areas (Implementation Map)
3. Confounding by other changes (e.g., addition of new water sources)
4. Spillovers to untreated areas (e.g., better system water supply)
5. Statistical power (e.g., due to limited knowledge of baseline outcomes and expected effect sizes)

Potential contribution(s)

- Very robust literature on household-level interventions in water and sanitation…but
  - Relatively few in urban areas: willingness to pay (Whittington et al. 1991); vending and coping costs (Pattanayak et al. 2005); utility inefficiencies (Schwartz & Johnson); gains in leisure (Devoto et al. 2011); health improvements from expansion of piped water supply (Galiani et al. 2005; Gamper-Rabindran et al. 2008)
  - Scant evidence regarding other economic impacts of water infrastructure (Hanemann, 2006)
- This IE aims to **provide high quality information on general economic benefits attributable to a large urban water investment**
  - Go beyond much of the literature that focuses on health
  - First comprehensive study for a Middle Eastern country (a relevant case)
  - First such impact evaluation in Jordan
- Through careful consideration of intermediate impacts or potential beneficiaries, will begin to **shed light on complex chain from cause to effect**

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IE Design & Methods: 3 Components

IE Component 1: What are the impacts of infrastructure improvements on urban households and enterprises in Zarqa? (WNP and WWNP)

Methods**:** Use matching to select survey zones *ex ante*; conduct longitudinal surveys to track outcomes over time; analyze using difference-in-differences

IE Component 2: How does the water balance change and what are impacts on irrigators? (WNP; WWNP; and AEP)

Methods**:** 1) Study outcomes of natural experiment in the Jordan Valley and other farm areas using longitudinal surveys; 2) Water balance analysis over time to track changes in water allocation

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IE Component 1: Main IE Questions

Impacts on water consumption: Does the WNP change the quantity of water consumed at the household (HH) and enterprise (E) levels?

Impacts on environmental quality: Does the WNP alter the quality of water at the HH / E levels? Does the WWNP reduce the risk of disease?

Impacts on expenditure: Does the WNP affect time and money expenditure on water? Does the WWNP change HH / E expenditure on wastewater management?

Impacts on income: Does the WNP change HH / E income?

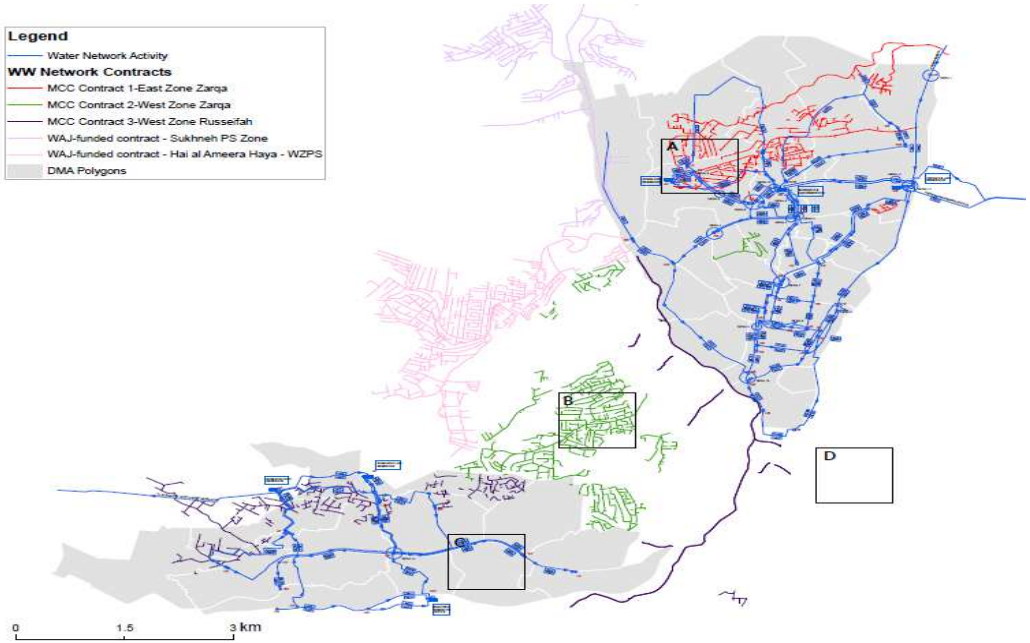
Impacts on asset value: Do the WNP / WWNP affect property values / investment?

Overall impacts on welfare in Zarqa: What is the net economic value of changes in quantity and quality of water consumed?

IE Component 1: Sampling strategy

Water Wastewater	Treated	Control
Treated	A. Both improvements	B. Wastewater network only
Control	C. Water network only	D. No improvements

Used matching to select areas A-D with similar Census characteristics **prior** to Compact interventions



Reduce confounding with matching

- Often used to reduce the possibility of confounding
  - WWNP and WNP infrastructure planned for specific places
  - These places may be different from each other and from non-selected locations
- **Method:** Match on Census characteristics (e.g., block socio-economic characteristics like education, population, income)
  - Helps reduce the possibility of bias in the estimation of treatment effects
  - Amount of bias reduction depends on richness of data and quality of matches
  - Bias only **eliminated** if the matching eliminates all differences between groups
- Analyze changes over time in different areas

IE Component 1: Sample details

- **Data Collection:** Household and enterprise surveys at least twice (baseline and endline); focus Group Discussions to inform instrument design; we also include shorter seasonal surveys to track key outcomes over time

- **Sample:** Sample size of ~3500 households and 350 enterprises (control and treatment) required to detect Δ = 10% on most important outcome variables

- **Inclusion of a set of controls from East Amman**

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IE Component 2: Main IE Questions

Impacts on water sourcing: Does the investment result in increased irrigation with additional blended KTR water? Does the volume of freshwater irrigation correspondingly decrease?

Impacts on farming costs: Do the combined projects lead to changes in farm input costs?

Impacts on farm output: Do the combined projects lead to changes in the value of farm output in affected areas?

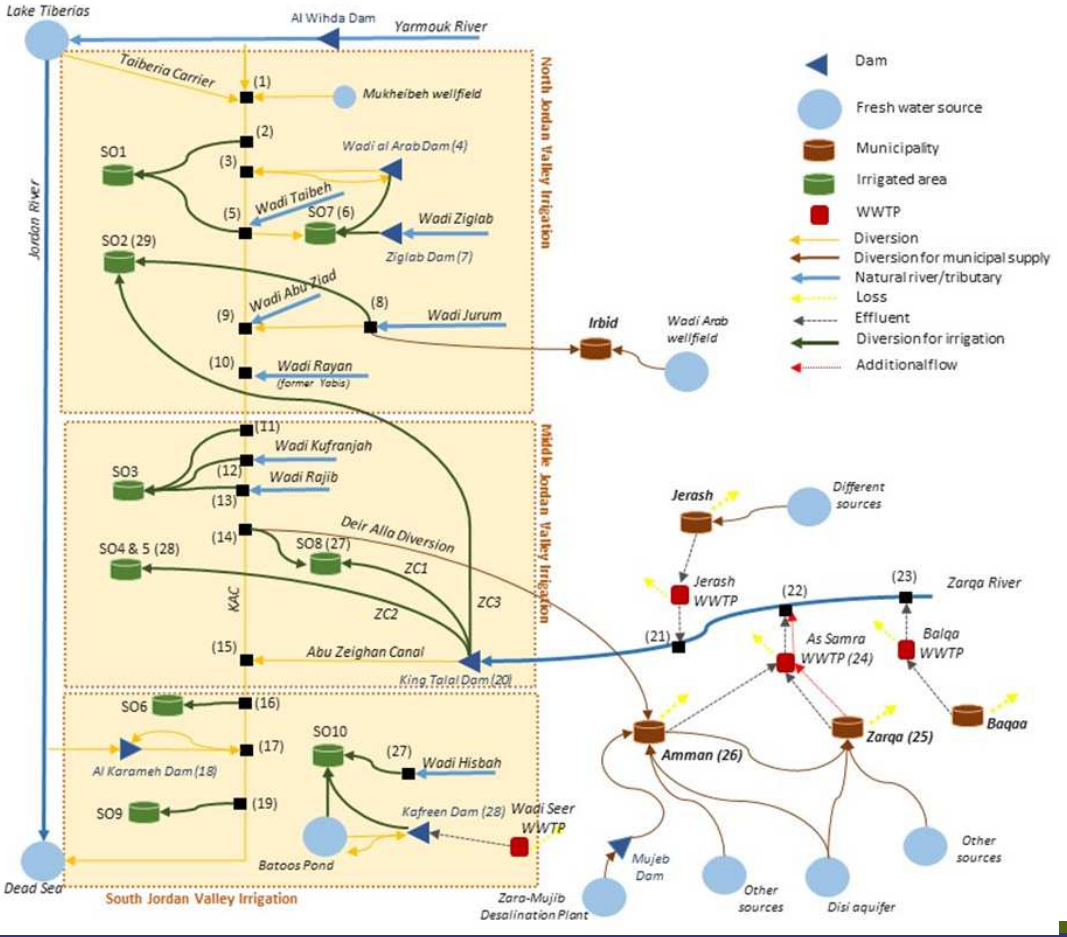
Impacts on asset value: Are farm values affected by the investments?

Overall impacts on farm welfare: What is the net economic value of changes in irrigation?

Impacts on compliance: Does the AEP result in compliance with wastewater effluent standards?

IE Component 2: Water Balance Analysis

Complex system with a great deal of human modification



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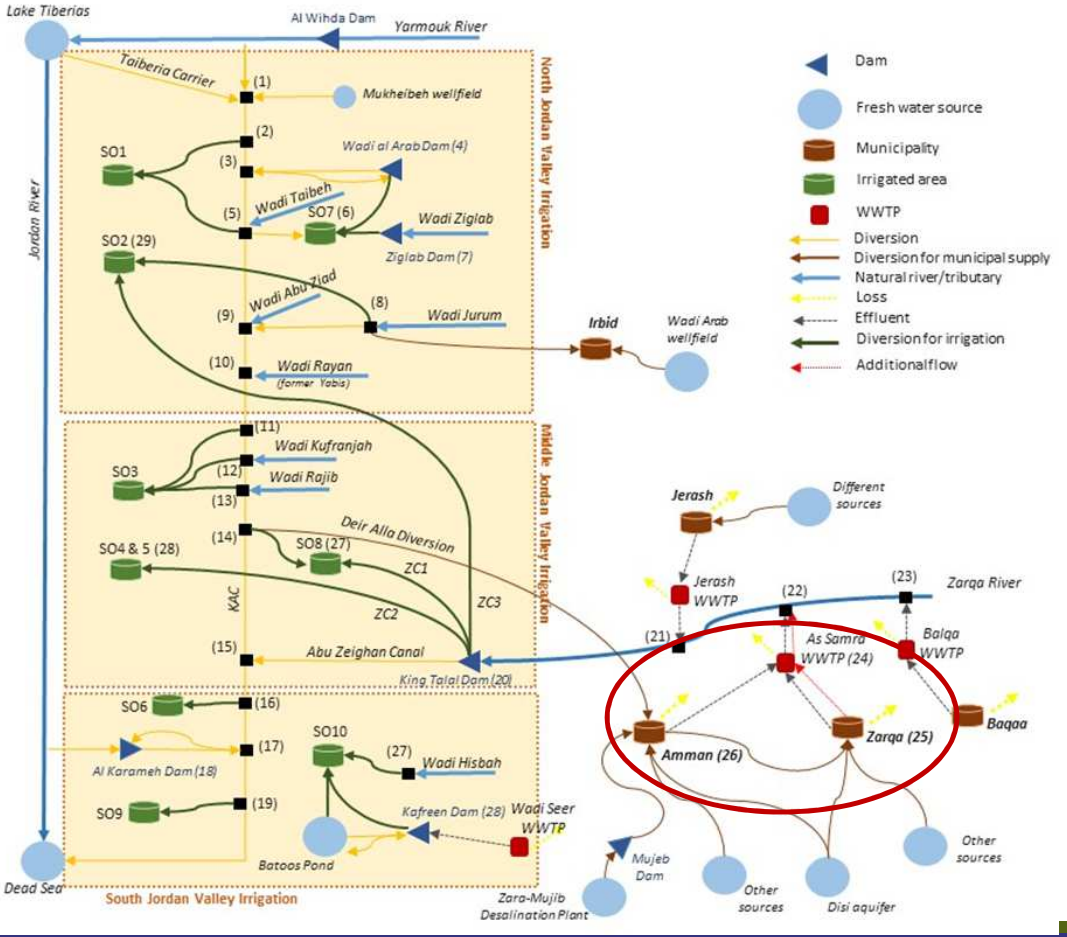
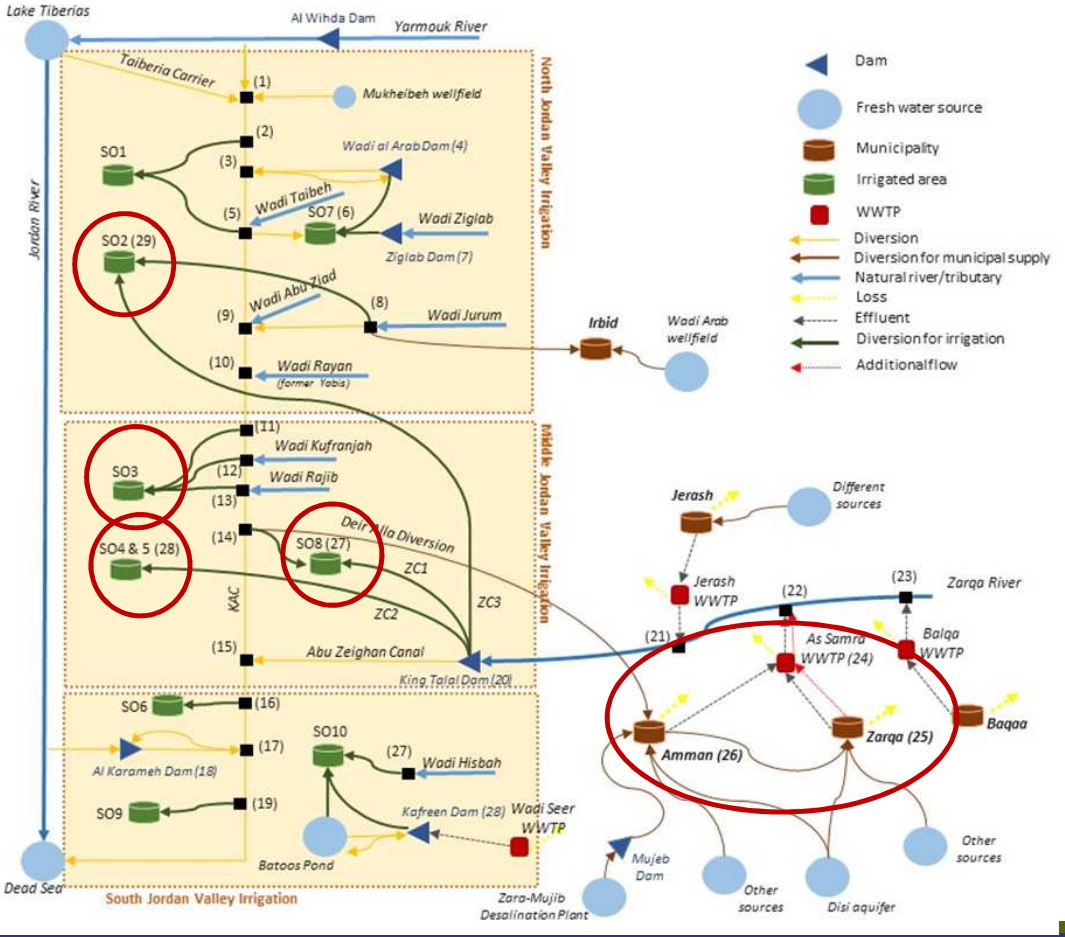
Additional wastewater collection from Zarqa



IE Component 2: Water Balance Analysis

Additional wastewater collection from Zarqa

Will allow greater use of treated wastewater in the Jordan Valley, and create gains for Zarqa and Amman



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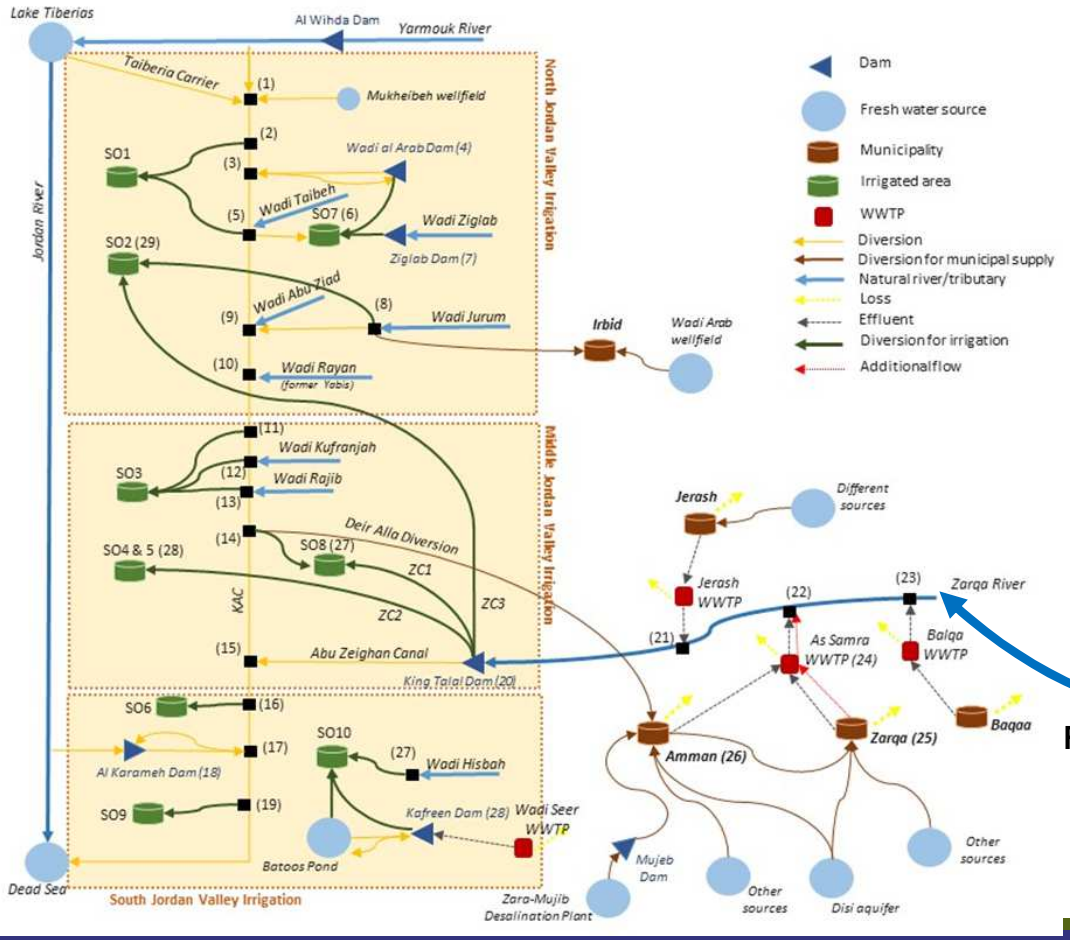
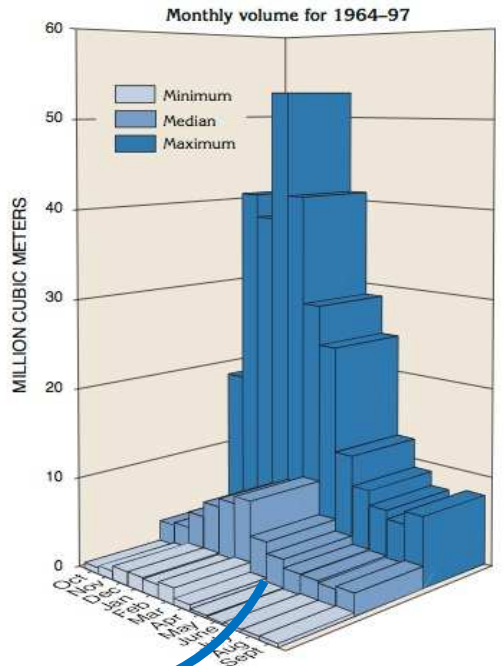
Complex system with a great deal of human modification and natural variability



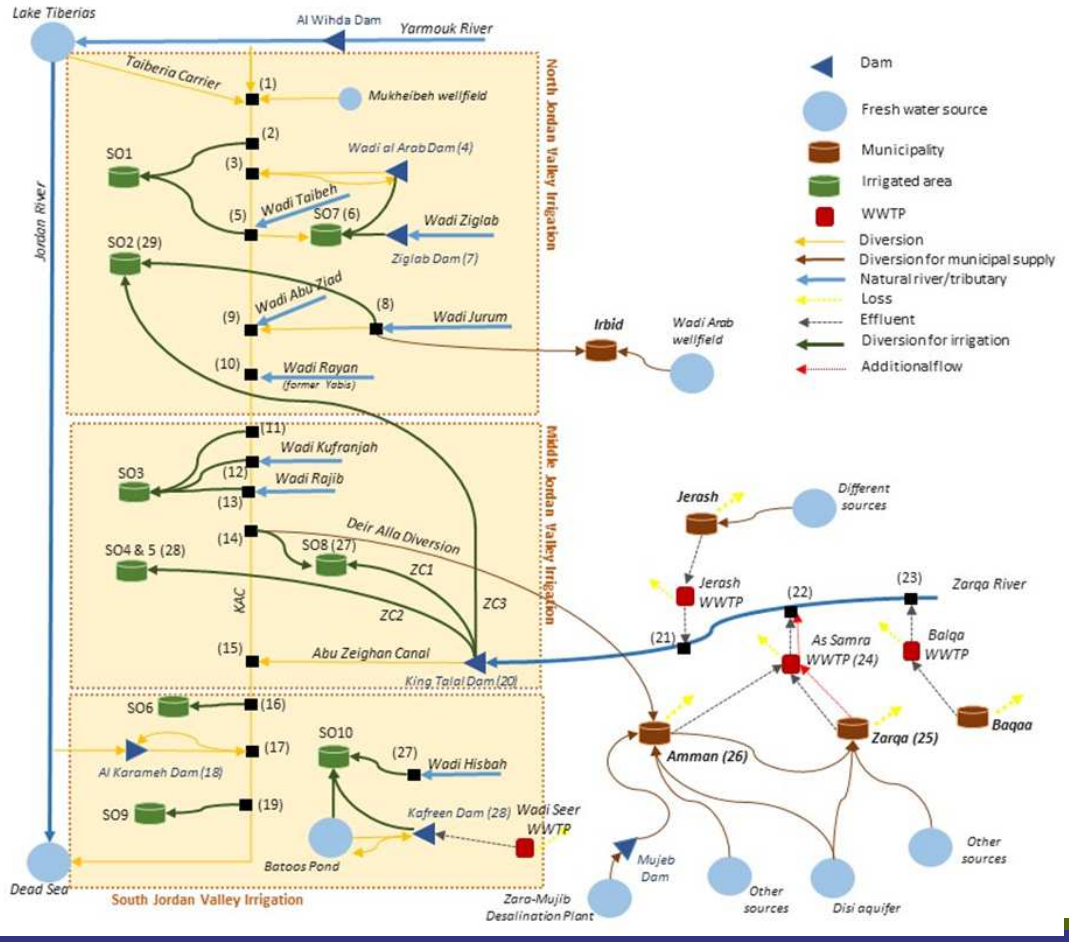


Flow variability in the Zarqa River (USGS EXACT, 1998)

IE Component 2: Water Balance Analysis

Complex system with a great deal of human modification and natural variability

Major non-Compact confounders (imported water, GOJ policy favoring water substitution)



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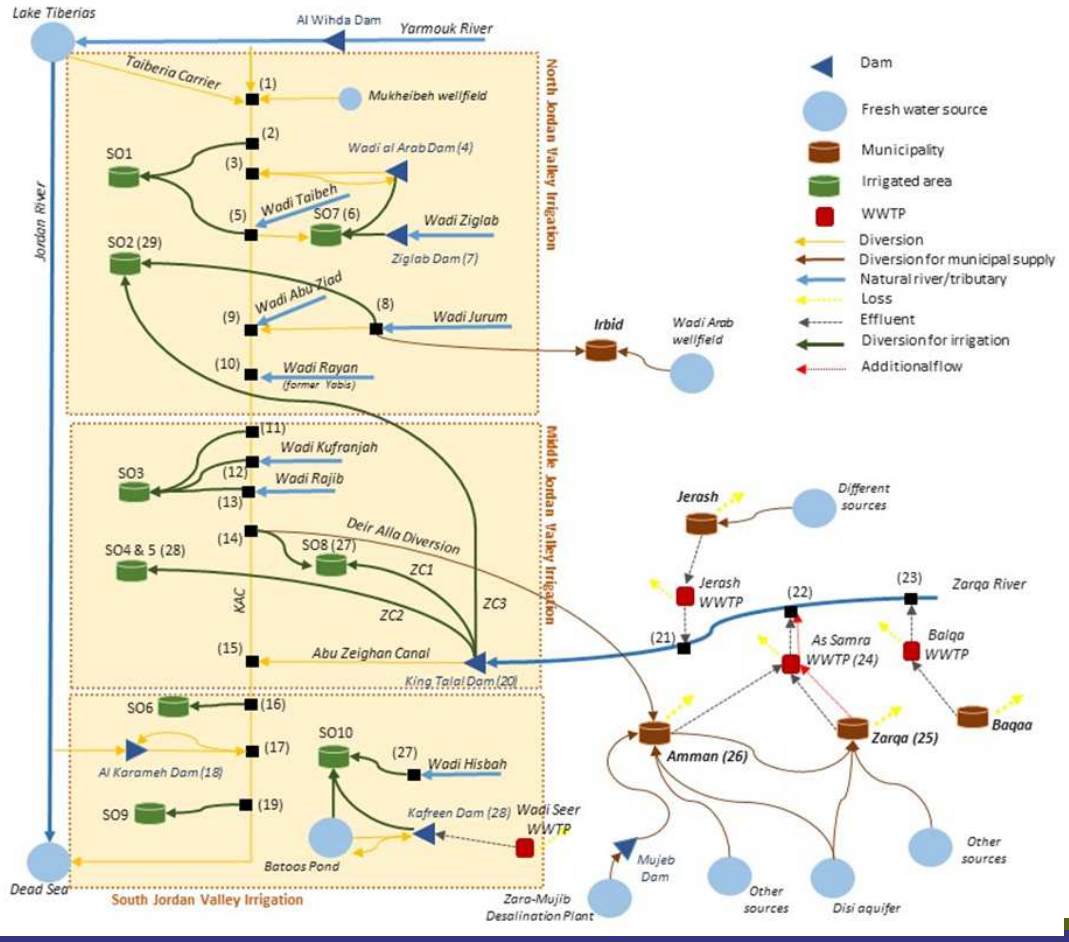
Need for substantial hydrological and agricultural water use data (various sources)



IE Component 2: Farm surveys

- Longitudinal (annual) farm surveys in the Jordan Valley and highlands

- Analyze changes in the quantities of fresh versus treated wastewater supplied to farms in differentially exposed regions

- Sample frame (550 farms) covers the following areas:

a) Area 1: North Jordan Valley 1 (primarily freshwater irrigation)
b) Area 2: North Jordan Valley 2 (currently freshwater, plan is to switch to blended water use)
c) Area 3: Middle Jordan Valley 1 (Blended fresh and Zarqa River water)
d) Area 4: Middle Jordan Valley 2 (Mostly Zarqa River water)
e) Area 5: Highlands along Zarqa River (all blended water)

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IE Component 3: Main Questions

Utility cost recovery: Does the net cost recovery of the utility improve due to the Compact, and is this related to service improvements?

Operations and maintenance: What is the impact of the Compact on the budget and execution of O&M?

Service improvements: At the utility level, are there measurable changes in service delivery quality trends in Zarqa relative to those of other municipal utilities in Jordan?

IE Component 3: Rationale & Activities

Rationale: Many of the benefits of the investments may be felt by the local water utility or by other larger government institutions responsible for water delivery in Jordan. Alternatively, the strain on these could increase if costs are not being sufficiently recovered through water/wastewater tariffs.

This could have long term implications for public sector debt and productivity of Jordan's economy.

Activities:

1. Utility indicator tracking and comparison across urban utilities in Jordan (range of operational, technical and financial indicators);

2. Water meter testing to properly calibrate consumption numbers (correct for systematic differential meter error).

Summary of methodology and sampling considerations

IE Component	IE Methodology	Data collection details
Component 1: Impacts of infrastructure on urban HHs & enterprises in Zarqa	• Matching for sample construction • Longitudinal HH survey • Longitudinal enterprise survey • Statistical analysis	• Use of Zarqa/Amman Census data • 3500 households • 350 enterprises
Component 2: Water substitution & impacts on irrigators	• Detailed water balance modeling • Longitudinal farm survey • Statistical analysis	• Secondary data from various sources • 550 farms
Component 3: Impacts on WAJ-Zarqa; testing for meter error	• Tracking of utility performance indicators • Testing for meter error • Comparative utility analysis	n/a

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IE Component 1: Analytical Strategy

1) Propensity Score Matching (PSM) using block-level Census data:

$$T_i = \beta X_i + \varepsilon_i, \quad (1)$$

$$p(x) = \Pr[T = 1|X = x] = \frac{e^{\beta x}}{1+e^{\beta x}} \quad (2)$$

2) Difference-in-differences model to estimate impact in sample balanced on observable characteristics that predict treatment status, and controlling for time-invariant unobservable differences:

$$Y_{ijt} = \alpha + \gamma T_{jt} + \delta d_{jt} + \kappa T_{jt} \cdot d_{jt} + \beta X_{ijt} + \delta_{ijt}, \quad (3)$$

Y_{ijt} = outcome of interest at HH/E level; i=unit; j=zone; t=time

d = treatment assignment dummy, indicating if community j was assigned to the treatment group

T = time period dummy, indicating if intervention has occurred in community j at time t

3) Various other econometric tools: **Control for X_{ijt}; instrumental variables; ex-post PSM.**

IE Component 2: Analytical Strategy

1) Difference-in-differences estimation to isolate the effects of changes in the quantities of KAC and KTD water supplied to a representative sample of farms extending over these various regions

$$Y_{ijt} = \alpha + \gamma Q^{KTD}{}_{ijt} + \delta Q^{KAC}{}_{ijt} + \beta X_{ijt} + \upsilon_i + \delta_{ijt}, \quad (4)$$

Y_{ijt} = outcome of interest at; i=farm; j=zone; t=time

$Q^{KTD}{}_{ijt}$ and $Q^{KAC}{}_{ijt}$ = quantity of KTD and KAC water delivered to the farm *i* in zone *j* at time *t, respectively*

2) Other econometric tools: **Control for X_{ijt}**

Summary of pre-PSM balance (Zarqa)

Census Variable	Area A Both (N=104)	Area B WWNP only (N=115)	Area C WNP only (N=524)	Area D Controls (N=1303)
1. Wealth index	**-0.54*** **	-1.13	**-0.77*** **	-1.21
2. Marital status – head	**91.0%*** **	**90.8%*** **	87.2%	88.2%
3. Male head of household	**91.6%*** **	**92.4%*** **	**89.3%*** **	90.3%
4. Head > Secondary educ.	**45.3%*** **	36.8%	**42.8%*** **	38.1
5. Average residency	**14.2*** **	16.7	**16.7** **	16.2
6. Non-Jordanian	**6.2%***	7.7%	**4.9%*** **	8.4%
7. # buildings in block	39.0	**49.1*** **	**34.3*** **	39.5
8. Population density	**66.6*** **	**72.2*** **	**266.1** **	238.4
9. Paid employee – head	**78.6%***	**78.6%***	79.7%	80.6%
10. # households in block	**70.6*** **	**89.8***	85.3	83.1
11. Handicap	5.6%	5.6%	6.2%	5.9%

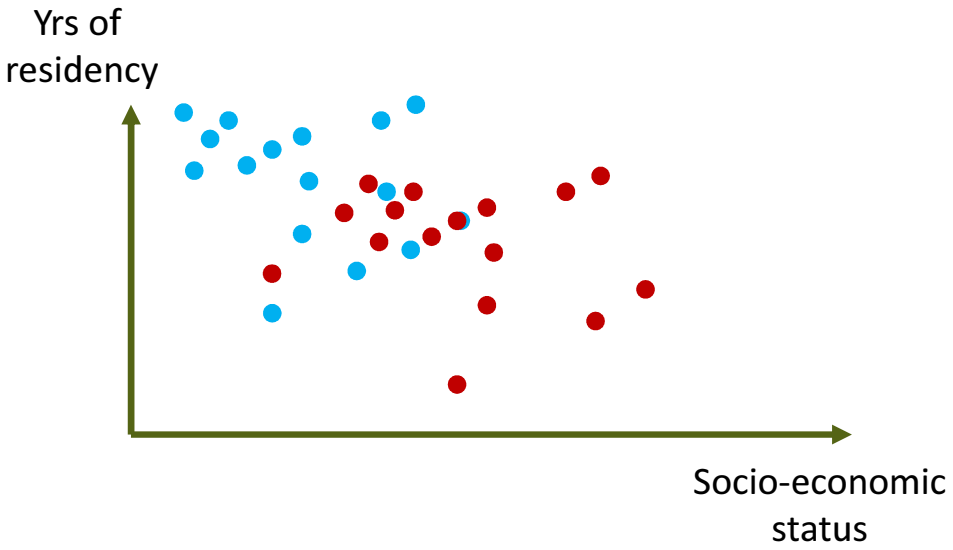
Notes: *** indicates p<0.01; ** p<0.05; *; p<0.1

Summary of balance after PSM (Zarqa)

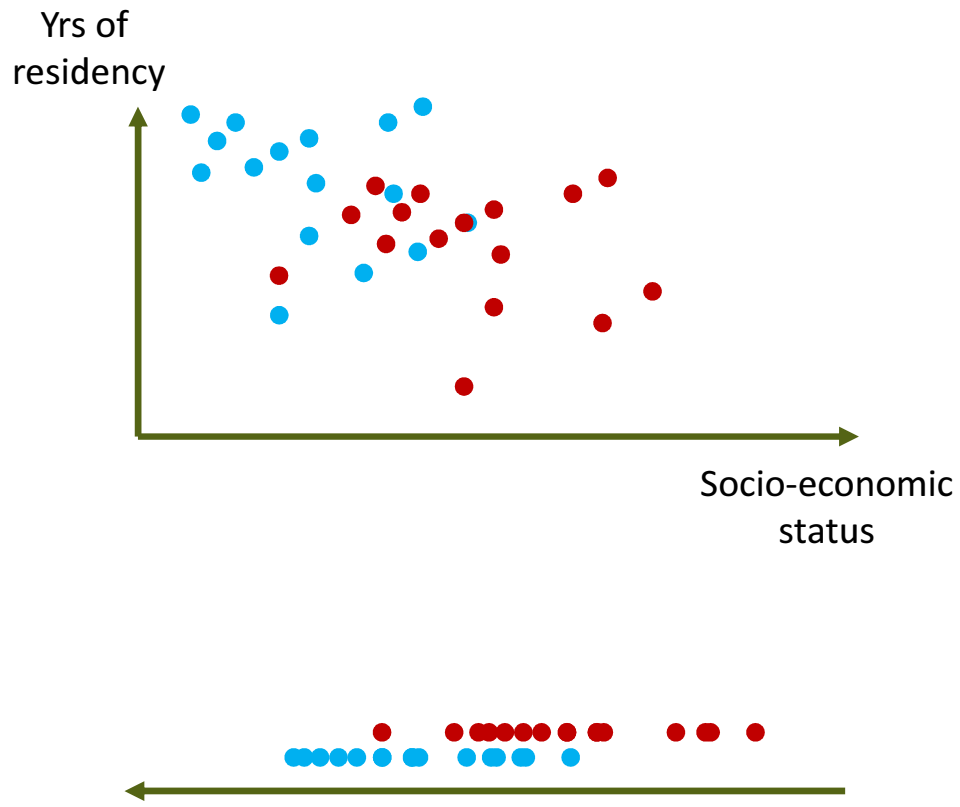
Census Variable	Area A Both	Area A Controls	Area B WWNP only	Area B Controls	Area C WNP only	Area C Controls
1. Wealth index	-0.25	-0.66	-0.94	-1.04	-1.08	-1.09
2. Marital status – head	89.1%	89.3%	89.5%	87.7%	88.4%	88.3%
3. Male head of household	90.1%	89.8%	90.1%	90.3%	90.2%	90.1%
4. Head > Secondary educ.	51.4%	47.2%	40.0%	38.3%	39.3%	38.6%
5. Average residency	15.9	15.9	16.7	17.2	16.3	16.7
6. Non-Jordanian	4.1%	4.3%	3.7%	4.7%	5.1%	5.0%
7. # buildings in block	35.1	37.6	**38.1****	45.6	36.1	36.0
8. Population density	98.4	118.2	113.5	160.2	278.6	251.7
9. Paid employee – head	80.3%	77.8%	81.5%	81.4%	80.9%	80.3%
10. # households in block	79.3	77.0	**83.7***	96.2	81.6	83.6
11. Handicap	4.5%	5.2%	5.7%	6.7%	6.2%	6.2%

Notes: *** indicates p<0.01; ** p<0.05; *; p<0.1

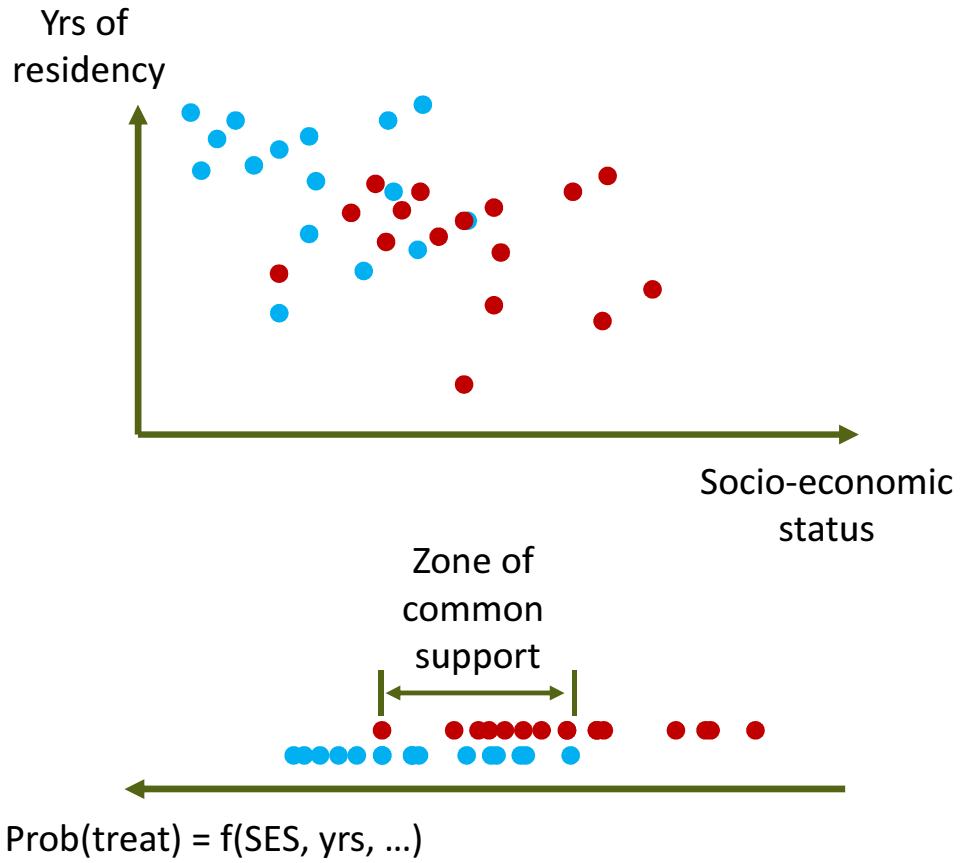
The basic idea behind PSM



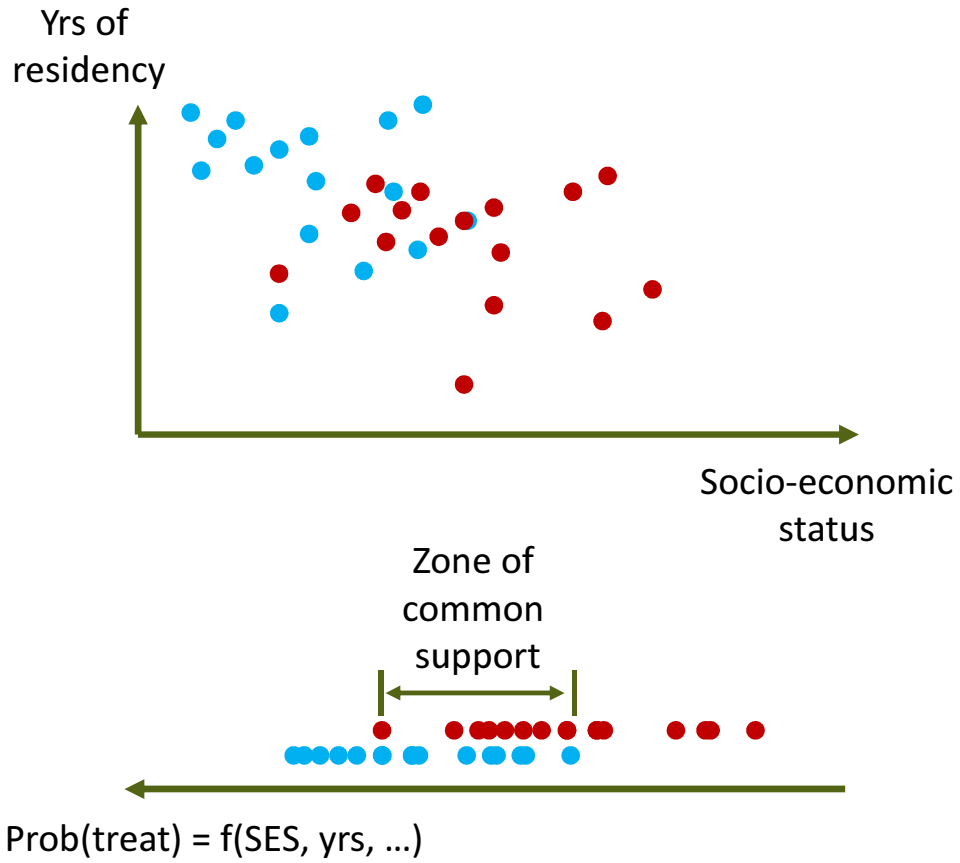
The basic idea behind PSM

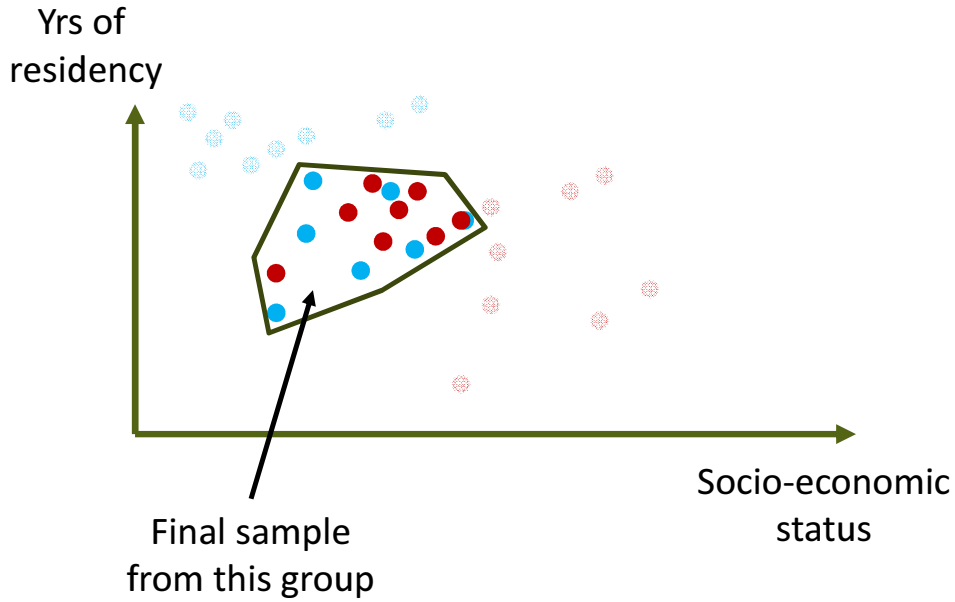


The basic idea behind PSM



The basic idea behind PSM





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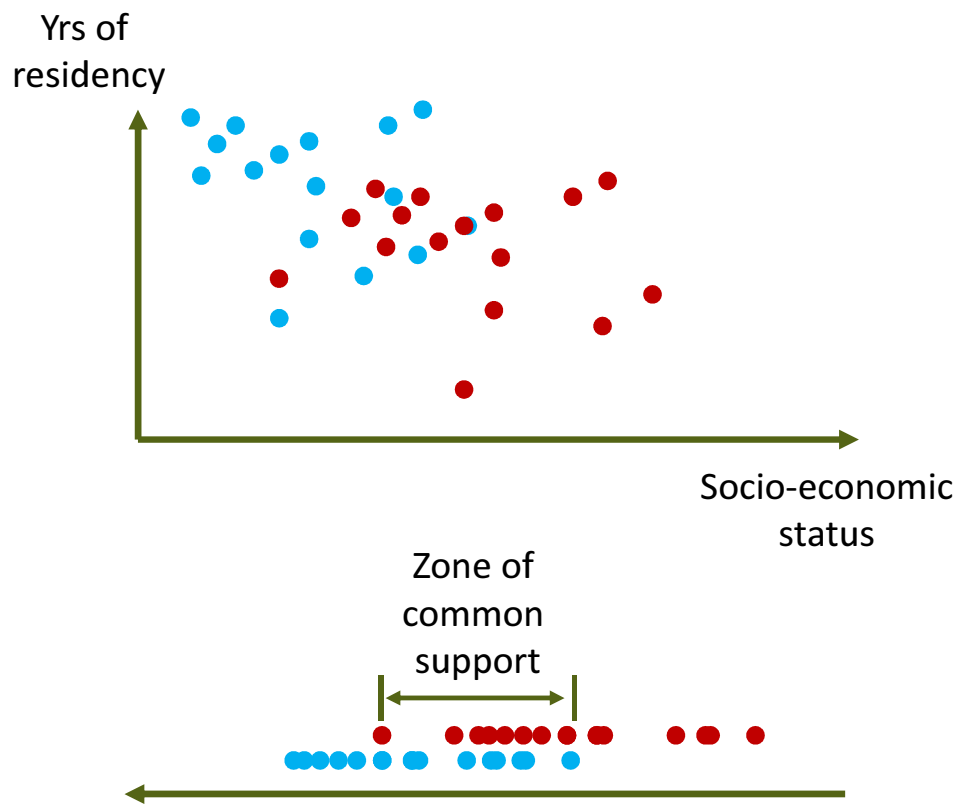
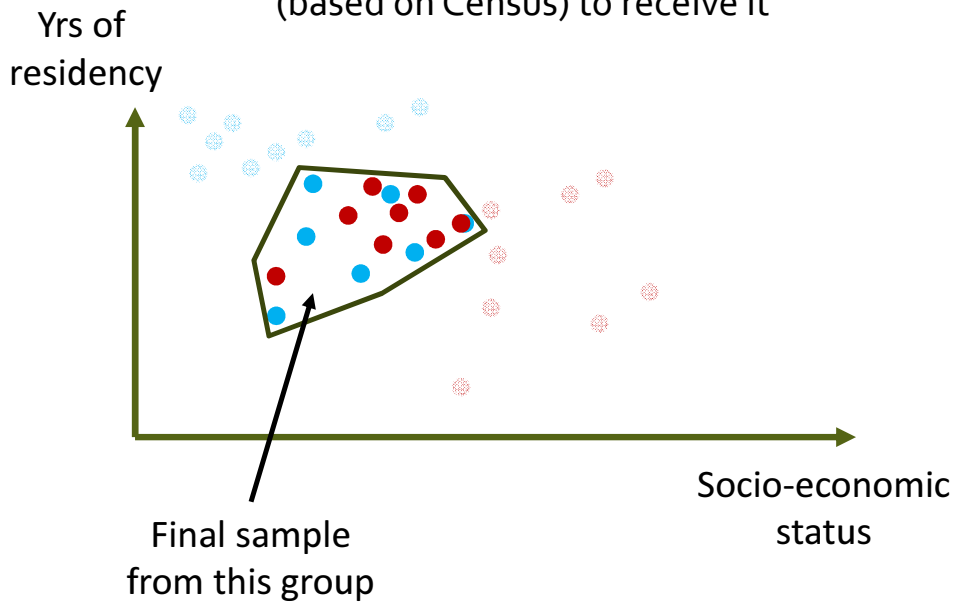
We use this to pre-select sample zones that are differentially exposed to intervention but that look equally likely (based on Census) to receive it