سلطنة عُمان
وزارة الثروة الزراعية والسمكية وموارد المياه

Assessment of the Sustainability of Water Management System in the Sultanate of Oman: A Case study of AL-Batha Basin

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Introduction

Geography

- ✓ South-eastern corner of the Arabian Peninsula and has a total area of 309,500 km^2

Climate

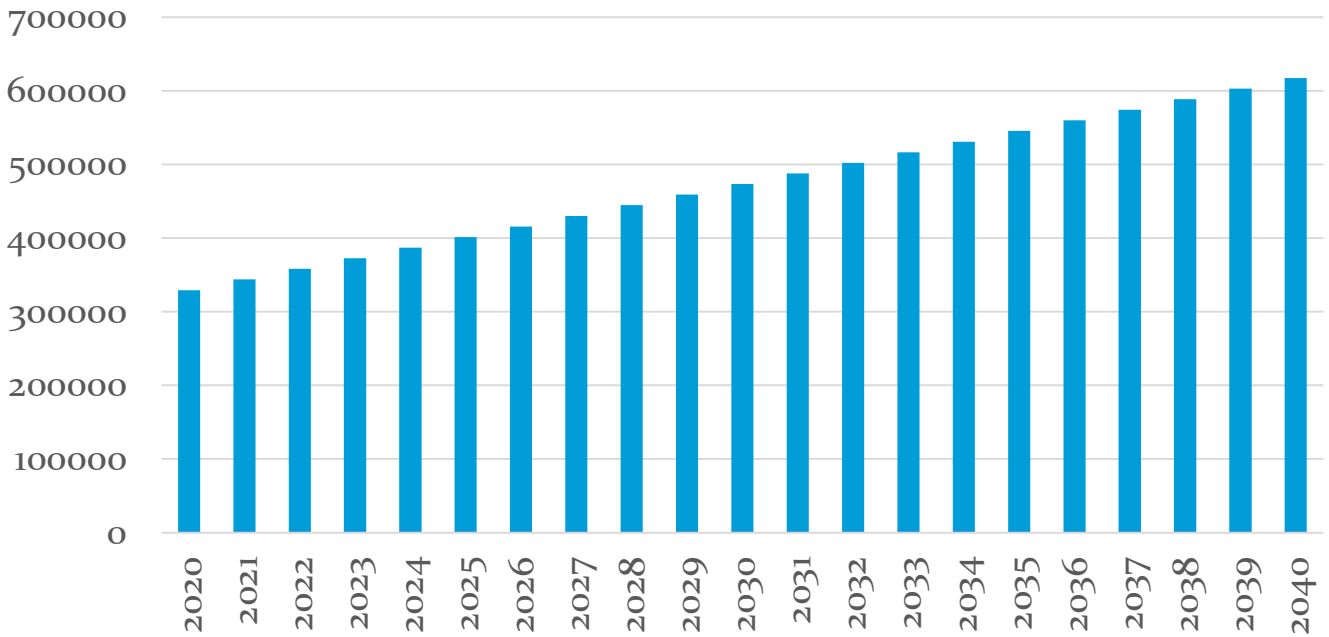
- ✓ Arid and semi-arid

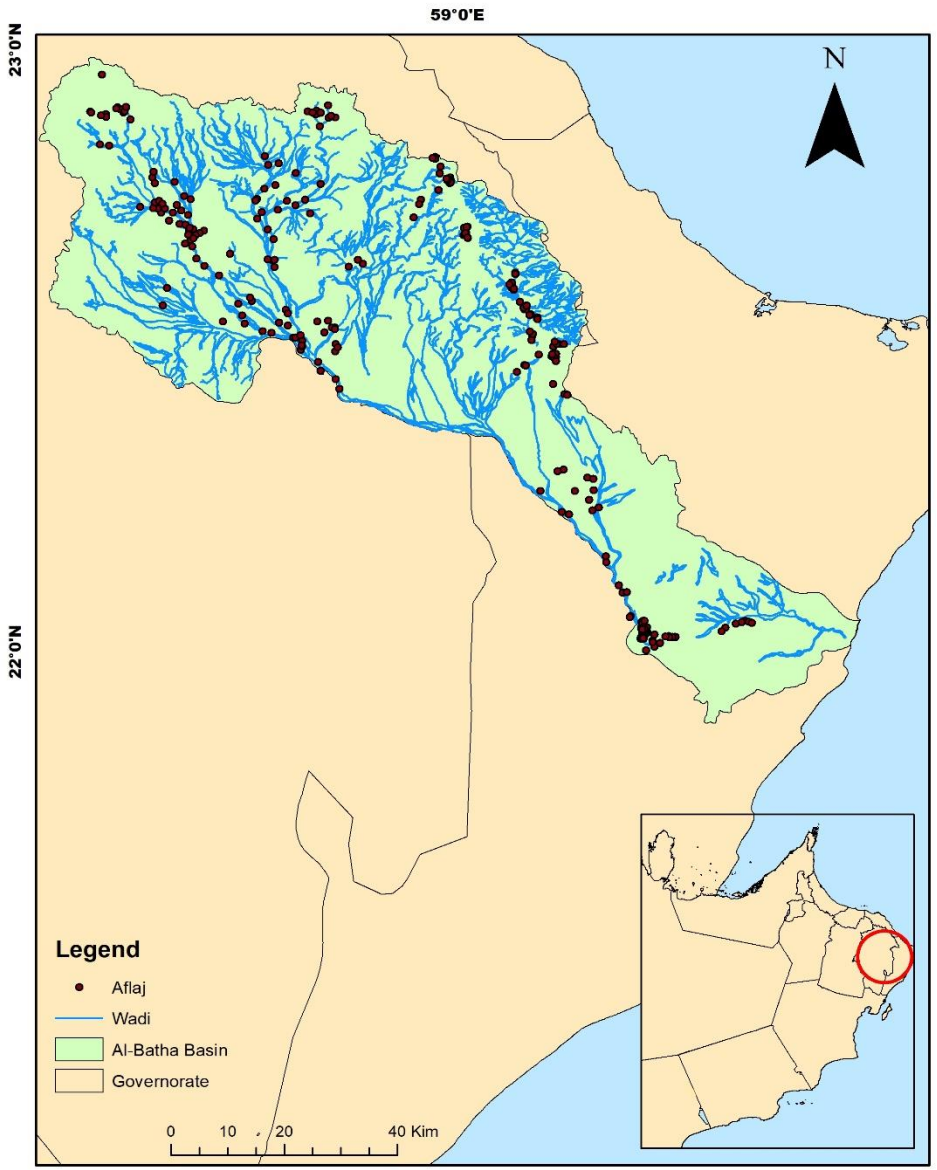
Water Resources Management

- ✓ In many areas of the Sultanate, demand for water far exceeds its availability

Case Study Location

- A'Sharqiyah governorates
- *Topographical features* (189 km²)
- *Population of Study Area* (327,371)
- Rainfall 1,136 Mm³/yr
- Evaporation losses = 933 Mm³/yr
- Deficit = 54,6 Mm³/yr





Problem Statement

- The Sultanate of Oman experience water shortages and a water deficit
- it is expected to continue in the future years

Research Significance

- efficiently managed water resources to continue to serve the sustainable development goals of the Sultanate
- Reduction of water deficit and subsequently costs
- Inform decision-makers on the effectiveness of management alternatives

WAA	Area (km^2)	Rainfall (Mm^3/yr)	Evaporative losses (Mm^3/yr)	Direct recharge (Mm^3/yr)	Wadi recharge (Mm^3/yr)	Reservoir recharge (Mm^3/yr)	Urban recharge (Mm^3/yr)	Agricultural abstraction (Mm^3/yr)	Urban abstraction (Mm^3/yr)	Capillary flux (Mm^3/yr)	Sum of Inter WAUA flows (Mm^3/yr)	Wadi flow (Mm^3/yr)	External flow (Mm^3/yr)	Storage (Mm^3/yr)	Deficit-Surplus (Mm^3/yr)
Musandam	1,993	333.0	206.0	100.6	2.8	0.2	0.5	-30.2	-0.8	-47.6	0.0	51.9	-36.8	-1.1	25.7
Shinas - Liwa	2,558	243.0	158.0	65.0	0.8	0.0	2.1	-46.1	-3.0	-67.5	0.6	87.8	-8.9	-0.5	-48.0
Sohar	2,804	261.0	169.0	70.5	0.9	2.6	3.3	-93.4	-4.6	-0.9	-5.3	111.7	3.6	-1.4	-27.0
Saham	2,783	247.0	160.0	66.4	1.0	4.3	3.6	-127.3	-5.0	-1.3	4.6	103.0	3.8	-0.7	-53.7
Al Khaburah	4,007	492.0	350.0	118.5	27.9	0.0	5.4	-248.1	-7.6	-30.2	6.3	79.5	-14.4	-0.8	-127.8
Barka	2,720	314.0	218.0	75.8	10.7	1.1	3.3	-137.5	-4.7	-32.7	-6.3	37.0	14.4	-0.3	-90.2
Daymaniyat Islands	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0
Samail	1,841	188.4	135.0	42.6	7.5	0.7	12.2	-70.1	-17.1	-46.7	-2.5	82.9	14.1	-1.6	-73.4
Muscat	1,056	84.0	56.0	18.4	1.5	0.0	17.1	-25.1	-3.0	-23.5	9.3	18.0	-22.5	-0.8	-5.1
As Sifah - Yiti	949	72.0	42.0	17.3	0.2	0.0	0.7	-5.0	-1.0	-5.1	-3.1	26.8	-9.7	-0.5	4.0
Qurayyat	2,695	362.0	200.0	102.7	3.2	0.0	2.9	-41.6	-4.1	-84.9	-0.7	339.4	-26.5	-0.6	-22.4
Tiwi	1,488	190.0	113.0	54.9	0.1	0.0	0.5	-6.1	-0.6	-16.7	1.0	14.2	-34.7	-1.5	33.1
Mahdah	2,959	256.0	141.0	97.9	0.4	0.0	1.6	-29.0	-2.2	-25.6	0.0	30.6	-69.2	-0.4	43.1
Al Masrat	25,705	1,787.0	1,568.0	165.1	33.5	0.0	3.5	-187.1	-5.0	-175.1	4.9	177.3	-25.4	-7.8	-160.2
Al Umeyri	27,381	1,453.0	1,222.0	195.6	27.5	0.0	2.0	-58.6	-2.8	-157.8	-4.9	121.0	-4.3	-33.2	1.0
Andam - Al Batha	14,189	1,136.0	933.0	172.0	12.0	0.0	3.7	-172.4	-5.2	-64.2	-0.4	75.6	-77.5	-24.9	-54.6
Masirah	657	43.0	30.0	10.5	0.1	0.0	0.3	-5.2	-0.4	-0.2	0.0	2.8	-1.2	-4.0	5.2
Haymah	52,289	0.0	0.0	0.0	0.0	0.0	0.1	-0.1	-0.1	0.0	0.0	0.0	4.2	-4.0	-0.1
Al Huqf	9,835	109.0	102.0	6.3	0.0	0.0	0.1	0.0	-0.1	0.0	0.0	0.7	-5.3	-1.0	6.2
Ad Duqm	7,928	767.0	599.0	119.6	0.3	0.0	1.6	0.0	-2.2	-72.3	-3.4	76.6	-38.5	-6.8	43.5
Al Jazer	10,462	1,018.0	804.0	153.5	0.4	0.0	0.2	0.0	-0.2	-82.7	-26.9	98.4	-43.4	2.1	44.3
Shalim	1,681	163.0	128.0	25.4	0.0	0.0	0.0	-0.3	0.0	-6.2	30.3	5.9	-49.2	-0.5	49.2
Mirbat - Sadh	1,900	96.0	50.0	26.7	0.0	0.0	0.3	-0.2	-0.5	-1.5	-7.1	0.0	-27.5	-1.0	17.7
Najd	88,967	2,635.0	2,382.0	71.1	18.9	0.0	0.7	-16.4	-1.0	-20.4	0.0	601.9	4.0	-4.9	53.0
Salalah	2,117	266.0	169.0	73.4	0.0	0.0	4.5	-93.1	-6.3	-3.9	1.2	6.5	-6.3	-0.4	-24.2
Rakhyut	1,711	134.0	94.0	29.9	0.0	0.0	0.2	-16.0	-0.3	-5.5	6.0	16.2	-29.2	-0.2	14.3
Total	**309,442**	15,841.4	12,552.6	2,397.3	240.4	10.3	77.1	-1,546.3	-87.5	-1,414.2	7.0	2,510.9	-538.4	-173.3	-315.8

Research Objectives

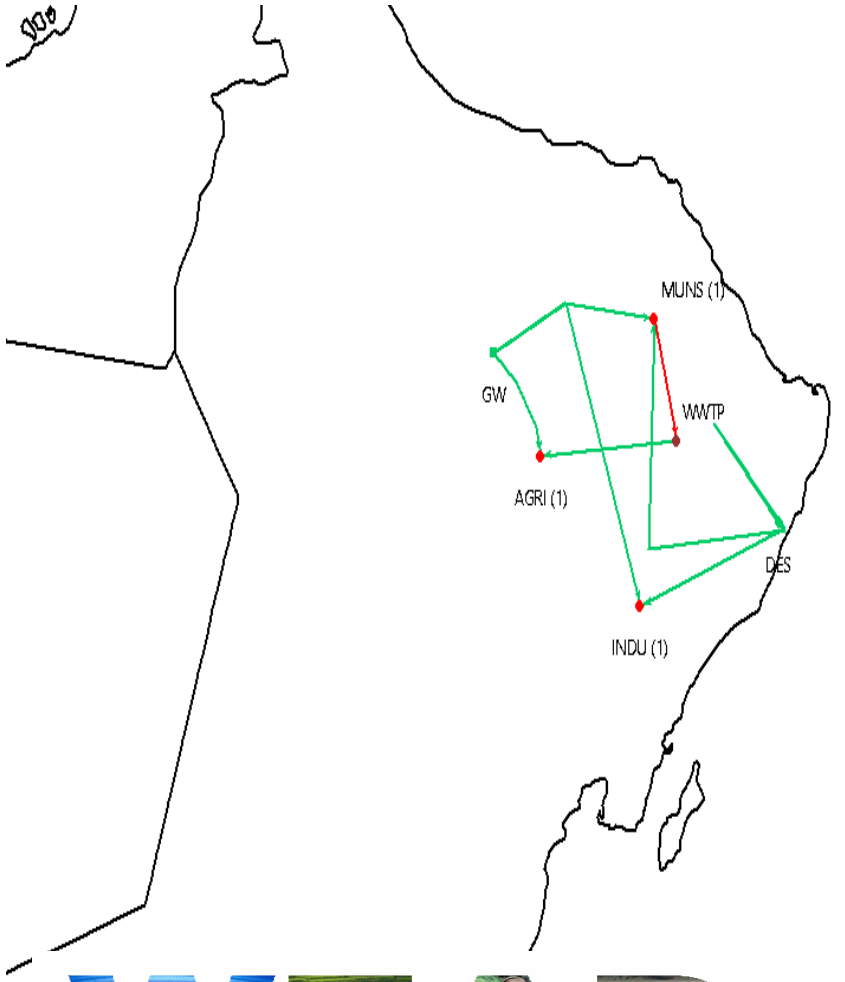
- Evaluating the current efficiency of water resources management in the Sultanate of Oman.
- Identifying the best future scenarios for managing water resources that are in line with Oman Vision 2040.
- Make appropriate recommendation for sustainable water management in the Sultanate of Oman.

Research Questions

- What is the current status of water resources management in the Sultanate of Oman?
- What are the best future scenarios for managing water resources in the Sultanate of Oman?
- What are the appropriate recommendation for sustainable water management system in the Sultanate of Oman?

Research Methodology

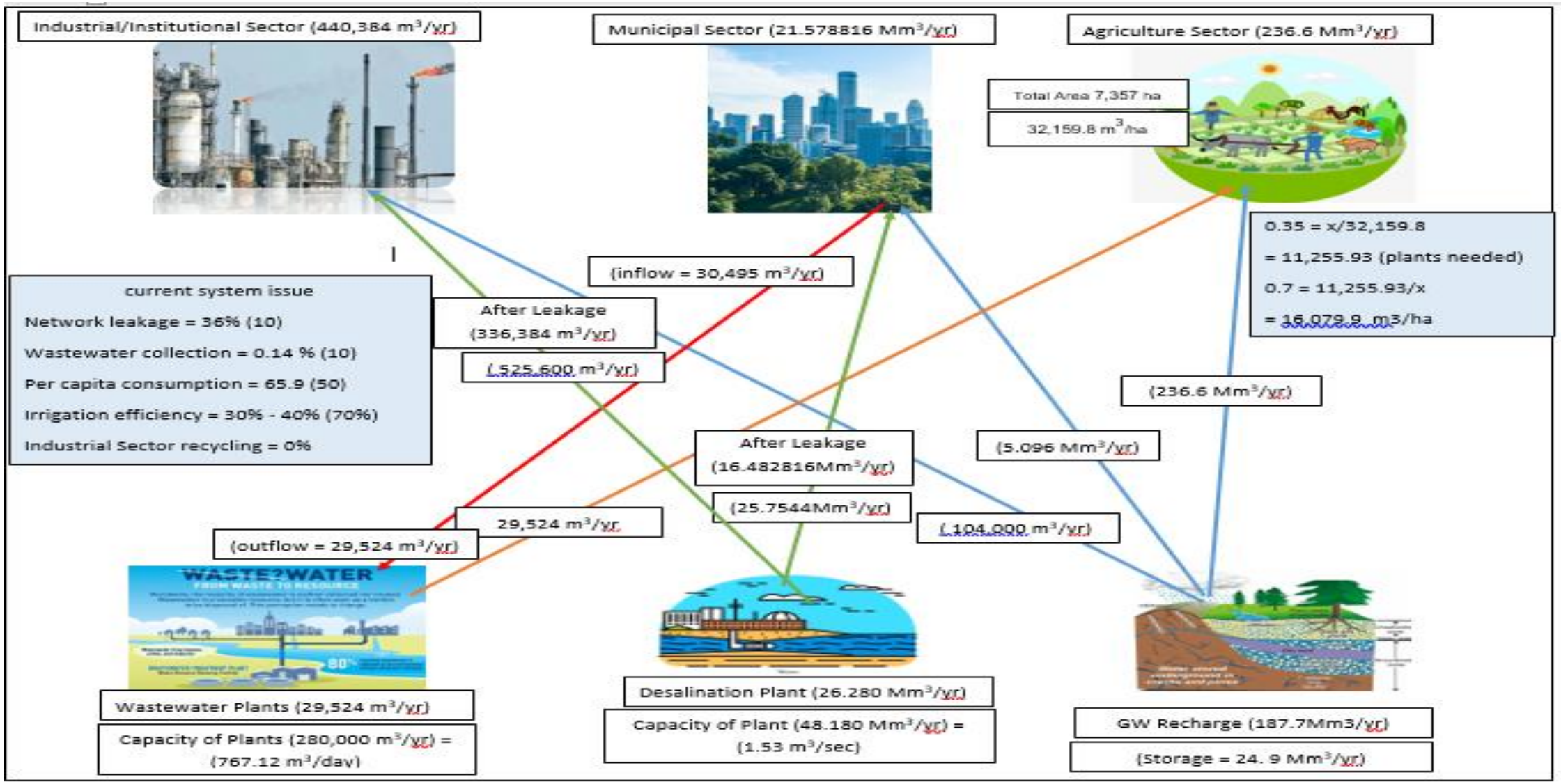
- **Evaluation of the current water resources management in the sultanate of Oman will be made using the following steps:**
  - Develop a dynamic mathematical model for the Al-Batha basin using WEAP (collecting data, inputting data, verification of model)
  - Running model for future scenarios under the business as usual (using the same management approach and policies) calculating/observing performance indicators).
- **Identifying best future scenarios**
  - Running model under various potential management interventions and calculating performance indicators
  - Comparing the performance indicators of the potential management scenarios with the business as usual performance indicators
- **Make appropriate recommendations for the effective balancing between supply and demand on long-term basis.**



WEAP
Water Evaluation And Planning

SEI Stockholm Environment Institute

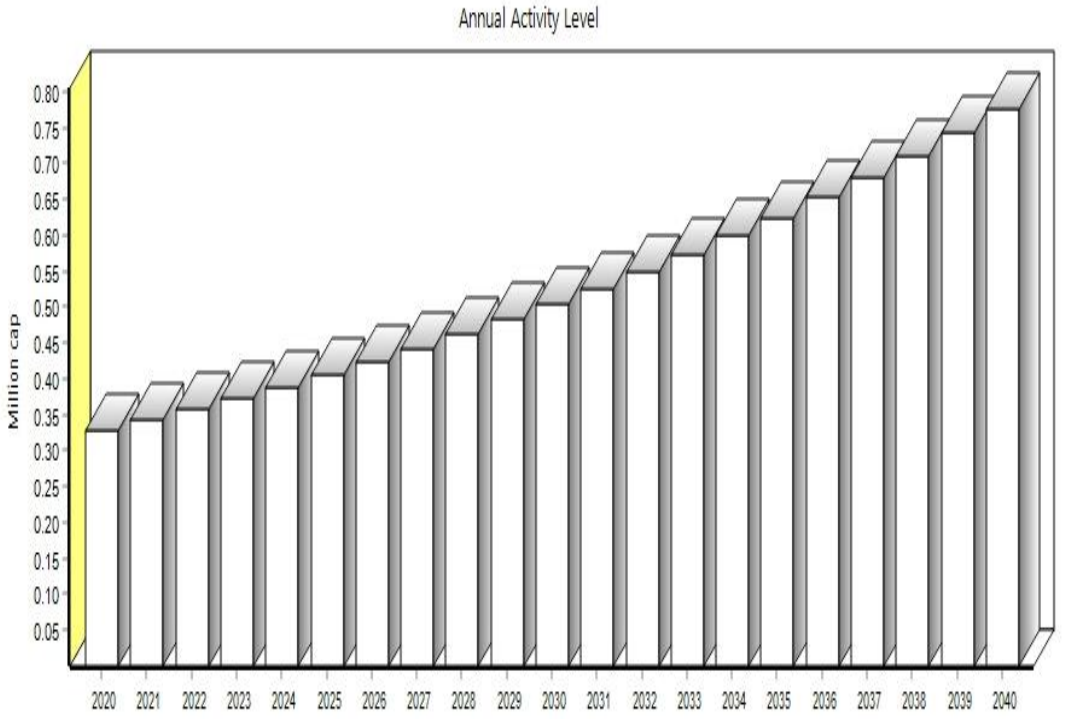
Data


Industrial/Institutional Sector (440,384 m³/yr)
Municipal Sector (21.578816 Mm³/yr)
Agriculture Sector (236.6 Mm³/yr)
Total Area 7,357 ha
32,159.8 m³/ha
0.35 = x/32,159.8
= 11,255.93 (plants needed)
0.7 = 11,255.93/x
= 16,079.9 m3/ha
current system issue
Network leakage = 36% (10)
Wastewater collection = 0.14 % (10)
Per capita consumption = 65.9 (50)
Irrigation efficiency = 30% - 40% (70%)
Industrial Sector recycling = 0%
(inflow = 30,495 m³/yr)
After Leakage
(336,384 m³/yr)
(525,600 m³/yr)
(236.6 Mm³/yr)
After Leakage
(16.482816Mm³/yr)
(5.096 Mm³/yr)
(25.7544Mm³/yr)
(104,000 m³/yr)
29,524 m³/yr
(outflow = 29,524 m³/yr)
WASTE?WATER
FROM WASTE TO RESOURCE
Wastewater Plants (29,524 m³/yr)
Capacity of Plants (280,000 m³/yr) = (767.12 m³/day)
Desalination Plant (26.280 Mm³/yr)
Capacity of Plant (48.180 Mm³/yr) = (1.53 m³/sec)
GW Recharge (187.7Mm3/yr)
(Storage = 24. 9 Mm³/yr)

Modeling the water resources system in the Al-Batha basin

Scenarios questions

- What is the impact of the population growth on water resources in Al-Batha basin over the next 20 years?
- What is the impact of the reuse of treated wastewater in the agricultural sector in reducing the deficit and enhancing the sustainability of the water system?
- What is the impact of increasing irrigation efficiency (through the use of modern irrigation system or other demand management means) in reducing groundwater deficit?
- What is the effect of introducing crops that are economically feasible and consume less water?
- What is the impact of changing per capita water consumption on the municipal water demands and in reducing the costs of desalination?



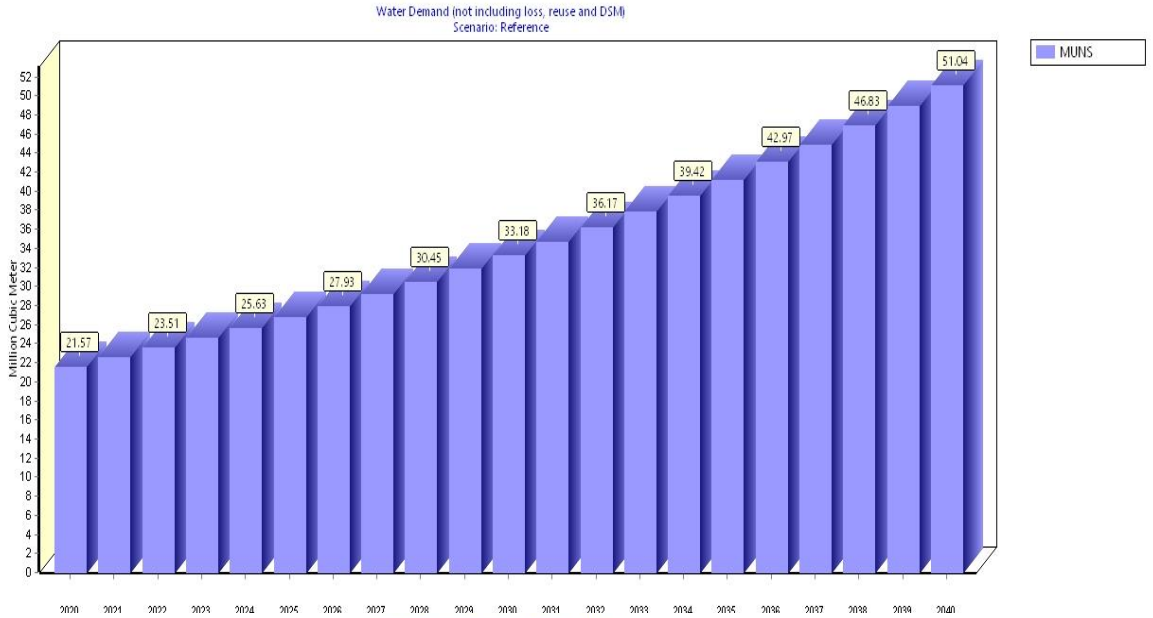
Reference Scenario

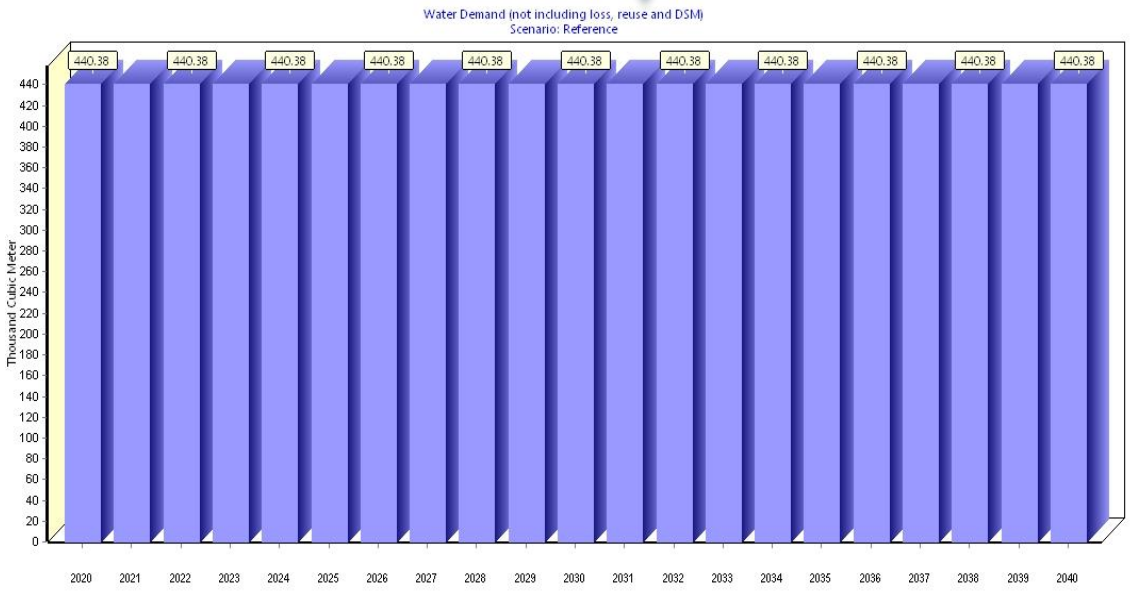
Results

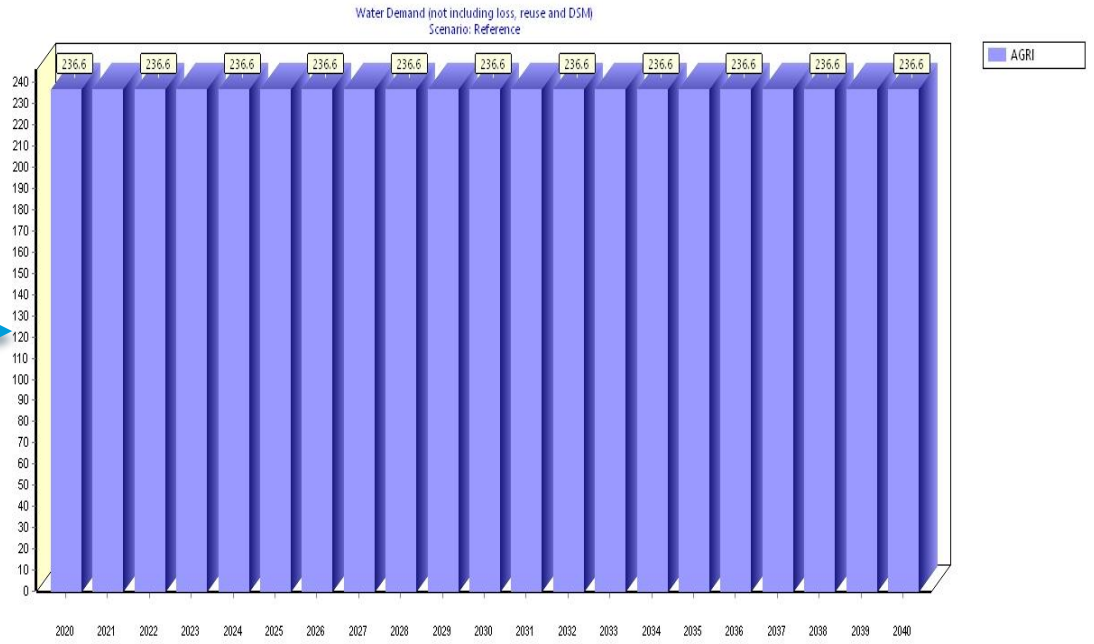
Municipal water demand

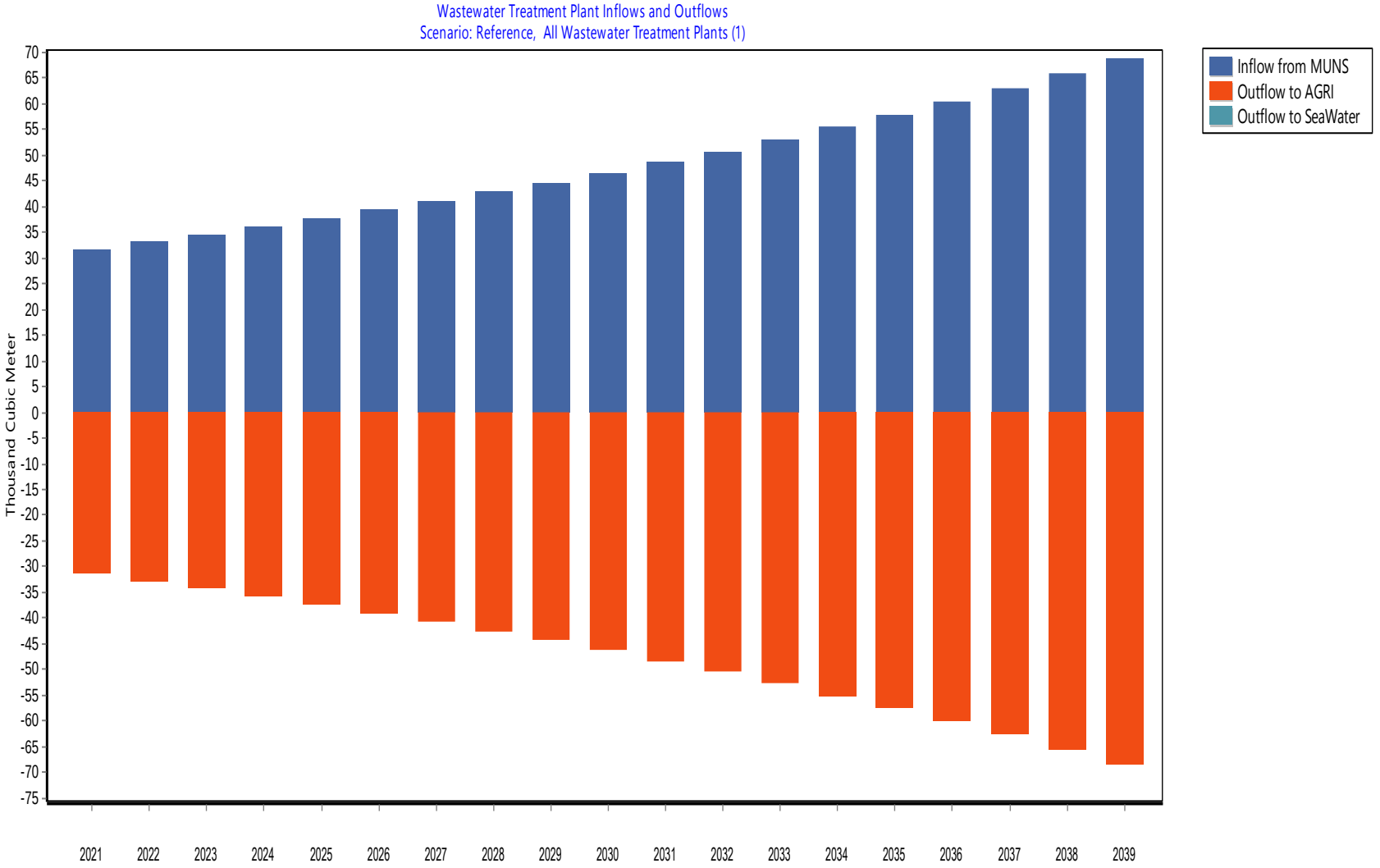
Agriculture sector demand

Industry sector demand









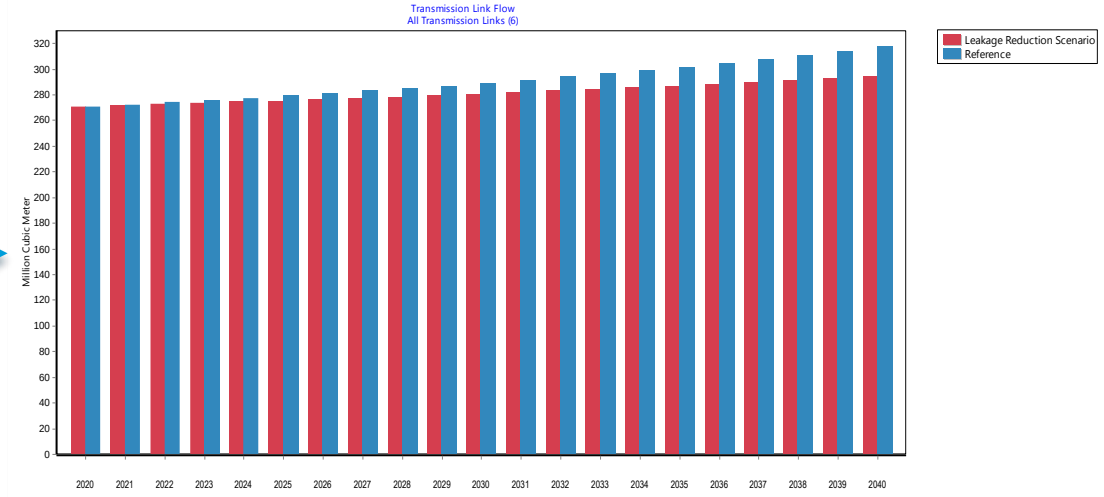
The quantities of inflow and outflow of the wastewater treatment plants according to the reference scenario 2020-2040

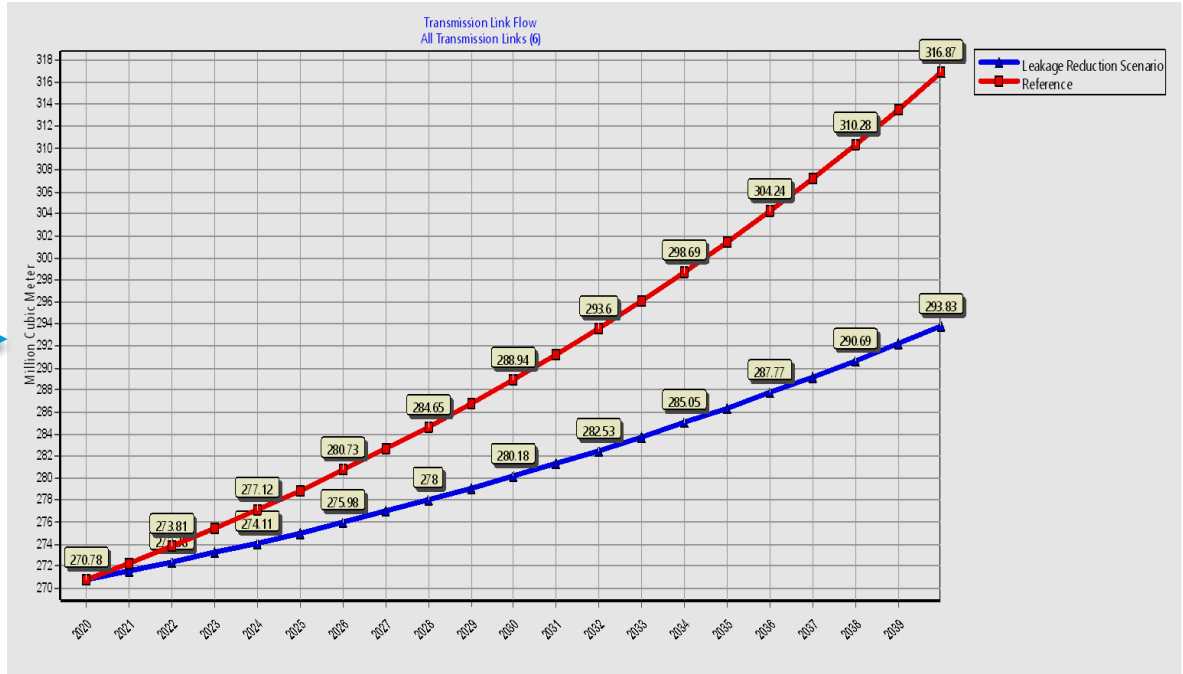
Strategic options for managing water resources in the Al-Batha Basin

- **Administrative options scenarios**

- The future scenarios that have been developed and simulated in a WEAP are:

Reducing leakages in the water network in the municipal sector.



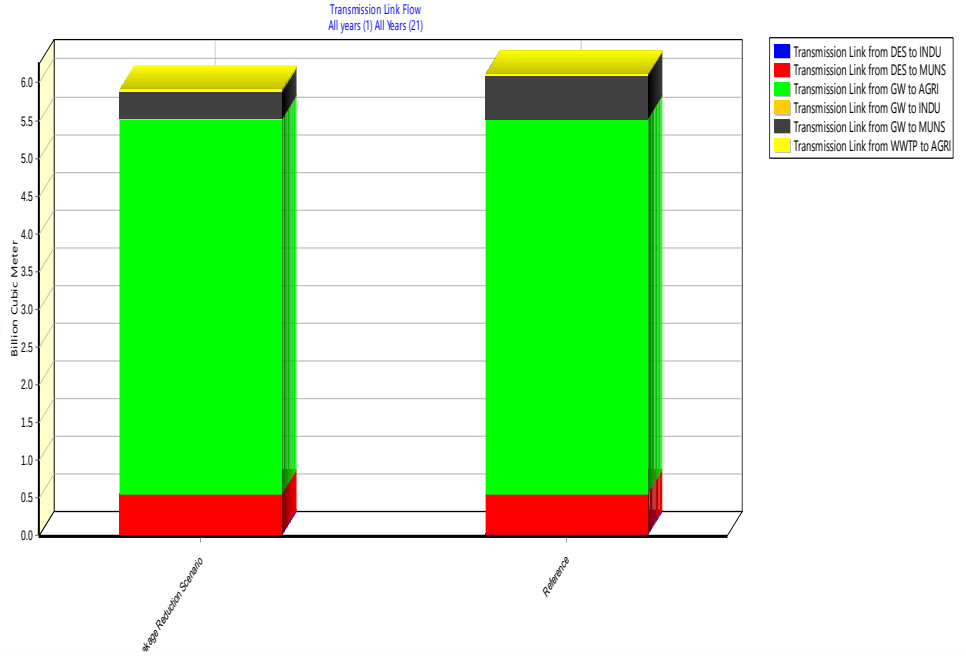


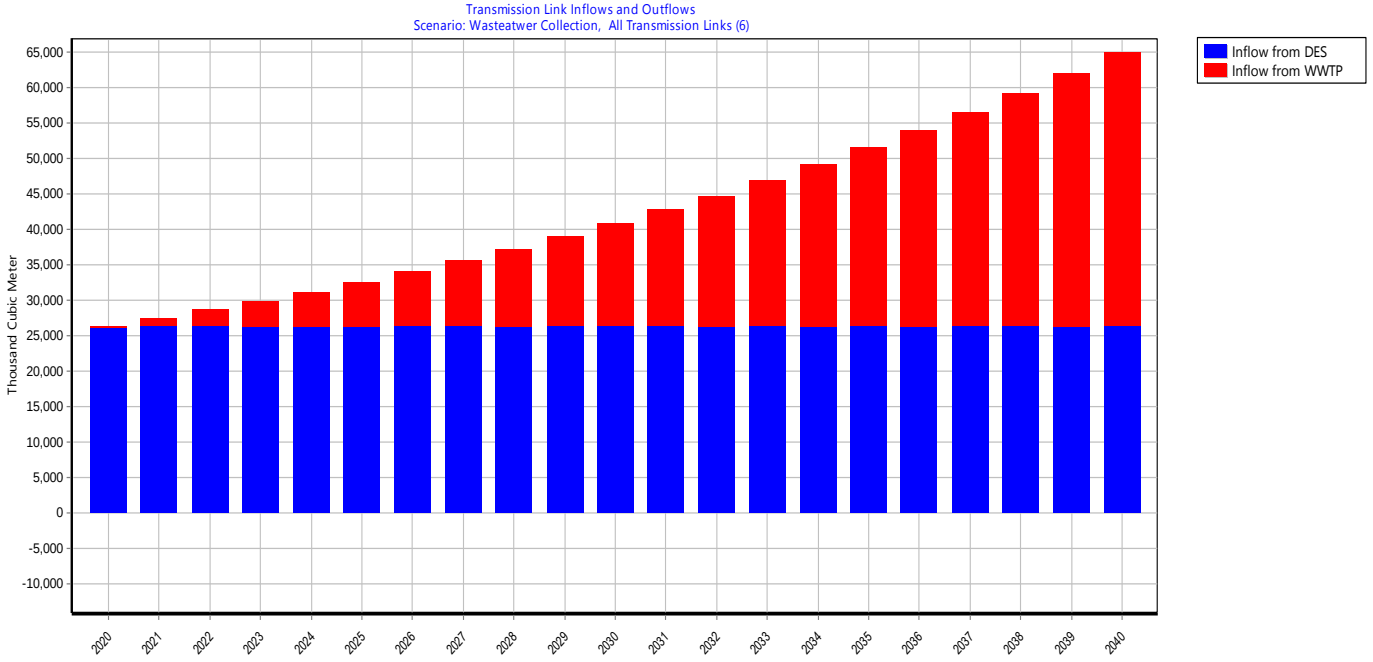
Increasing wastewater collection and reuse in the agricultural sector.

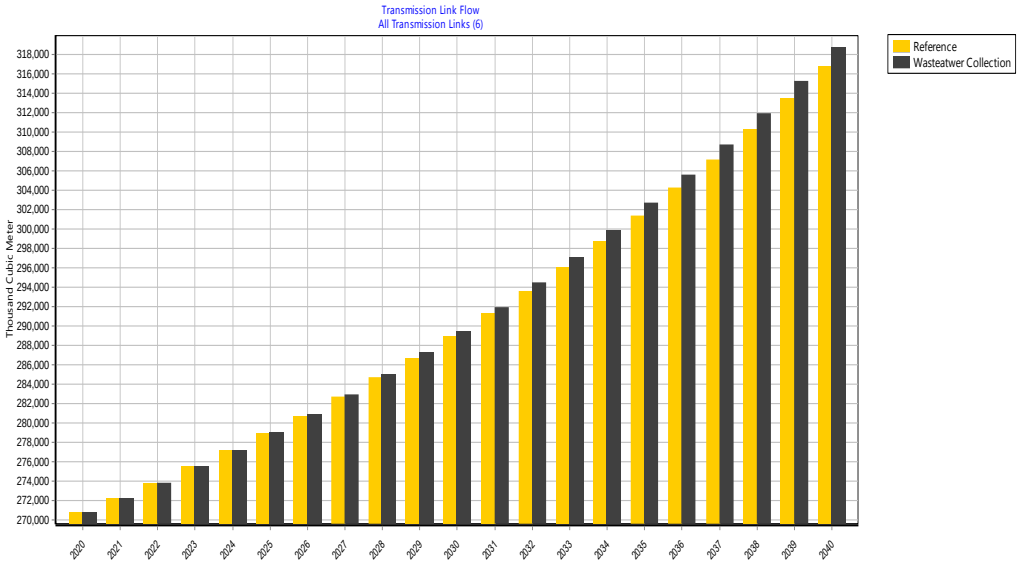
Comparison of municipal water supply quantities between the leakage reduction scenario and the reference scenario (2040-2021).

Wastewater collection comparing with reference scenario (2021 -2040).

Inflow water quantity From WWTP (2021 -2040).

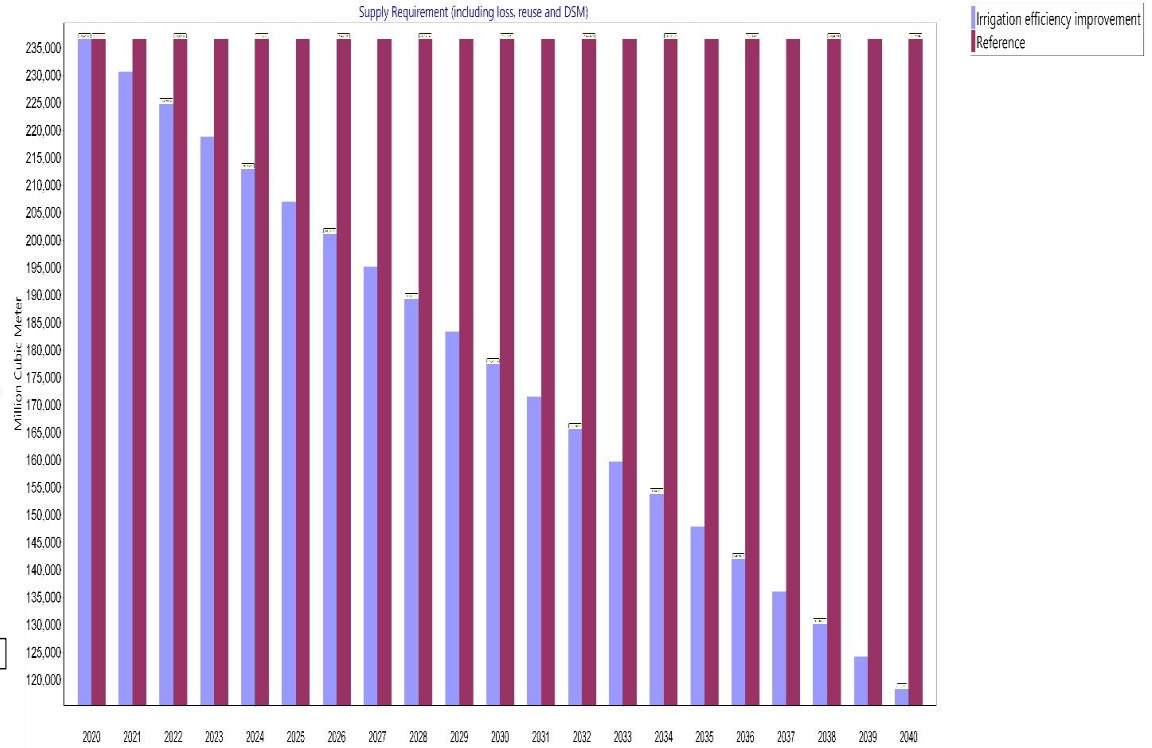


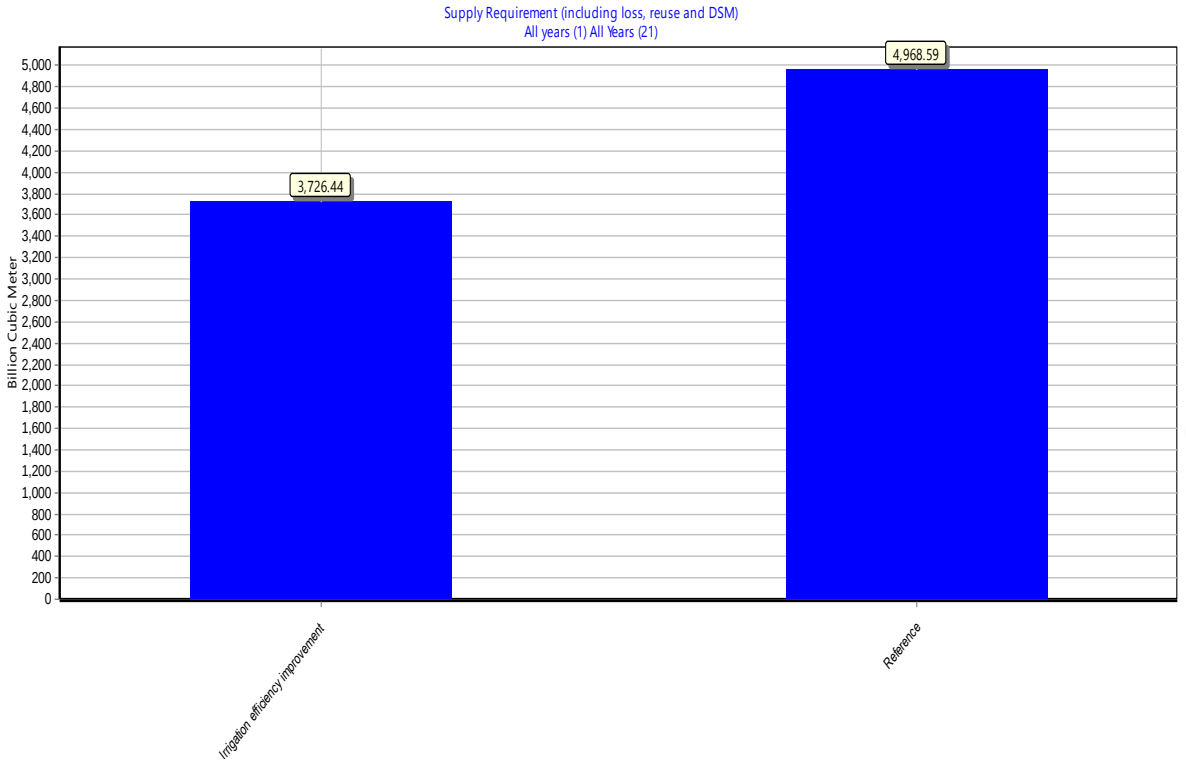




Increasing the efficiency of irrigation systems.

Comparing the irrigation efficiency scenario with the reference scenario on the demand for water used in agriculture (2021-2040)

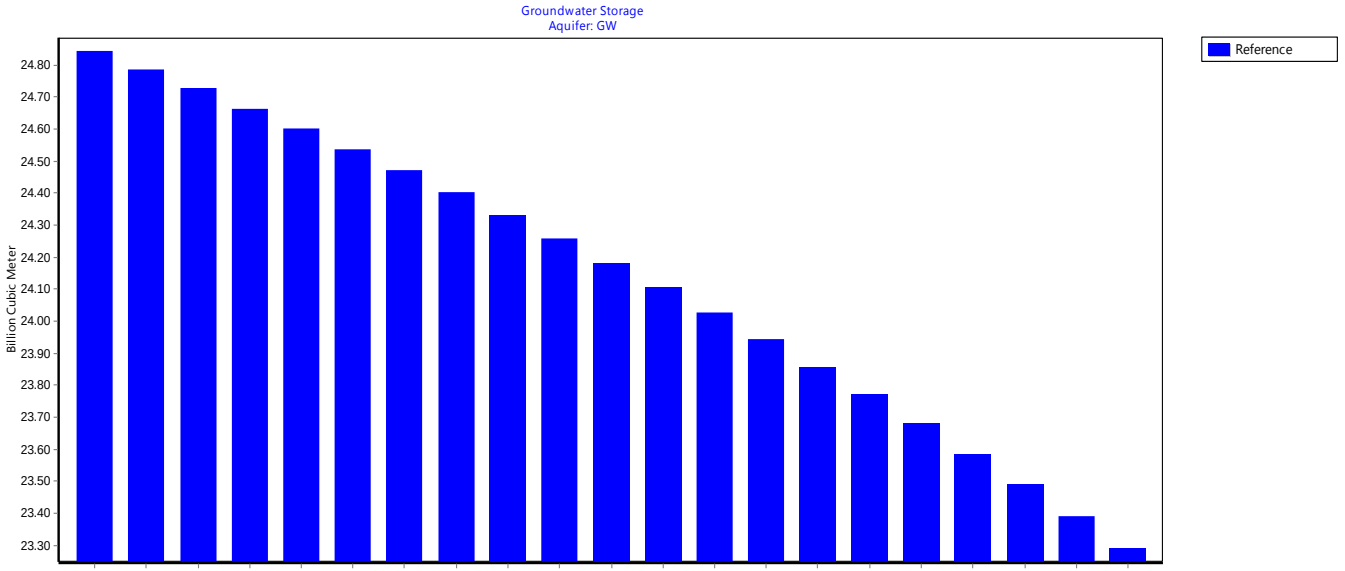




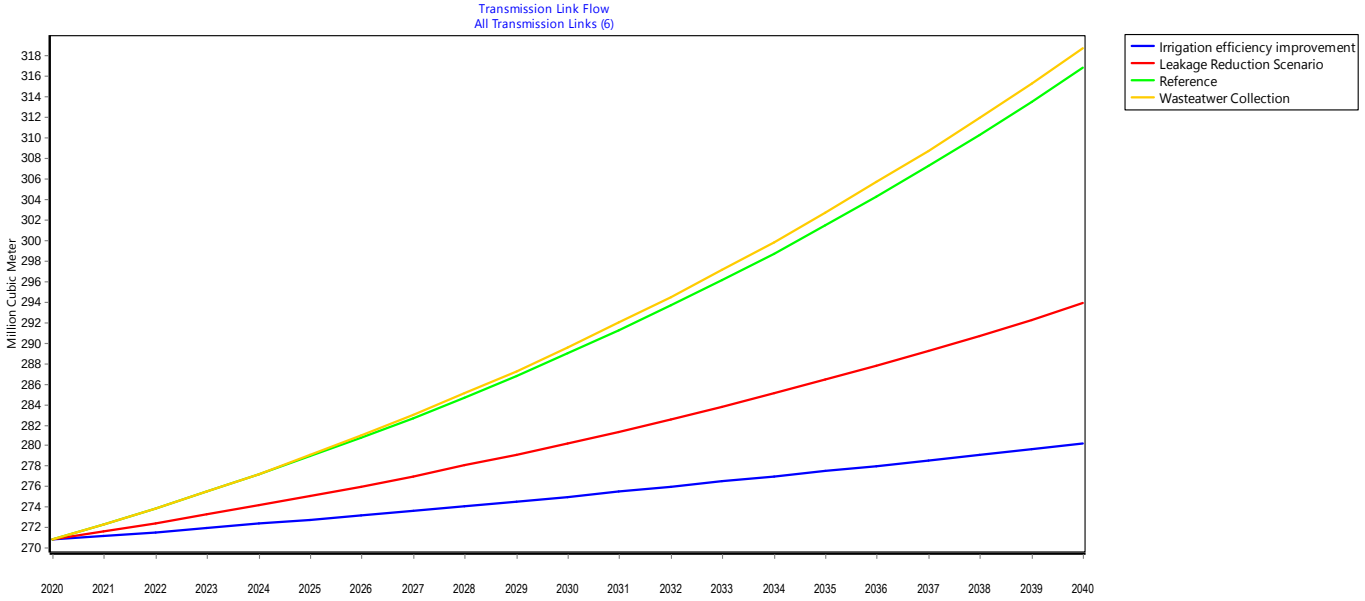
Comparison of the quantities of water demand used in agriculture (cumulative) between the reference scenario and the scenario of raising irrigation efficiency during the period (2021-2040

All options together

Comparison between the quantities of water in the aquifer in the reference scenario and the quantity after 20 years.



Comparison between the quantities of water in the reference scenario and the quantity of water in all scenario after 20 years



Conclusion

- The water deficit of the Al-Batha basin is estimated at about 54.6 Mm^3/yr (about 17% of the Sultanate deficit)
- Municipal water demands 317 Mm^3 → 294 Mm^3 Increasing Population growth water demand.
- Current water recourses management → excessive pumping of water from GW.
- The aquifer storage will decrease from 24.84 Mm^3/yr → to 23.29 Mm^3/yr.
- Collected quantity wastewater 270,779 m^3 in 2020 → 316,866 m^3 in 2040 in the reference scenario compared to the amount of 318,744 m^3 in 2040, as the amount of increase It will be 1,878 m^3.
- Agricultural sector reduced from 236. 6 Mm^3 → 118.3 Mm^3 irrigation efficiency measures are implemented, (35% to 70%).

Recommendations

- Wastewater should be collected as much as possible to be used in agriculture
- Farmers should be encouraged and educated about the use of wastewater after studies have proven that there are no obstacles from using wastewater in agriculture
- Work must be done during the coming period to reduce the general network leaks
- In the Al-Batha basin, most of the farms are irrigated with traditional irrigation, so work must be done to raise the efficiency of irrigation through modern irrigation

Credits and Acknowledgements (if any)

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Thanks!