Economic analysis of managed aquifer recharge (MAR)

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- Brief introduction to MAR
- IAH-MAR economic working group
  https://recharge.iah.org/working-groups/economics-of-mar
- Outcomes of assessment of benefits & costs of MAR
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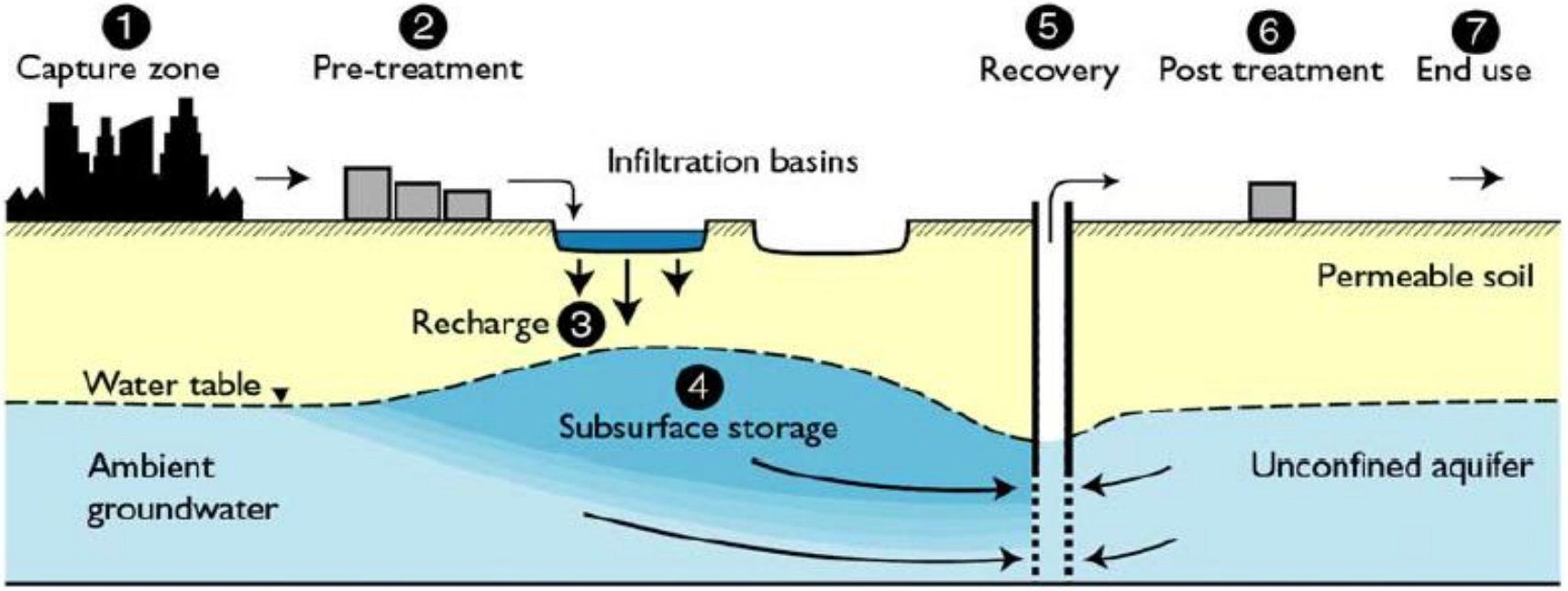
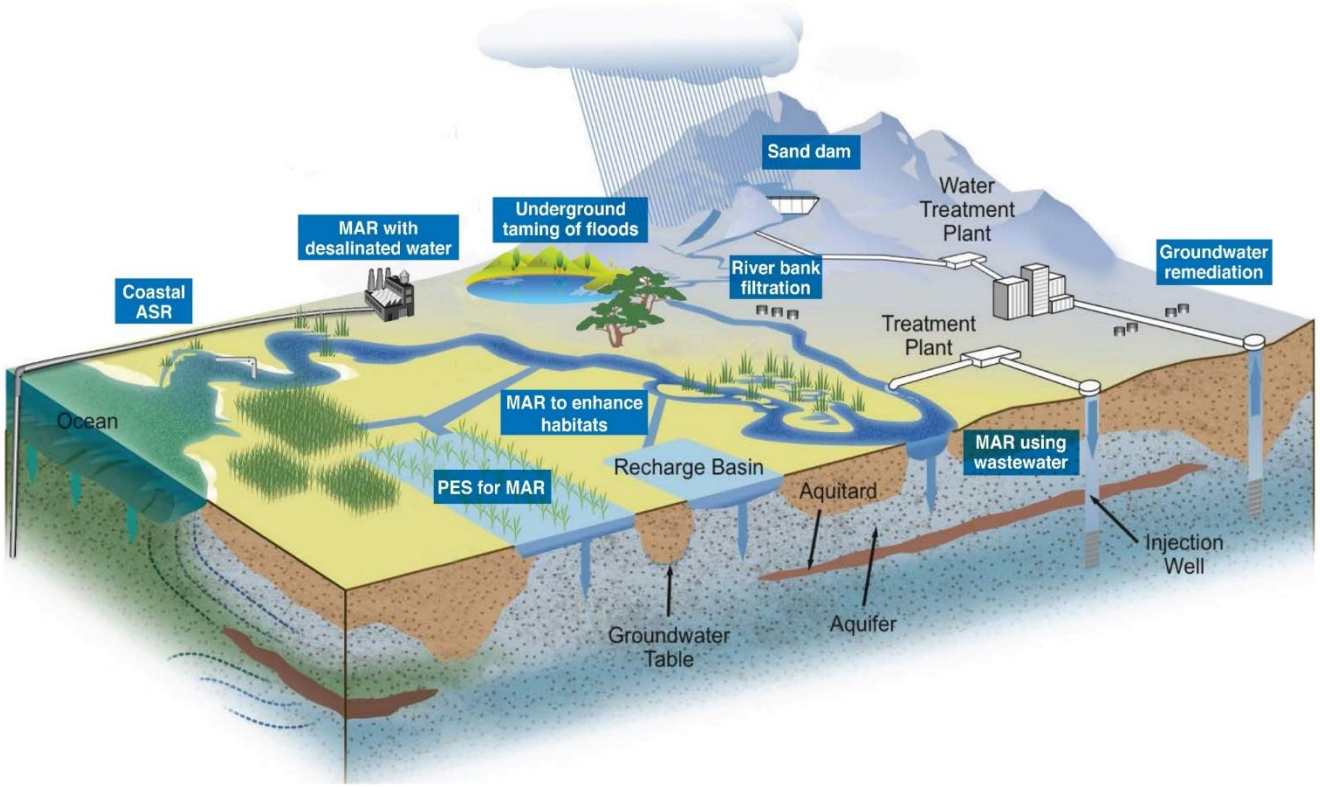
MAR = intentional recharge of water to aquifers and recovery for social or environmental benefit

Elements of MAR schemes



MAR objectives and solutions

- Groundwater storage
- Water Retention and Regulation
- Water quality
- Environmental support



http://gripp.iwmi.org/natural-infrastructure/guide-for-gbni-solutions

MAR schemes are very diverse: 3 Main Types

Infiltation Check Dam
Rajasthan India

Infiltation Rainwater
Harvesting Bangladesh

Infiltration Basins Burdekin
Australia

Injection well Adelaide
South Australia

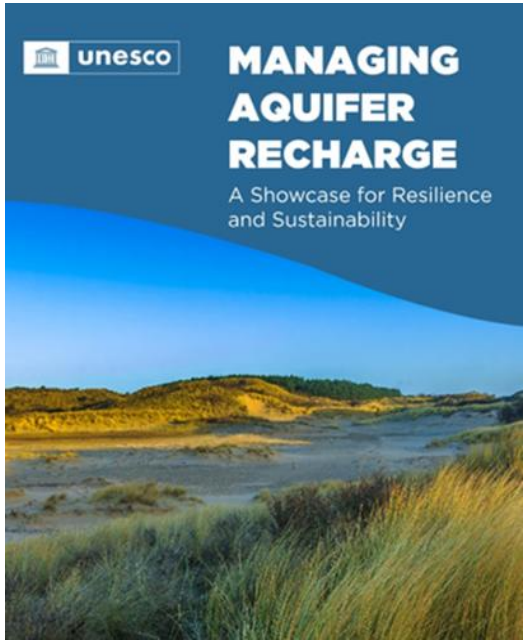
Riverbank Filtration Dresden Germany

IAH MAR economic working group

Aims to

- Collect financial and economic information about costs and benefits MAR schemes
- Analyse economic and institutional aspects of MAR and water banking

2016-21
Development of standard framework for analysing financial costs of MAR:
Ross, A and Hasnain, S (2018) Factors affecting the cost of managed aquifer recharge schemes. Sustainable Water Resources Management 4 (2):179-190.



2022-25

- Journal article Ross A. (2022) Benefits and Costs of Managed Aquifer Recharge: Further Evidence. Water 2022, 14, 3257 2022
- 2025 ISMAR 12: special session on avoiding MAR scheme failure

Further details:
https://recharge.iah.org/working-groups/economics-of-mar

Objective of collection of financial and economic information about MAR schemes

- Promote consideration of MAR as an effective and efficient solution in water policy, management and investment decision making
  - Publication of financial and economic data helps to demonstrate scientific and business credentials of MAR sector

- Lack of public financial & economic data about MAR schemes
  - Most MAR schemes are project based, data is held by private or public corporations and is commercial in confidence
  - IGRAC Global MAR inventory does not include economic data

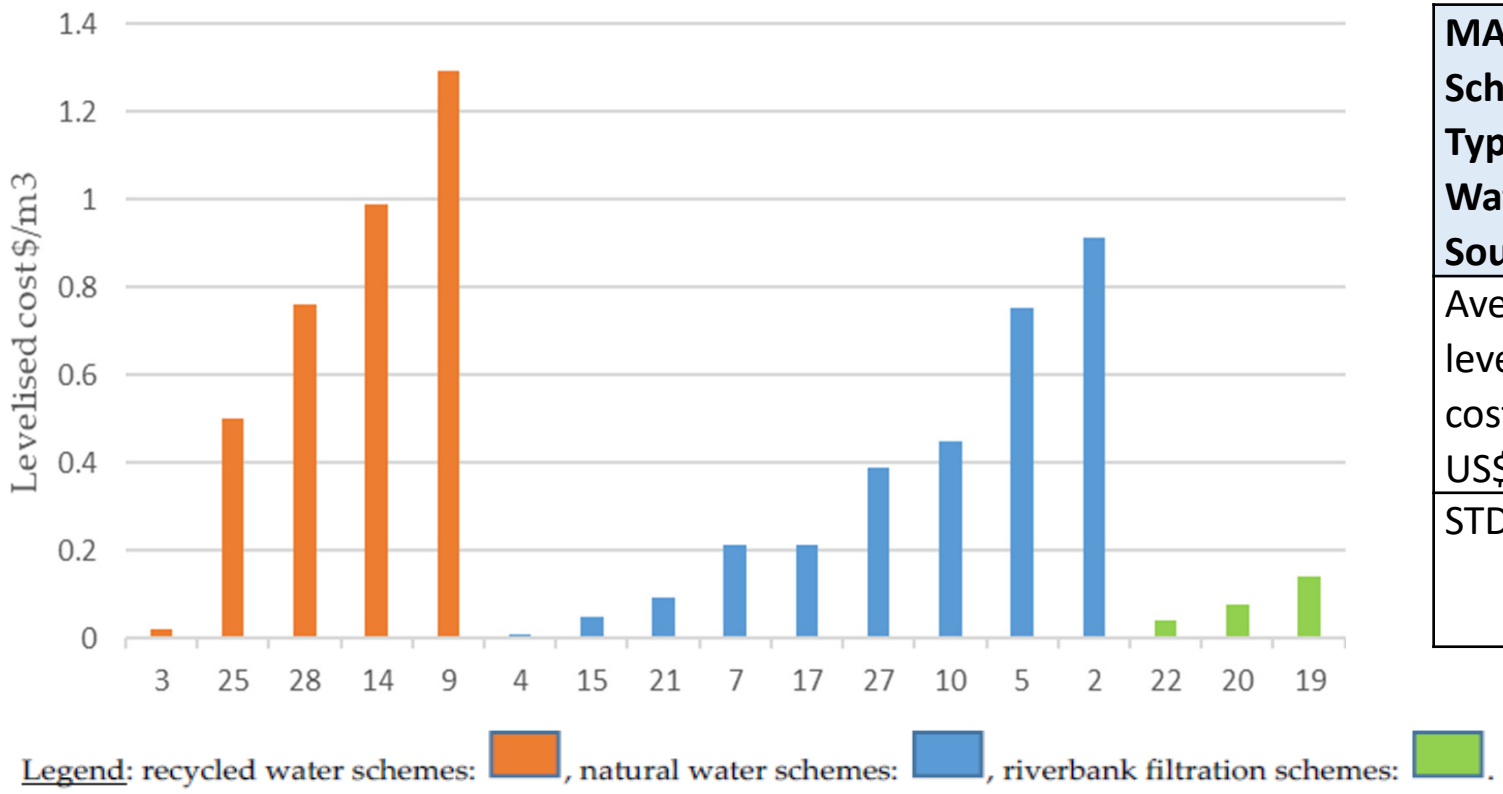
Methodology for estimating financial costs of MAR schemes, and comparing them with alternatives

- **Metadata & physical inputs** needed to understand interpret financial data
- **Capital & operating costs** adjusted for inflation & converted to US dollars
- **"Levelised cost"** estimated by adding discounted capital costs & operating costs
- Estimation of **output indicators**; levelised cost per M3 water infiltrated &/or recovered

Levelised cost is the constant level of annual revenue needed to recover capital, operating and maintenance expenses over a project's life divided by the annual volume of water supply provided by the scheme

Reference: Ross, A. and Hasnain, S., 2018. Factors affecting the cost of managed aquifer recharge (MAR) schemes. Sustainable Water Resources Management, 4(2), pp.179-190

Average levelised costs for MAR schemes by type and water source in US$/m3



MAR Scheme Type: Water Source	Recycled water: wells & infiltration	Natural water: wells & infiltration	River Bank Filtration
Average levelised costs in US$/m3	0.74 (5)	0.24 (11)	0.11 (3)
STDEV	0.58	0.16	-

Costs of 3 emergency water supply schemes were estimated by cost of daily recovery capacity and are not shown in this chart. Khulna scheme not included because of the very high costs of this small scheme.

Adapted from Zheng, Y., Ross, A., Villholth, K.G. and Dillon, P. (eds). 2020. Managing Aquifer Recharge: A Showcase for Resilience and Sustainability. Paris, UNESCO

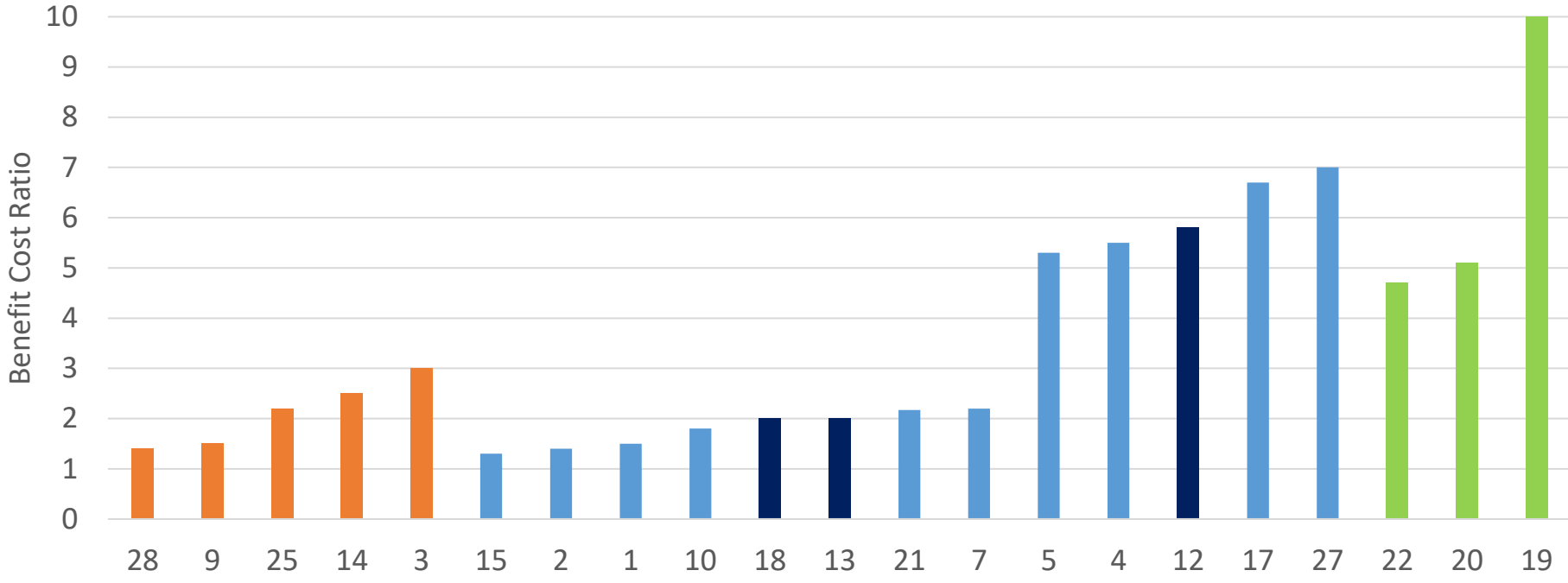
Benefits of MAR schemes and benefit cost ratios (BCRs)

- **Additional quantitative and qualitative analysis of benefits** of 21 schemes in the UNESCO publication

- **Valuation of benefits** complicated because of general absence of market price for stored or treated water. Various techniques are used to value MAR schemes including
  - next best alternative cost of water supply or water treatment
  - net value of production using recharged water (e.g. farm production)
  - environmental & social benefits assessed using indicators

Reference: Ross, A. Benefits and Costs of Managed Aquifer Recharge: Further Evidence. Water 2022, 14, 3257. Available online: https://www.mdpi.com/2073-4441/14/20/3257

BCRs for 21 MAR schemes



28 Dinteloord Netherlands
9 Perth Australia
25 Koksjide Belgium
14 Salisbury S Australia
3 San Luis Rio Colorado Mexico

15 Uttar Pradesh India
2 Turku Finland
1 Khulna Bangaladesh
10 Orange Co USA
18 Hilton Head USA
13 Windhoek Namibia
21 Arizona water bank USA
7 Ei Carracillo Spain
5 Genevois France-Swiss
4 Dharta Rajasthan India
12 North London UK
17 Central Platte Nebraska USA
27 Wala Wala Jordan

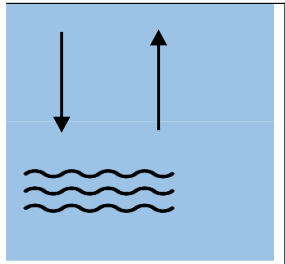
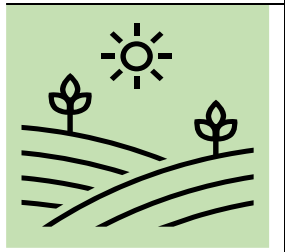
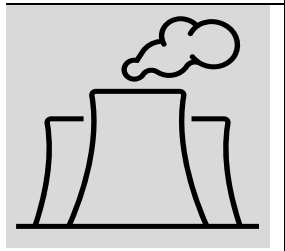
22 Sidfa Egypt
20 Haridwar India
19 Serchi R Lucca Italy

Factors affecting benefit cost ratios (BCRs) for different MAR types, source water and end uses

Factor	BCRs		
Source water	4.8 (13) Natural water	2.2 (5) Recycled water	
End use	4.6 (11) Human consumption	4.3 (7) Non-potable use & agriculture	
MAR type	1.8 (6) Injection Wells	3.8 (9) Infiltration methods	7.2 (3) Riverbank Filtration

Excludes BCRs from 3 very large schemes Orange Co, Arizona and North London

Qualitative indicators of benefits of MAR

	Twelve of the 21 schemes have a positive effect on aquifer integrity and well water levels. The other 9 have a neutral effect.
	16 schemes have a positive (4) or neutral (12) impact on water quality. 4 agricultural MAR schemes and 1 scheme producing water for human consumption do not meet national water quality standards.
	10 schemes have a neutral impact on environmental flows and 3 are assessed to have positive impacts. 12 schemes provide additional project specific social and environmental benefits.
	Measured energy requirements (ER) of MAR schemes ranges from 0.16–3.9 kWh/m^3. Most schemes are in the range 0.3–0.85 kWh/m^3. ERs of schemes for agicultural and non-potable use and RBF schemes are low.

Conclusions from work to date

- MAR schemes are very diverse in objective, type, water source and end use

- MAR type, water source, end use & water treatment are major factors affecting costs and benefits
  - schemes recharging untreated water using infiltration & RBF relatively cheap with good BCRs
  - schemes using wells with substantial infrastructure & or water treatment have lower, positive BCRs
    - stormwater & wastewater recycling can offer substantial benefits

- MAR costs & benefits are also influenced by
  - soil & aquifer characteristics; scheme operating periods & frequency of utilisation; range of scheme objectives
  - legal & institutional settings; stakeholder knowledge about MAR; trust in MAR

Further economic evaluation of MAR

- Good start on assessment of commercial benefits in water supply and agricultural production.
- Further work needed on
  - delivery and distribution costs
  - environmental and social benefits
- NPV calculations to improve precision
- Mixed methods eg BCA, MCA

Next activity: **Special issue on economics of MAR for ISMAR 13**

- Call for EOIs for case studies
- Theme Economics of MAR and water banking for water security and resilience to droughts and floods
- Sub themes to be developed e.g MAR for town and rural water security, MAR for aquifer and environmental conservation

Next steps

- Process results of initial EOI, provide feedback to interested parties
- Further development of terms of EOI and proposal for special issue
- Welcome suggestions and feedback about priorities for IAH MAR economic WG; contributions of information, case studies, and organisation
- email a.ross@anu.edu.au phone 61 478436288

References

- Ross, A. Benefits and Costs of Managed Aquifer Recharge: Further Evidence. Water 2022, 14, 3257. online: https://www.mdpi.com/2073-4441/14/20/3257