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for Sustainable
Development

Unconventional Water Resources

MunichRe Module

presented by: Linda Schwarz, Marlene Kommallein, Madeleine Maomou,
Till Heitmann, Juri Häbler, Artinesa Sylmetaj, Ana Moreno

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Outline

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1) Intro to UWR, including Definitions
2) Four in-depth Examples
3) South Africa and UWRs
4) Transfer Project: Algae Treatment

1. Intro

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- 97% of Earth's water is salty
- 3% Fresh Water:
    - 68,7% Glaciers
    - 30.1% Groundwater
    - 0,3% in flowings as lakes, ponds, rivers, etc.
    - 0,04% Atmosphere

Water Stress:
- Physical scarcity,
- Economic scarcity

Water source	Water volume, in cubic miles	Water volume, in cubic kilometers	Percent of freshwater	Percent of total water
Oceans, Seas, & Bays	321,000,000	1,338,000,000	--	96.54
Ice caps, Glaciers, & Permanent Snow	5,773,000	24,064,000	68.7	1.74
Groundwater	5,614,000	23,400,000	--	1.69
Fresh	2,526,000	10,530,000	30.1	0.76
Saline	3,088,000	12,870,000	--	0.93
Soil Moisture	3,959	16,500	0.05	0.001
Ground Ice & Permafrost	71,970	300,000	0.86	0.022
Lakes	42,320	176,400	--	0.013
Fresh	21,830	91,000	0.26	0.007
Saline	20,490	85,400	--	0.006
Atmosphere	3,095	12,900	0.04	0.001
Swamp Water	2,752	11,470	0.03	0.0008
Rivers	509	2,120	0.006	0.0002
Biological Water	269	1,120	0.003	0.0001

Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources (Oxford University Press, New York).

1. 1. What are UWRs?

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WR which **have not been traditionally used** to meet existing water demands. (Odendaal, 2009)

Any WR other than freshwater that **need new technologies to make them useable**. (Ahmed, 2010; Negm et al., 2018; Ji et al., 2020)

2. Overview of UWR

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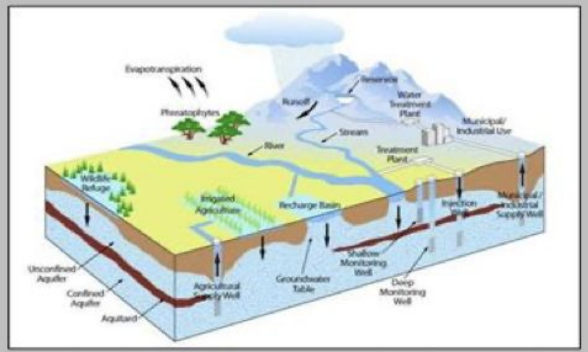
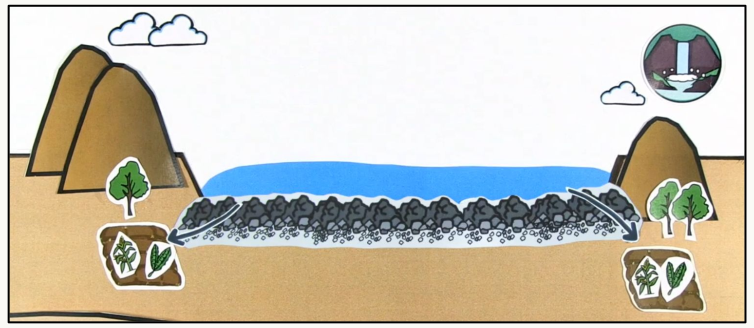
Wastewater (Municipal, agricultural)

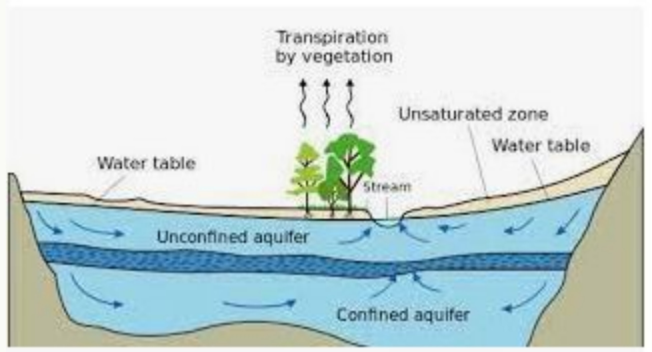


Groundwater (Undeveloped, deep, off-shore)

Micro-catchment rainwater(Ruvival,2018)

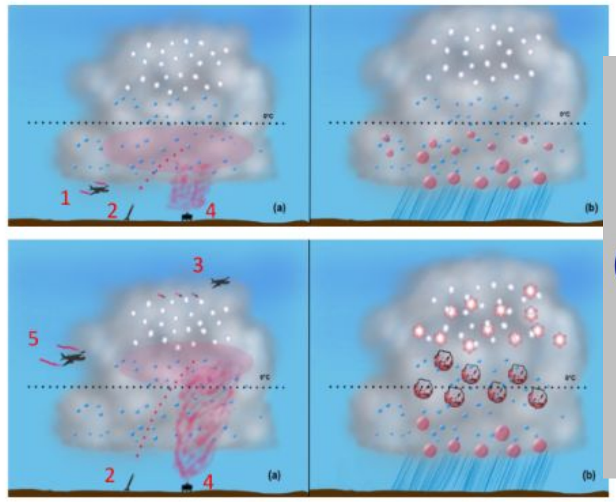


Macro-catchment rainwater(Ruvival,2018)

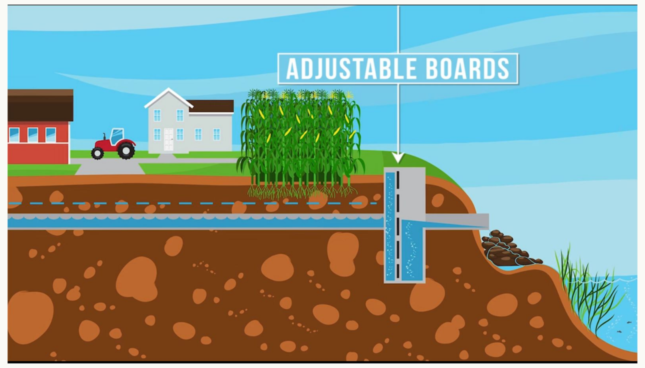


Fossil Water(Hans Hillewaert/Wikipedia)

Desalinated water



Atmospheric water capture (Fog harvesting, cloud seeding)

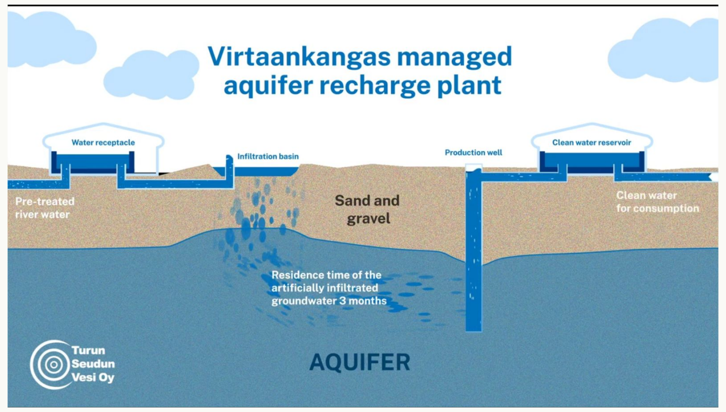


Agricultural drainage water (BRD Farms Network.,2018)

Ballast water? (bulkcarrierguide)

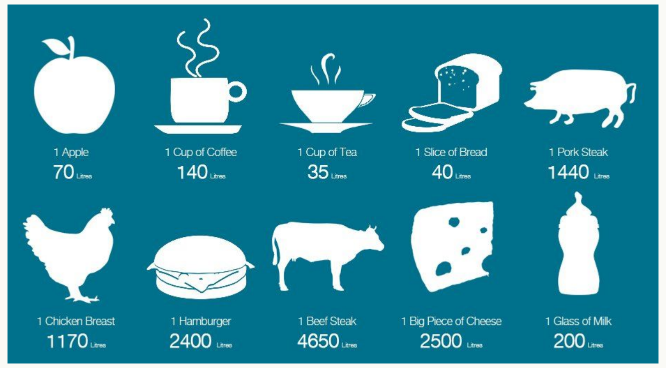
Transported water (Iceberg towing)

Resource: Munich Re-Foundation, 2021



Artificial recharge Water. (Turun Seudun Vesi Oy,2021)

Dew water (AEE,2018)



Virtual water? (Ableskills.co.uk,2017)

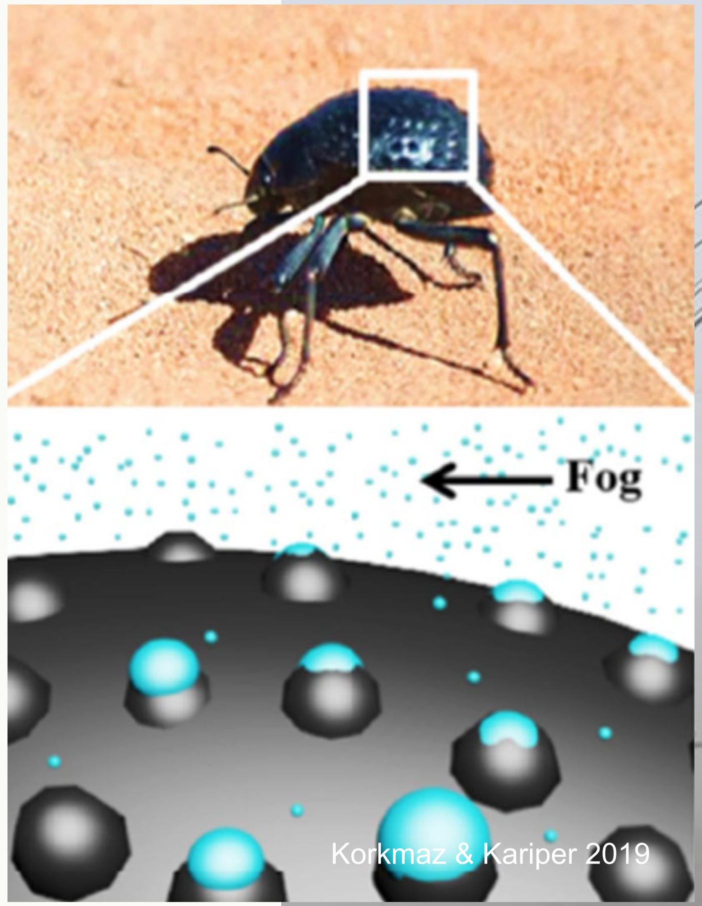
3.1. Fog Harvest

- accumulation of water droplets on a vertical mesh
- hydrophilic-hydrophobic-hybrid
- collecting in water tanks
- technology inspired by desert species

12,900 km³
Water in atmosphere

0.001% of the total Earth's Water

0.04% freshwater existing on the planet



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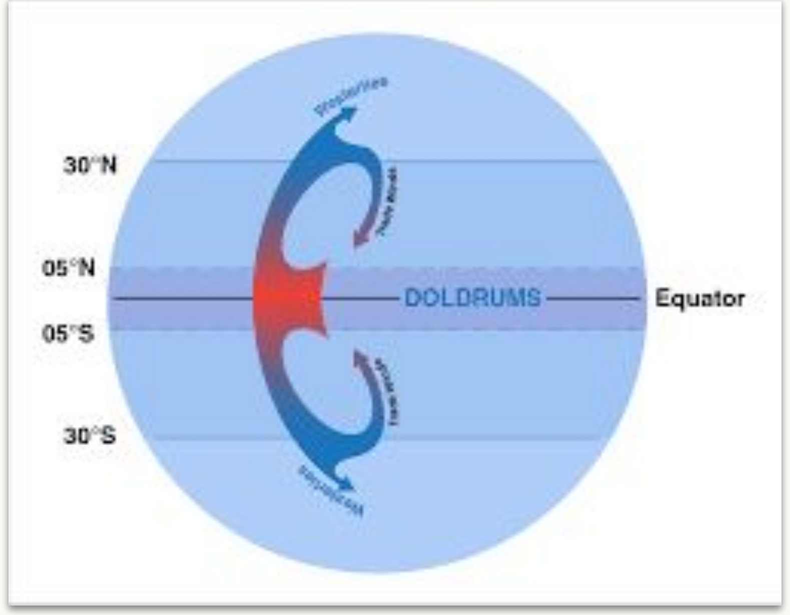
Fog Harvest

Water yields range from 1 to 20 L/m²



Physical Conditions

Fog water yield largely depends on...

SUFFICIENT SPACE AND ALTITUDE

FREQUENT FOG EVENTS

- **Fog collection sites:** ***from 60 to 360 days***

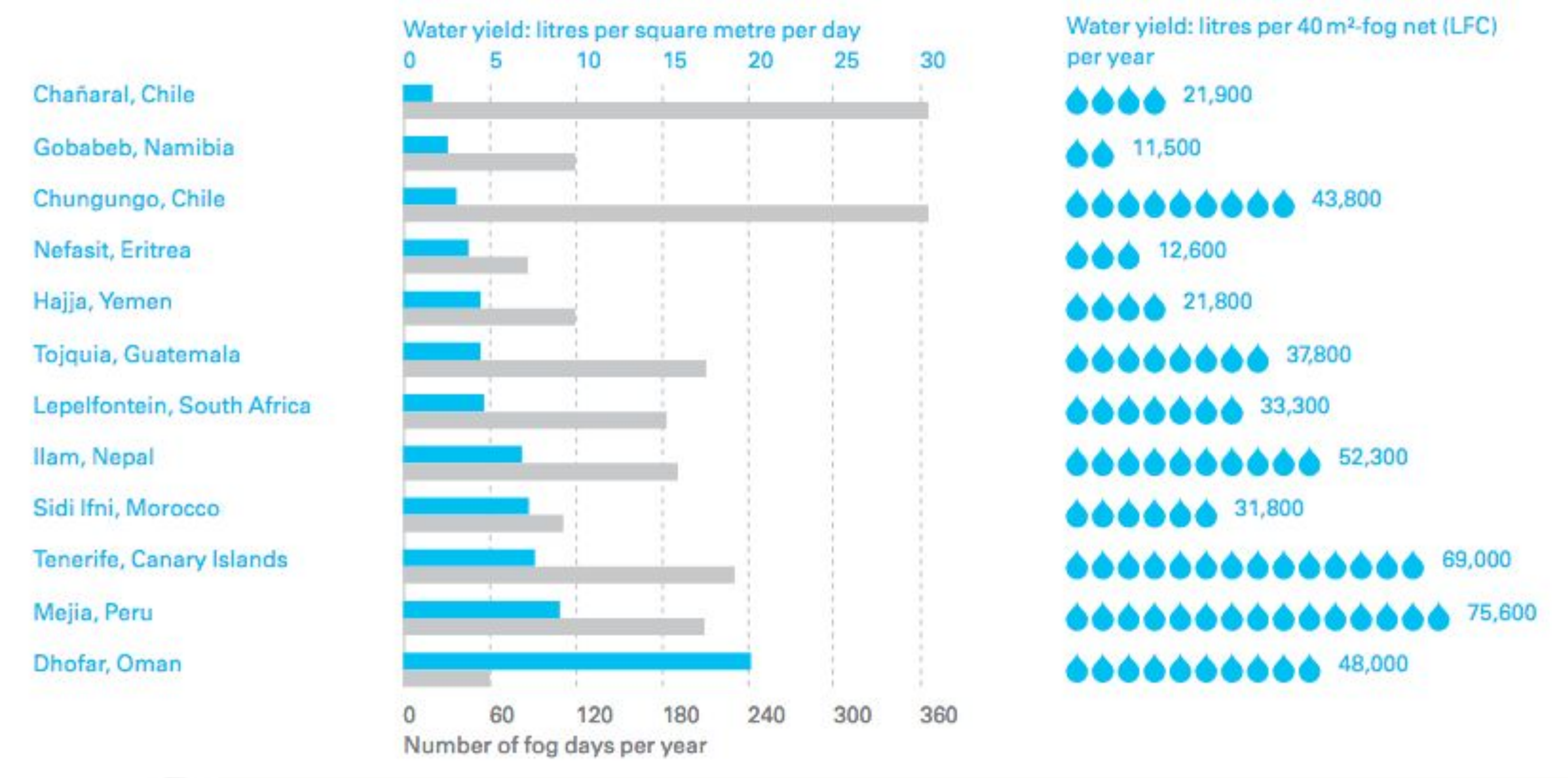
PERSISTENT WINDS

Such as *trade winds* from one direction (4-10 m/s = 14-36 km/h)

HIGH FOG CONCENTRATION

Droplets with diameters typically from 1 to 50 µm

Fog Harvest



Munich Re Foundation 2015

used for drinking water in 17 countries

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Fog Harvest -SWOT

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Strengths

- Passive collection system; no energy input
- Simple and cheap design and construction.
- Low maintenance and easy to repair
- Water quality is generally good in non-industrial areas
- Modular system/Easy to scale up
- Sustainable, Impact on environment has not been detected so far.
- Inspired by bionic principles

Weaknesses

- Yield completely reliant on weather, climatic and topographic conditions.
- Yield is difficult to predict; pilot project is required in every case.
- Local level scope: (ex.400 personas/small village)
- Useful just in rural areas
- requires community participation

Opportunities

- requires community participation
- Usable in remote regions
- Potentially reduces gendered differences due to collection of water.
- Raising awareness/funding for UWRs
- bionic principles can be explored since many species use fog harvesting for hydration
- Potential development due to unexplored massive

Threats

- Significant change in the water regimen
- used materials do not have a long life-span
- collectors need to be close to site of utilisation and easily accessible to keep their positive effects
- Periods with less fog might require back-up plan
- Adjacent air pollution can pollute fog quality
- Harvesting activity could increase car accidents since they are done in foggy conditions

3.2.Towed Icebergs

The towing of icebergs as a water resource, an idea which was met with almost universal derision, is now under serious consideration as a means of alleviating water shortages.

Iceberg-harvesting has been considered as a potentially viable freshwater source since the 1950s.

It was first demonstrated near Newfoundland, Canada.

https://www.newscientist.com/article/2168339-towing-icebergs-to-cape-town-is-a-poor-way-to-halt-water-crisis/

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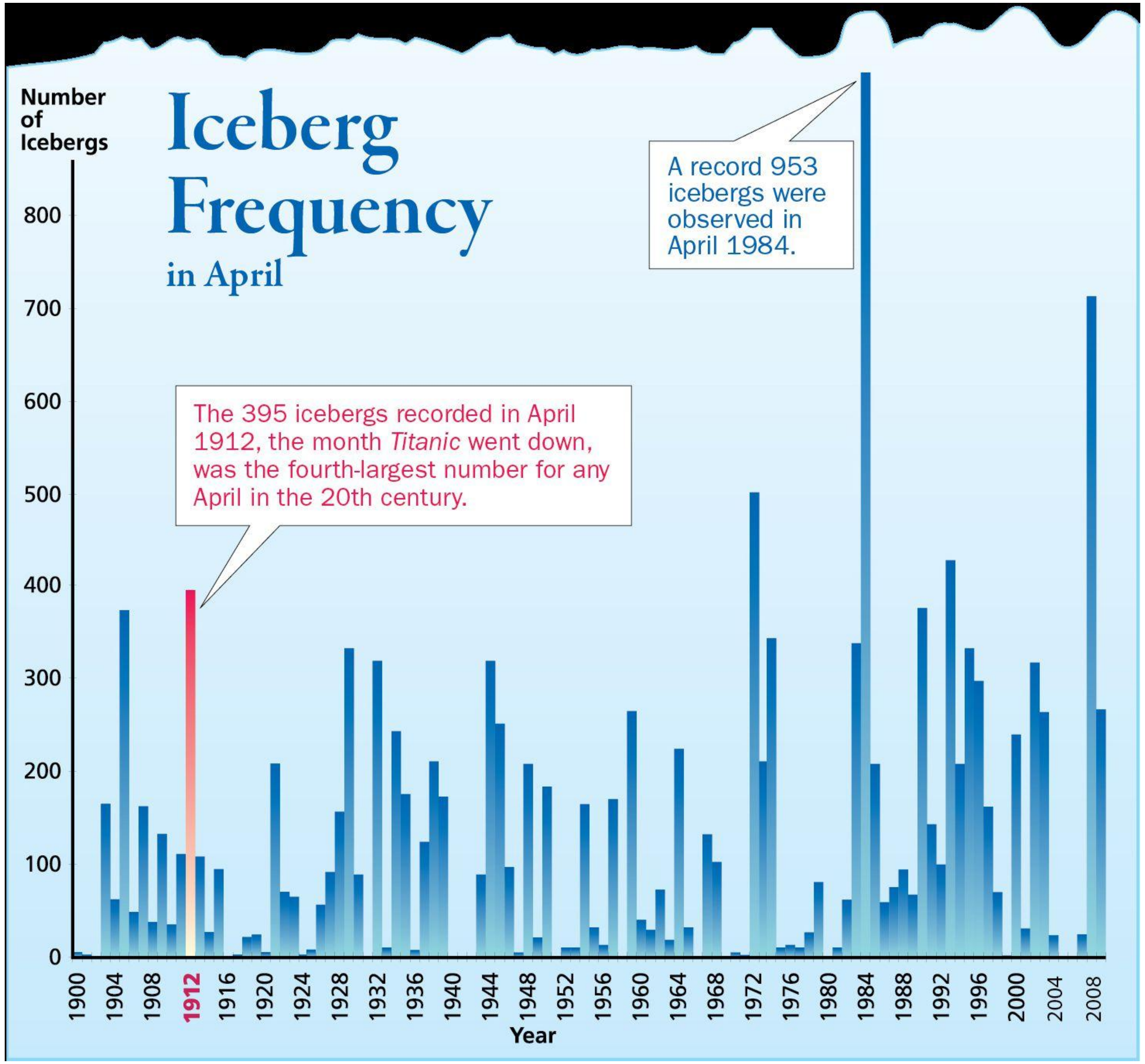
Two-thirds of the world's freshwater is bound up in polar ice.

An iceberg holding 20bn gallons of fresh water could meet the needs of a million people for five years.



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Water from towed icebergs -SWOT

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Strengths

- Very pure
- Low energy consumption
- Is not needed to treat the water with chemicals

Weaknesses

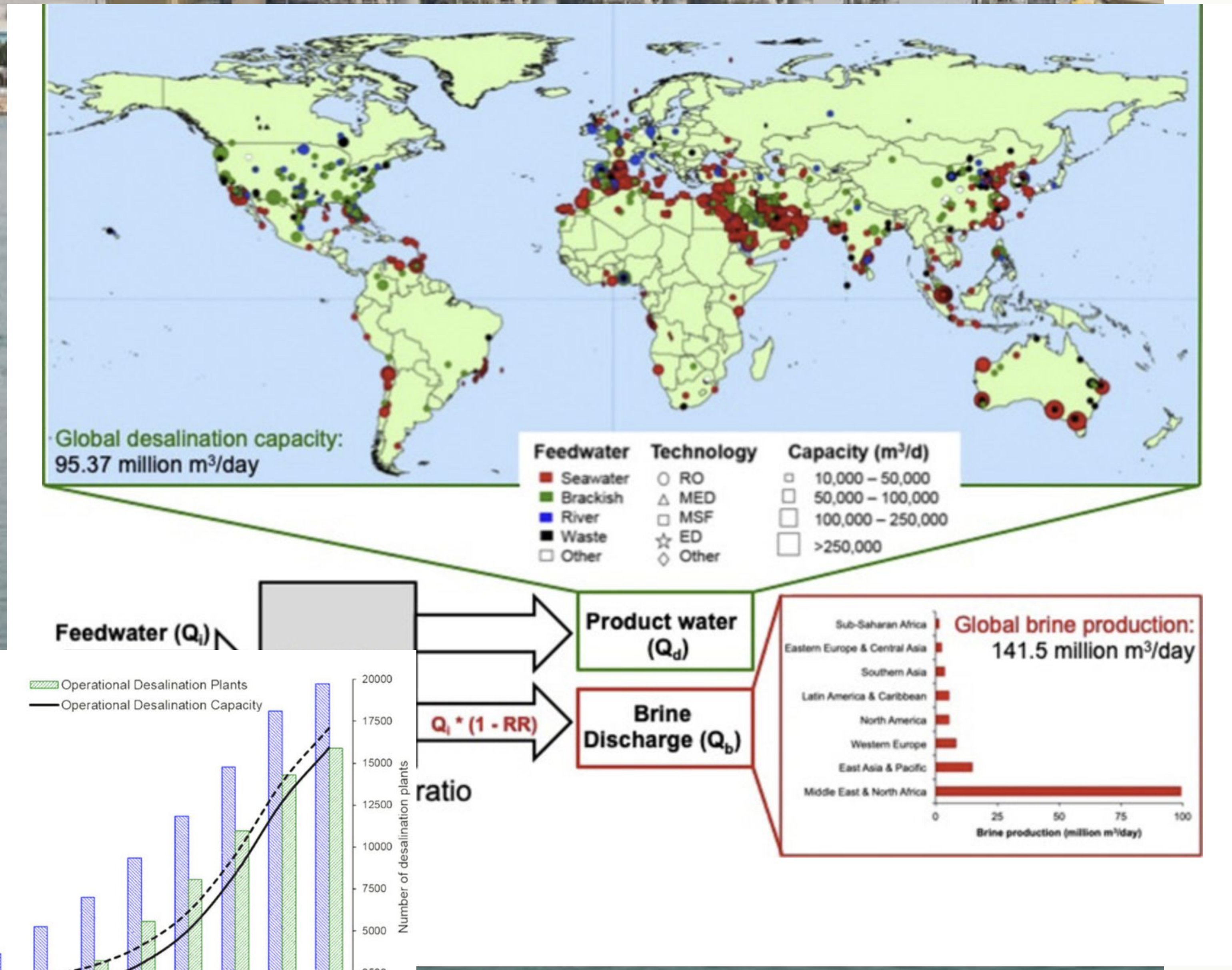
- Extremely expensive procedure.
- Hazardous to transport
- 3000km3 of iceberg freshwater lost to the sea due to climate change yearly
- It requires a lot of time

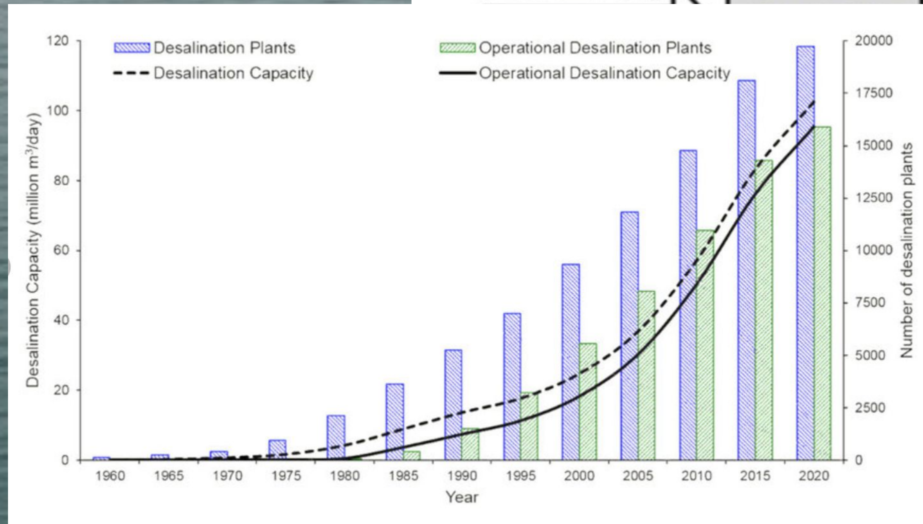
Opportunities

- New jobs
- Could reduce iceberg risks in coastal regions
- Due to climate change, more icebergs are expected to detach

Threats

- Can block off large areas and prevent wind and currents from facilitating normal ice break-up that’s important for summer productivity
- Water temperatures collide





Global desalination growth, 1960-2020. Reprinted figure with permission from [10]. Copyright (2019) Elsevier.

[SFAO Report, 2018]

3.3.Desalination

- 300 million people get their water from desalination plants
- 20,000 desalination plants worldwide

- technology: thermal or membrane technology

Desalination- SWOT

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Strengths

- ocean contains > 97.2 % of the planet's water resources → Large availability
- already developed experience and infrastructure
- drought proof

Weaknesses

- High Energy Consumption and Price → exclusive
- Environmental impacts due to brine discharges (ratio*1.5)
- High GHG Emissions
- Agronomic concerns
- problems from

sucking in of seawater

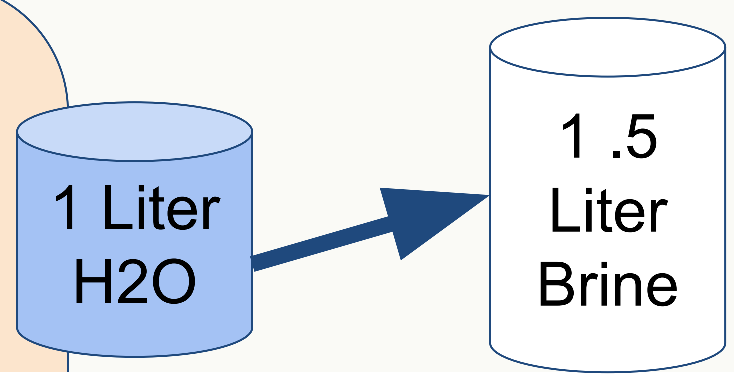

Table 4. Energy consumption according to seawater desalination stage and other water sources in south-east Spain.

Desalination Stage/Water Source	Energy Consumption (kWh/m³)
Seawater intake pumping	0.12–0.62
Desalination processes	2.78–3.38
Pumping to an elevated regulating reservoir	0.43–1.04
Seawater Desalination (Total)	3.49–4.84
Surface water	0.06
Groundwater	0.48
Reclaimed water	0.72
Brackish Desalination	1.21
Transferred water	0.95

Source: [110,113].

Opportunities

- Growing demand → better technology, cutting of costs
- Desalination capacity continues to increase in every region, at 7% per annum
- developed infrastructure and experience
- high potential and therefore more research also into more sustainable, cost-efficient solutions

Threats

- Urban Water tariffs increase could aggravate water poverty/social injustice
- Permanent water subsidies may compromise WFD cost-recovery-principle
- Brine production is 141.5 million m3/day, 50% greater than previous estimates

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3.4.Waste Water

- from households
- from industries
- from storms

https://5.imimg.com/data5/SD/DQ/LK/SELLER-1091431/effluent-treatment-500x500.jpg

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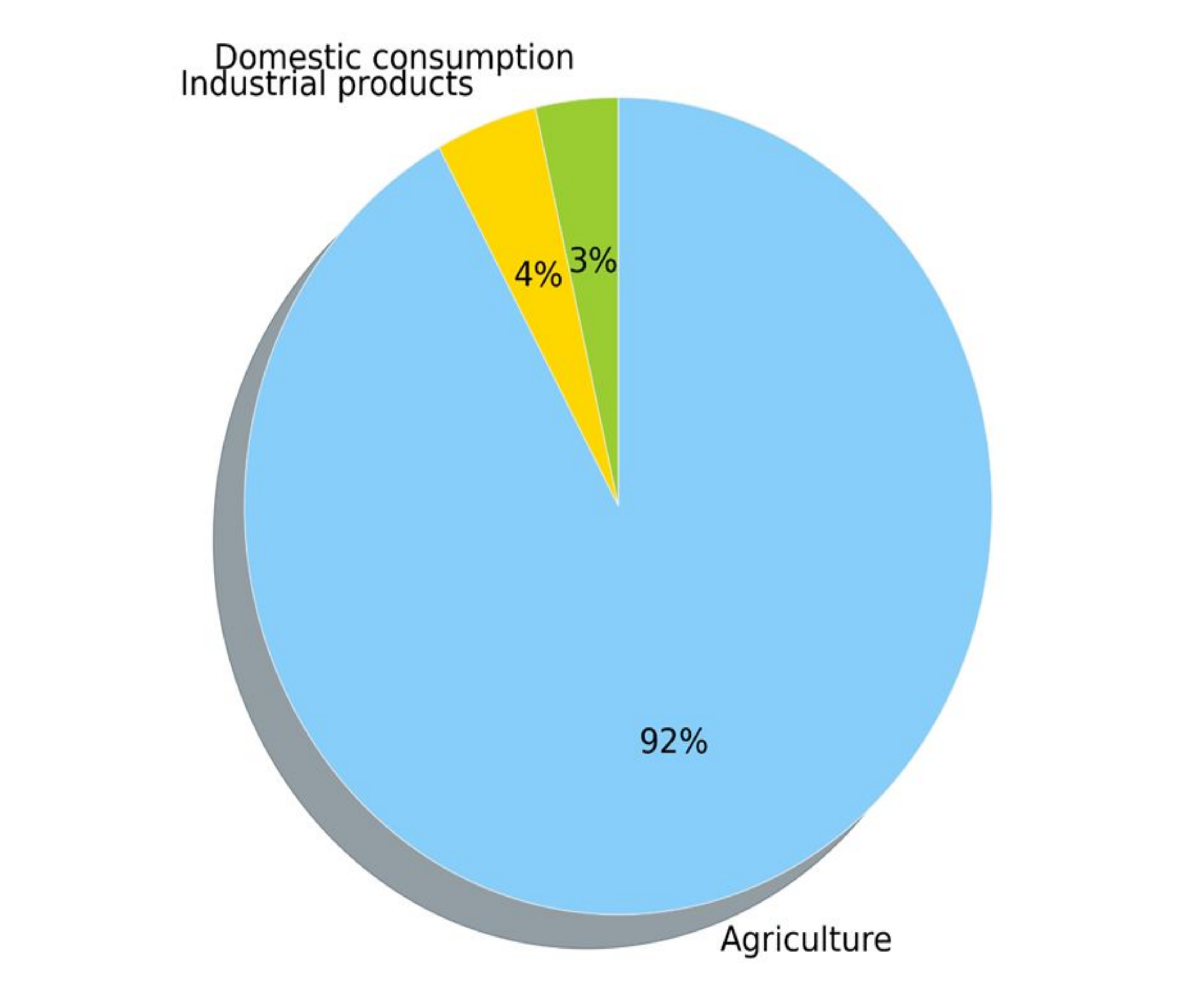
3.4.Waste Water

- 4% of industry production
- 3% of domestic consumption
- 92% of agriculture
- 30 gallons of water waste every day by an average person.
- 1.7 trions gallons of water are waste every year



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Wastewater: SWOT

Strengths

-Reduced dependence on external factors
-Possible use in combination with other sources of energy
-feasibility of effluent cool down
-low fluctuations of temperatures and flow rates
-No need to use intermediate circuits

Opportunities

-Decreased use of fossil fuels and reduced emissions of pollutants
-Increased environmental awareness
-Introducing relevant legal regulations subsidies
-Satisfying energy requirements of treatment plants

Weaknesses

-High capital expenditure
-lack of operational experience
-Limited length of discharge pipes

threats

-Lack of approval from potential users
-Increased capacities for exploiting other energy sources
-Varied sewage treatment technologies in different facilities

Case Study: South Africa

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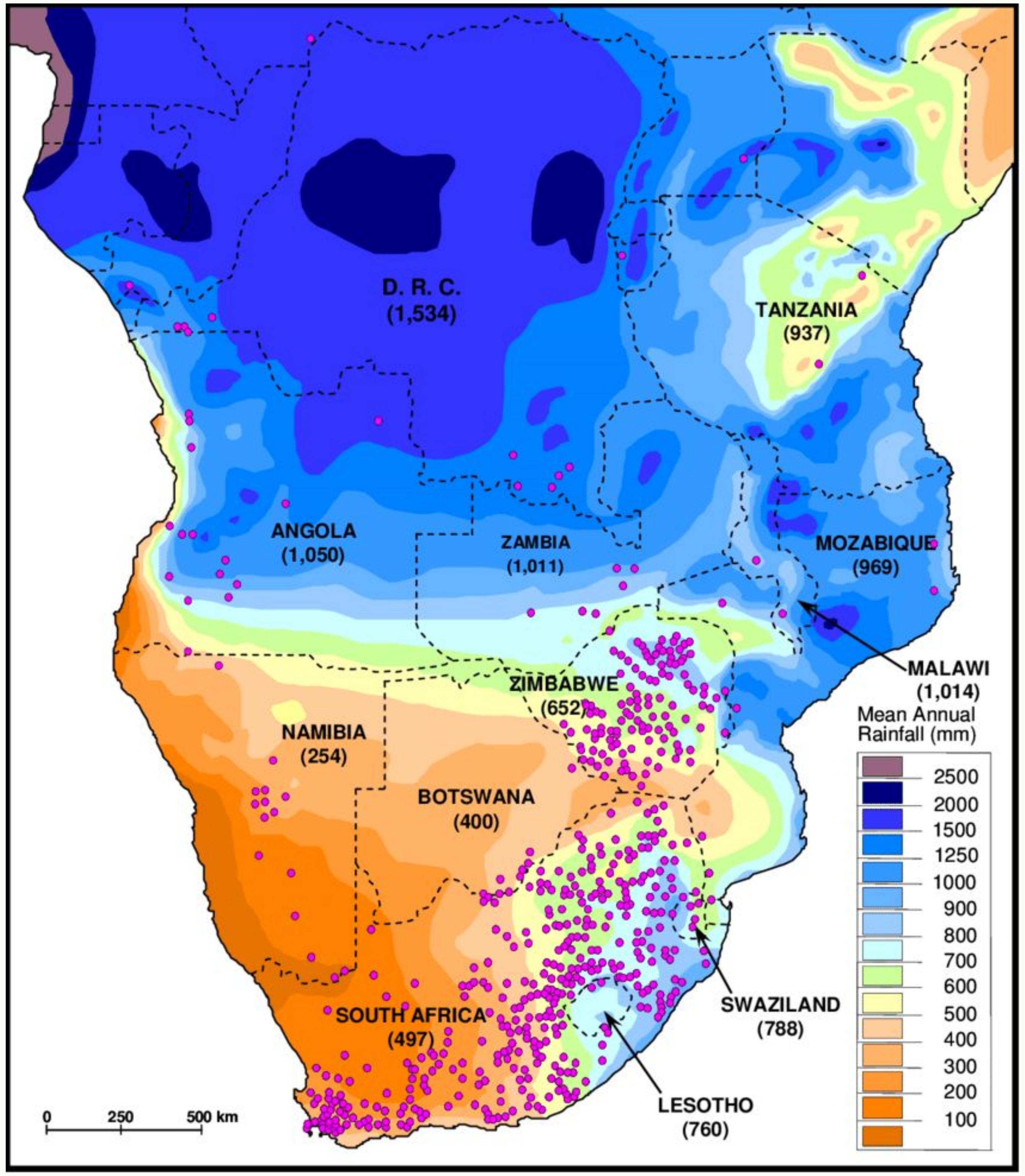


[Researchgate.net, 2009]

- 53 million inhabitants, rapid urbanisation, high economic growth, still struggling with high social inequalities
- agricultural water demand: 62%, loss of 30%
- 18% of the GDP: mining sector with high pollution
- 13% water dependency, water stress 41%
- 3.8 million people (6,8%) don't have access to safe drinking water [World Bank Group, 2020]
- “Everyone has the right to have access to [...] sufficient food and water."

[SDG-Report, 2021]

Indicators

- Population using at least basic drinking water services
- Population using at least basic sanitation services
- Freshwater withdrawal
- Anthropogenic wastewater that receives treatment
- Scarce water consumption embodied in imports

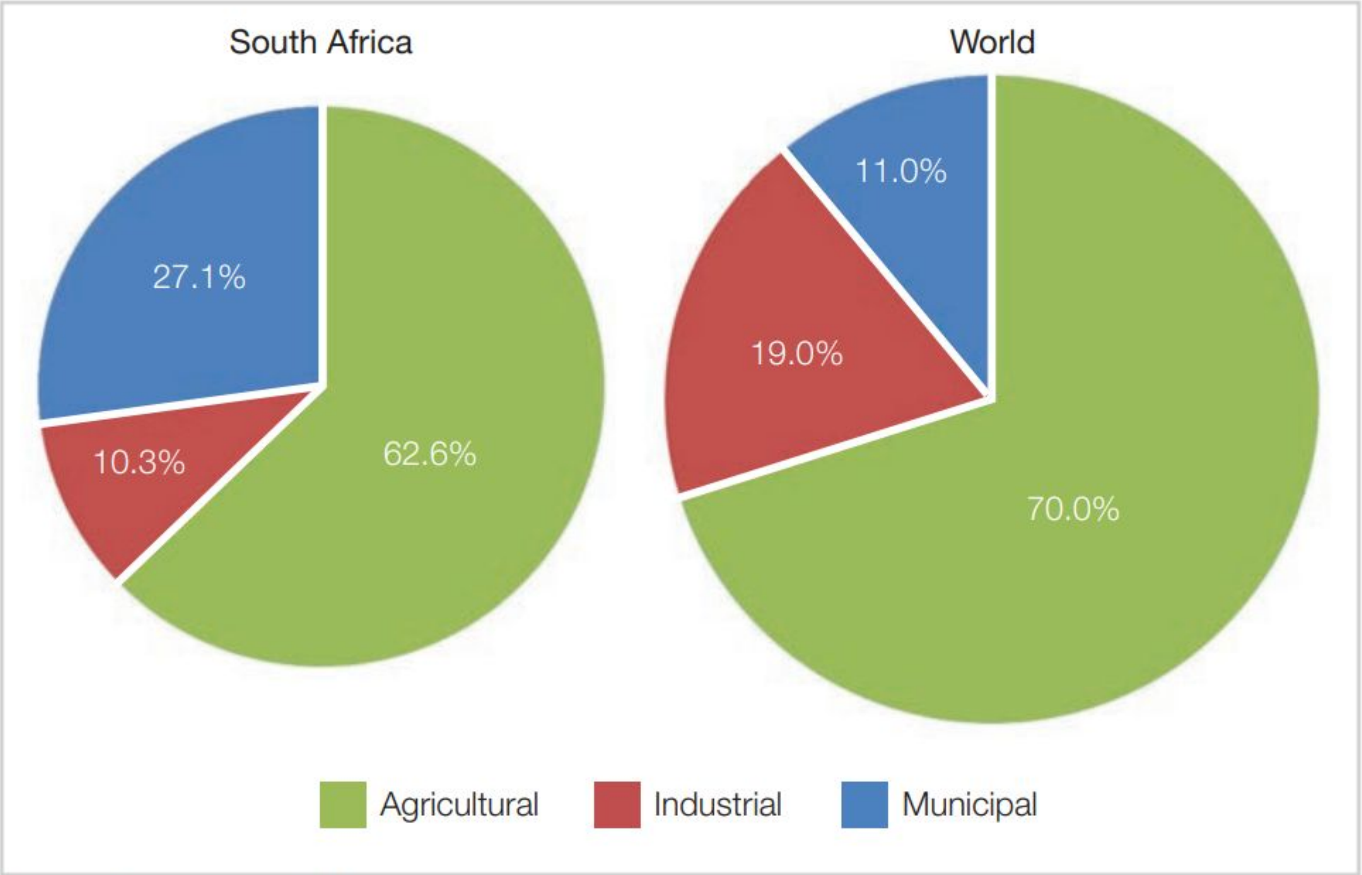
Todays problems

- high water usage
- stolen water, leaking pipes
- low level of wastewater treatment applied

Cape Town Water Crisis 2018

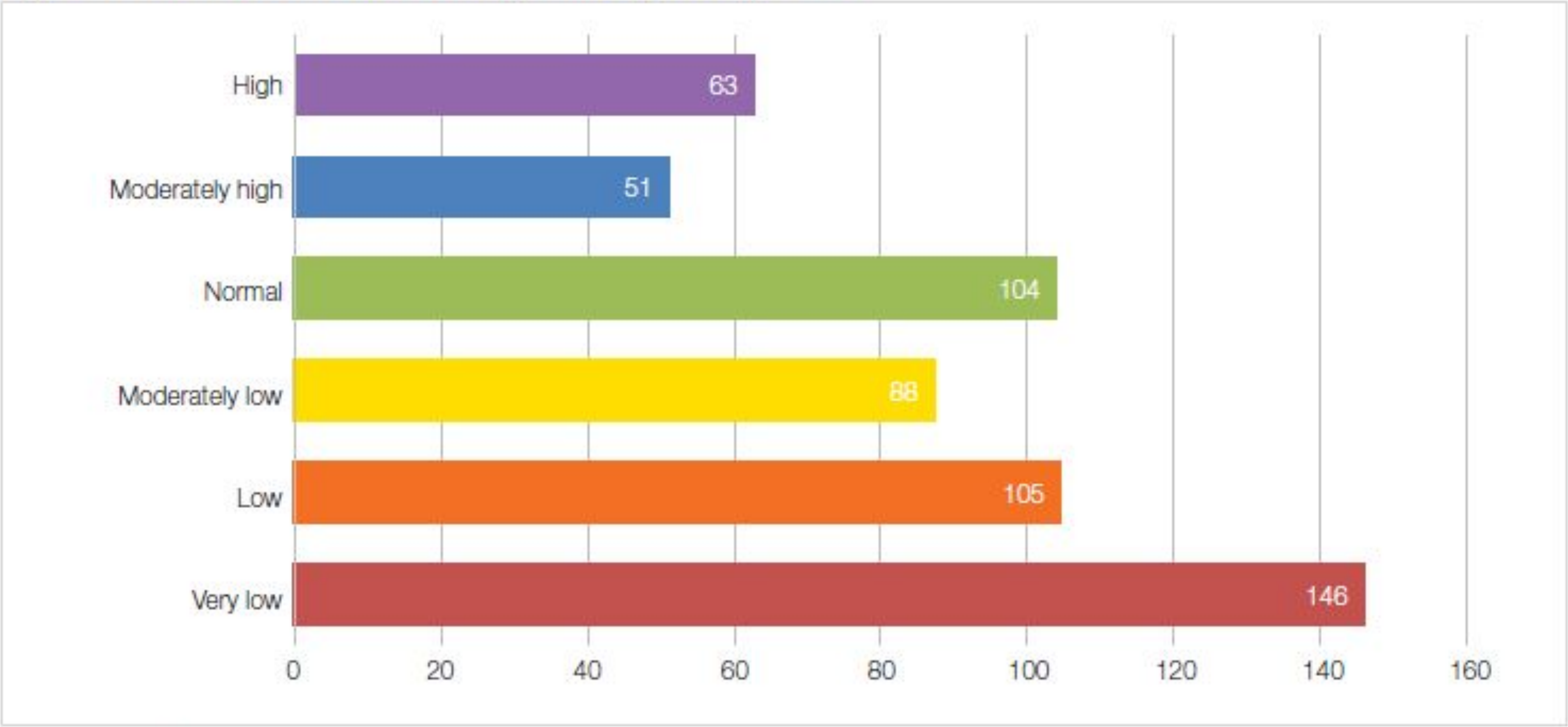
- March 2018: dams are below 13,5% capacity
- daily allowance cap of 50 liters per person

Figure 3: Total withdrawals in South Africa and the world by sector



Source: IFs v. 7.31 and FAO Aquastat data.

Figure 1: Rivers in South Africa categorised by average flows



Source: DWS NIWIS website (8 February 2018).

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SOUTH AFRICA'S WATER CONSUMPTION IS ABOUT

235

LITRES PER CAPITA PER DAY. THE GLOBAL AVERAGE IS

175

LITRES PER CAPITA PER DAY

THE GOVERNMENT'S 'WAR ON LEAKS' CAMPAIGN AIMS TO REDUCE THE LEVEL OF NON-REVENUE WATER BY EMPLOYING

15 000 South Africans

AS PLUMBERS AND ARTISANS BY THE END OF 2018

[Donnenfeld, 2018]

Todays UWR use in South Africa

(un)conventional water resources of today

- currently, South Africa has access to *surface water* (77 percent of total use), *groundwater* (9 percent of total use), *and recycled water* (14 percent of total use) [MIT, 2017]
- 74% of rural population are dependent on groundwater
- *desalination* currently accounts for less than 1% of South Africa's total water demand [Donnenfeld, 2018]
- 60% of the countries *wastewater* is untreated and about two-thirds of the wastewater treatment facilities did not meet minimum quality control standard - problem: public perception [Donnenfeld, 2018]
- *fog harvesting* projects exist but only in specific areas for small selected communities (Tshiavha village harvesting up to 2500 L a day)

[Donnenfeld, 2018]

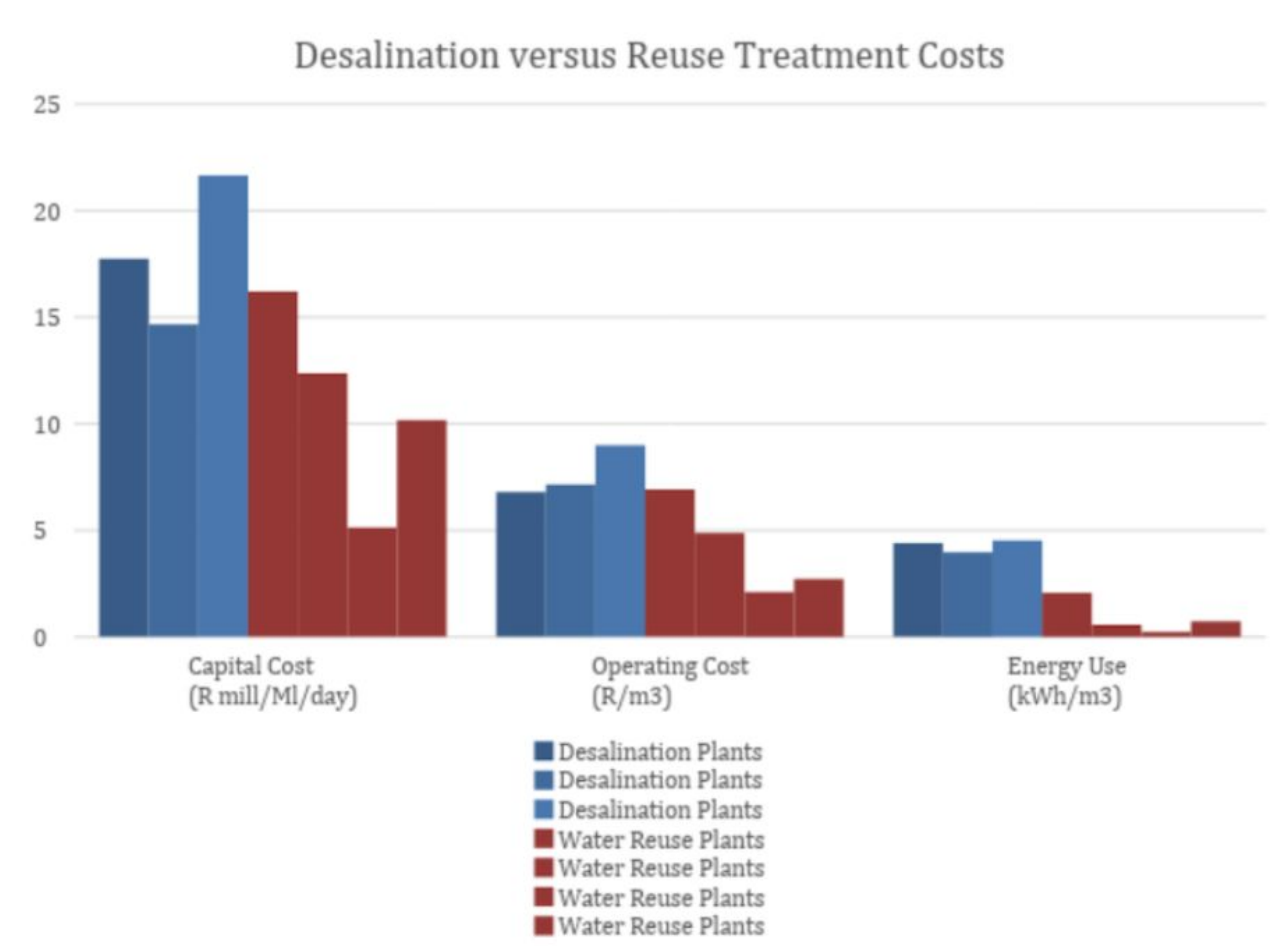

Figure 1. *Cost Comparison of Desalination versus Water Reuse (Source: Water Research Commission, Best Practices on Cost and Operation of Desalination and Water Reuse Plants, 2015).*

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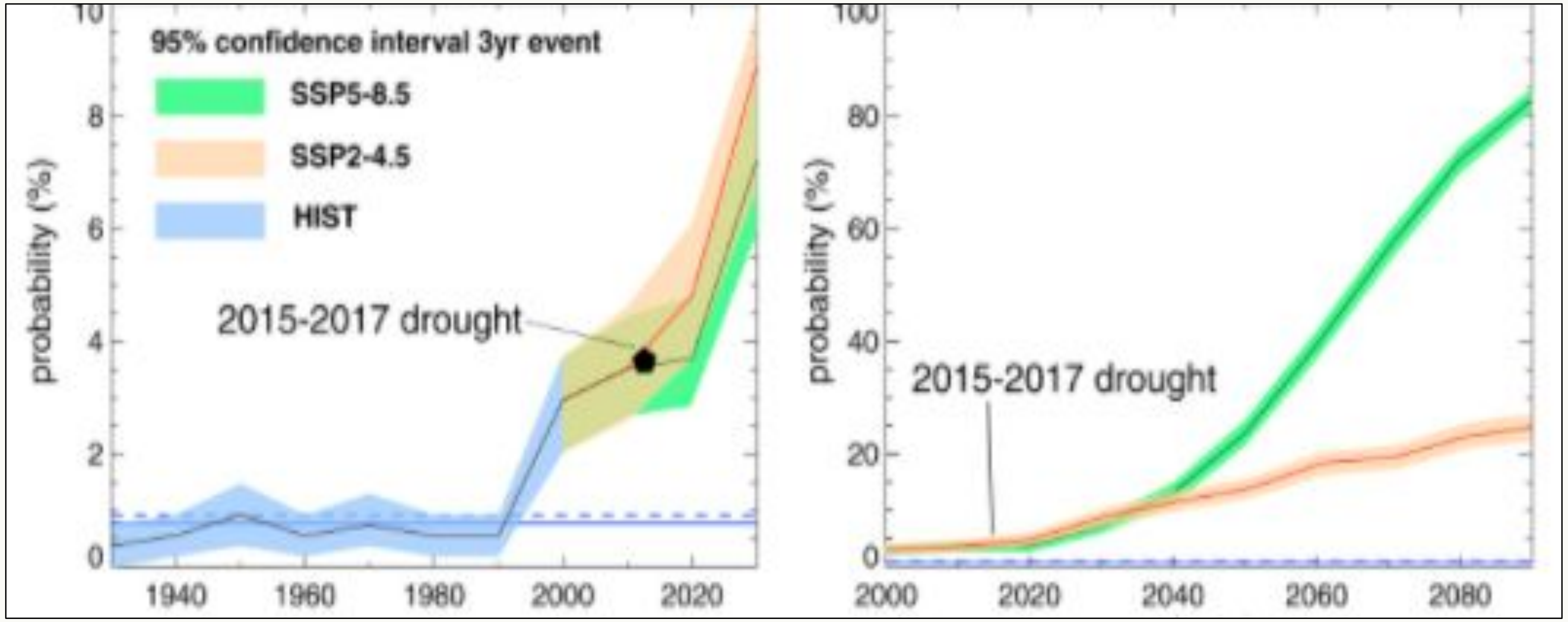
Future Outlook I: Challenges

I. Climate Change

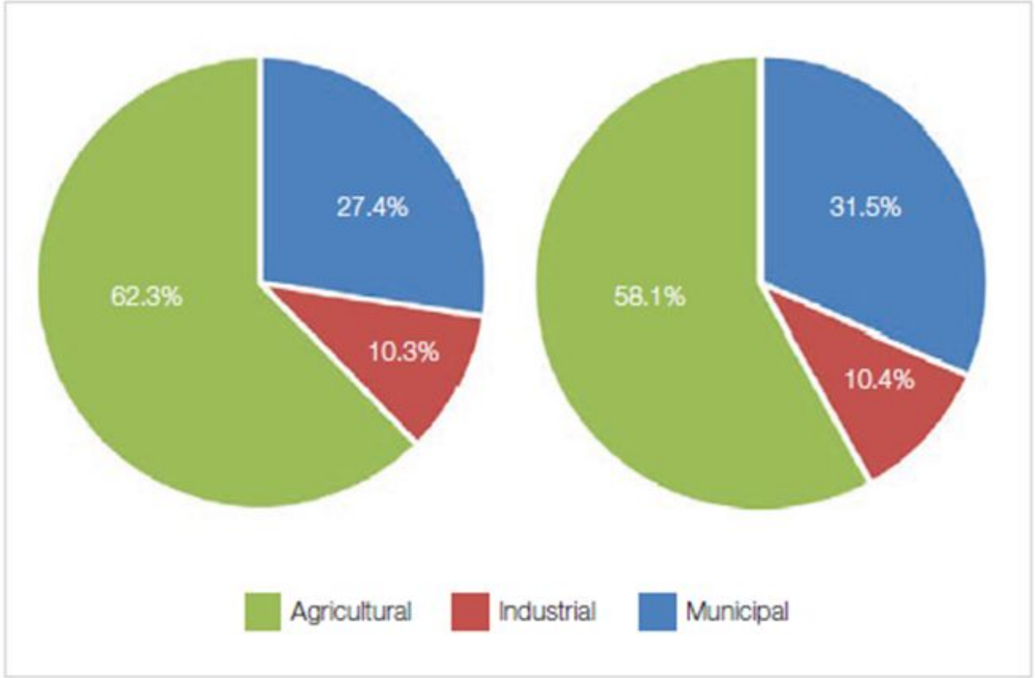
- increased likelihood of a 3-year drought



II. Increases in…

- …population growth
- …urbanisation
- …non-renewable electricity
- …water demand (in all sectors)

Figure 4: Water withdrawals by sector in South Africa in 2017 (left) and in 2035 (right)



Source: IFs v. 7.31 and FAO Aquastat data.

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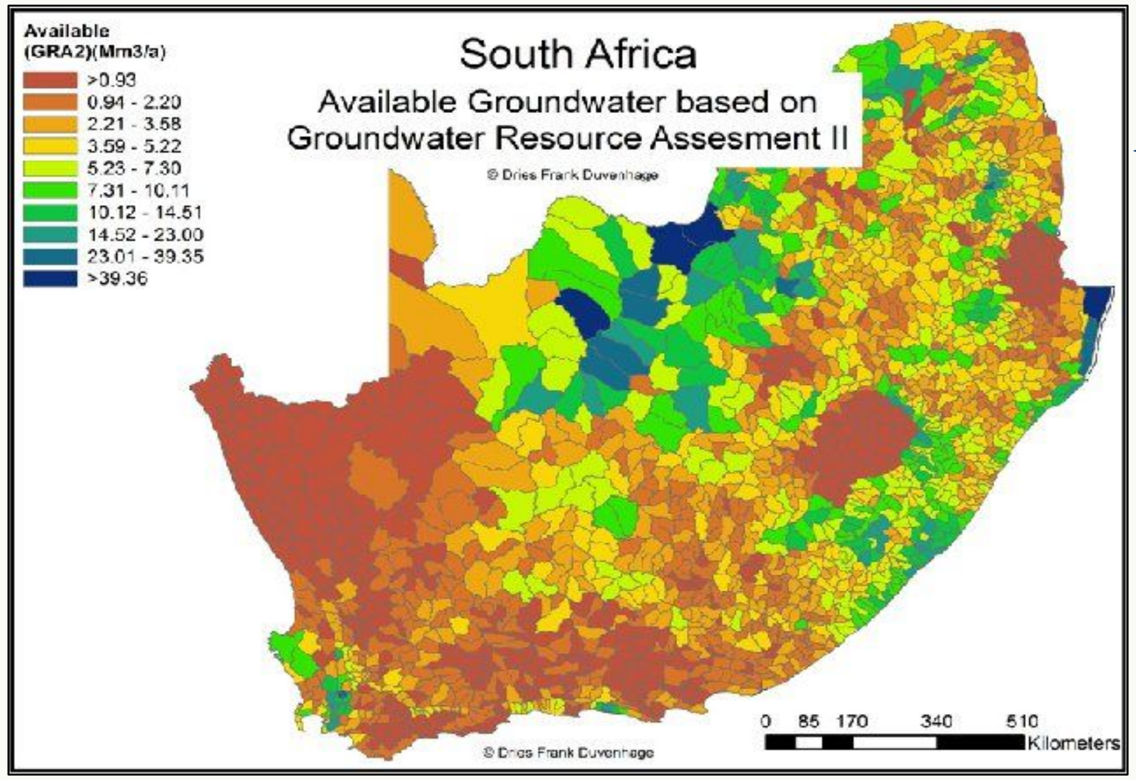
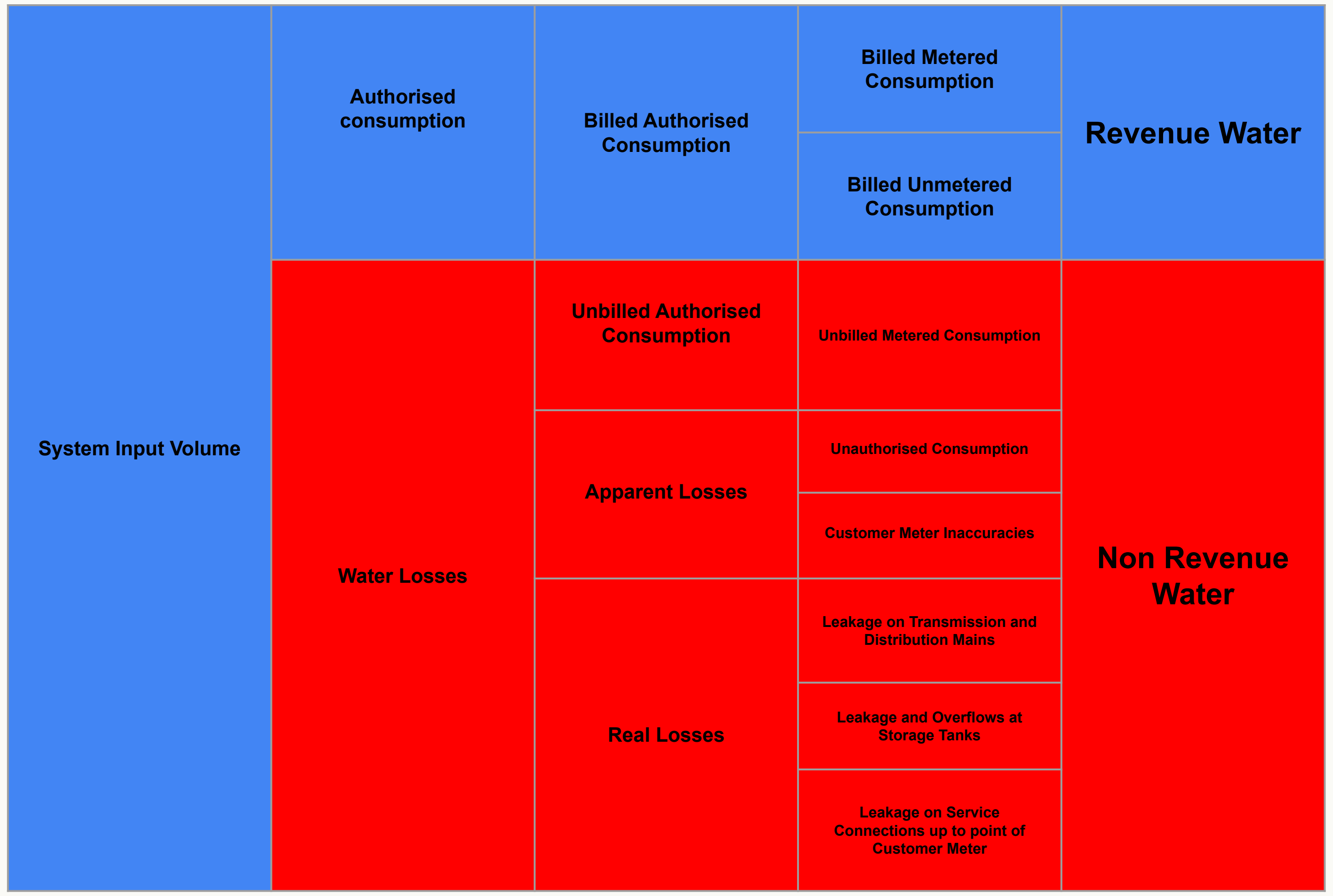
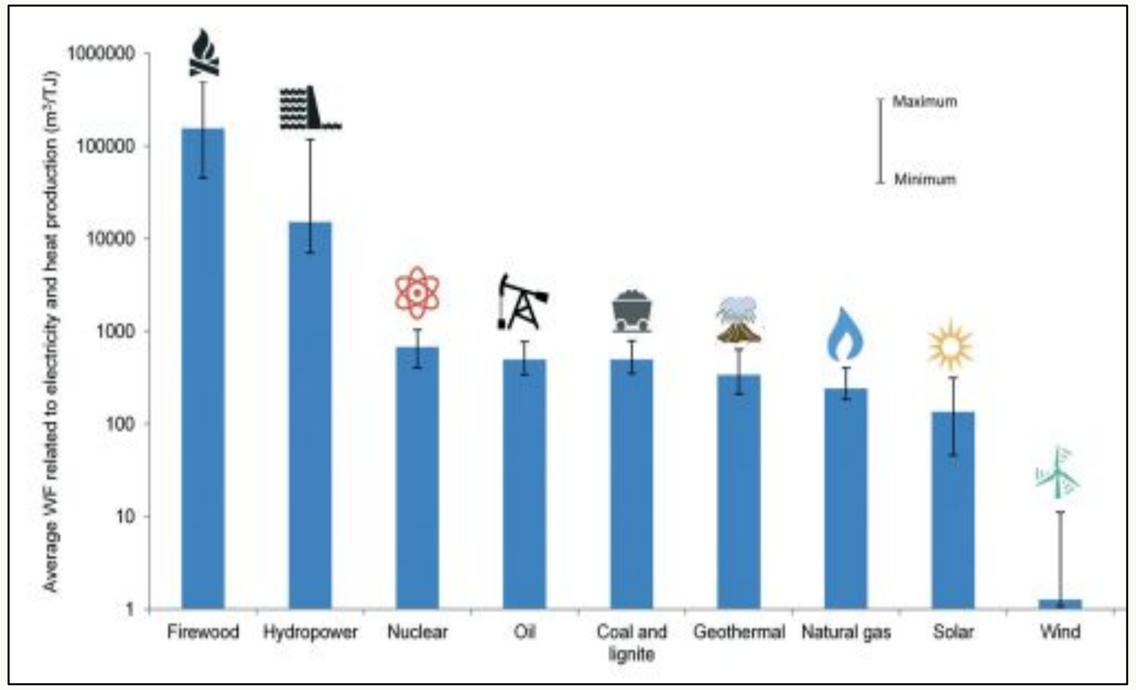
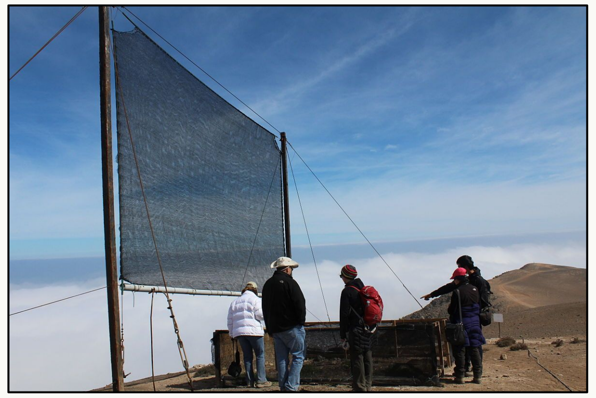
Future Outlook II : UWR potentials and diversification

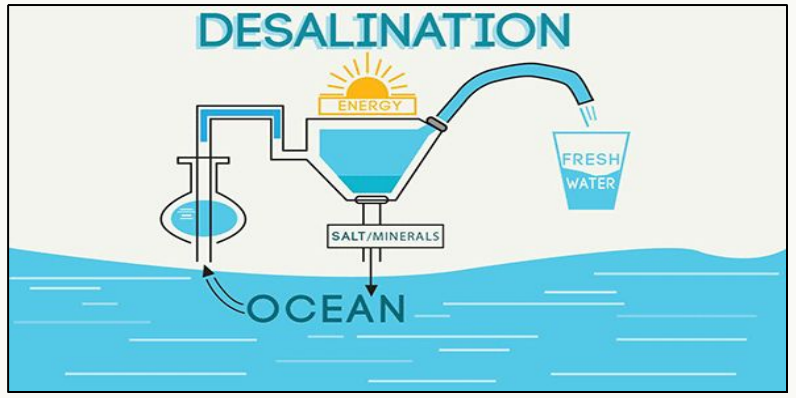


1. **increase groundwater extraction**
2. **reduce non-revenue water**
3. **switch to water-friendly renewables**
4. **Decentralized UWRs**









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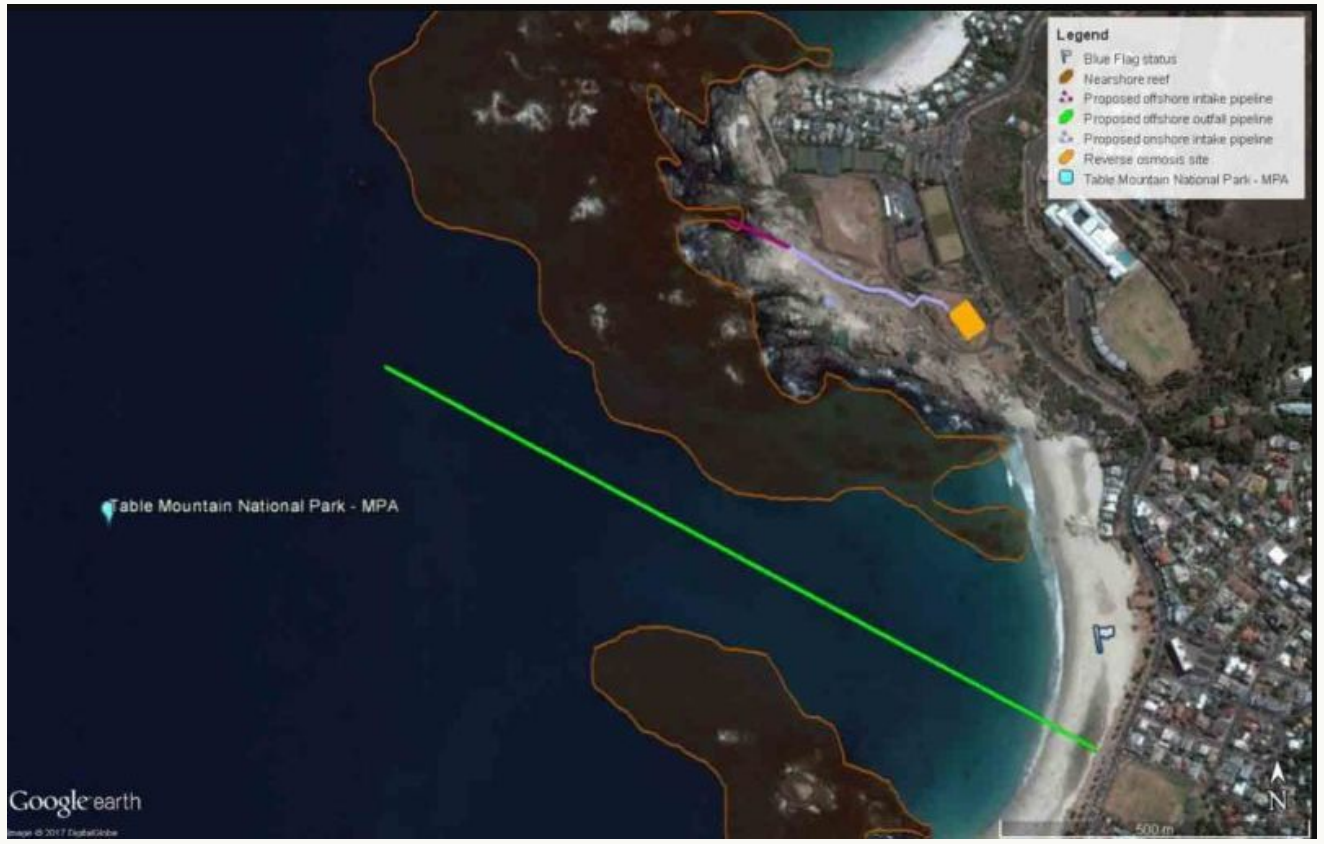
Future Outlook III: Wastewater treatment

South Africa only treats ~40-55% of its wastewater

"The City of Cape Town pumps 40 million litres of untreated sewage into the Atlantic ocean from the Green Point outfall pipeline every day. This results in microbial and chemical pollution of the sea (including persistent organic pollutants), marine organisms and recreational beaches, all of which breaches the City's constitutional commitment to 'prevent pollution and ecological degradation' and in doing so fails to uphold the constitutional right to an environment that is not harmful to 'health or well-being'."



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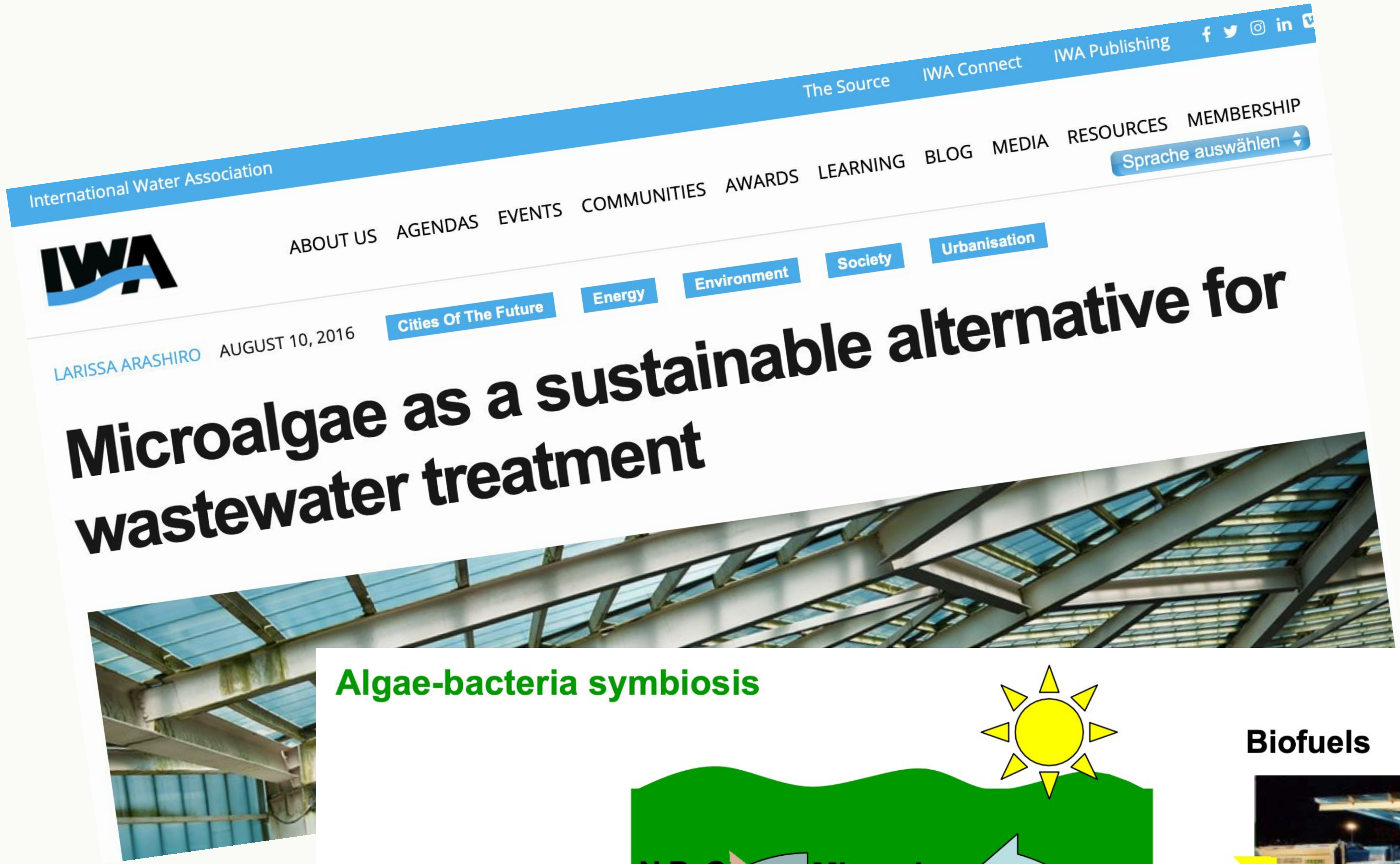
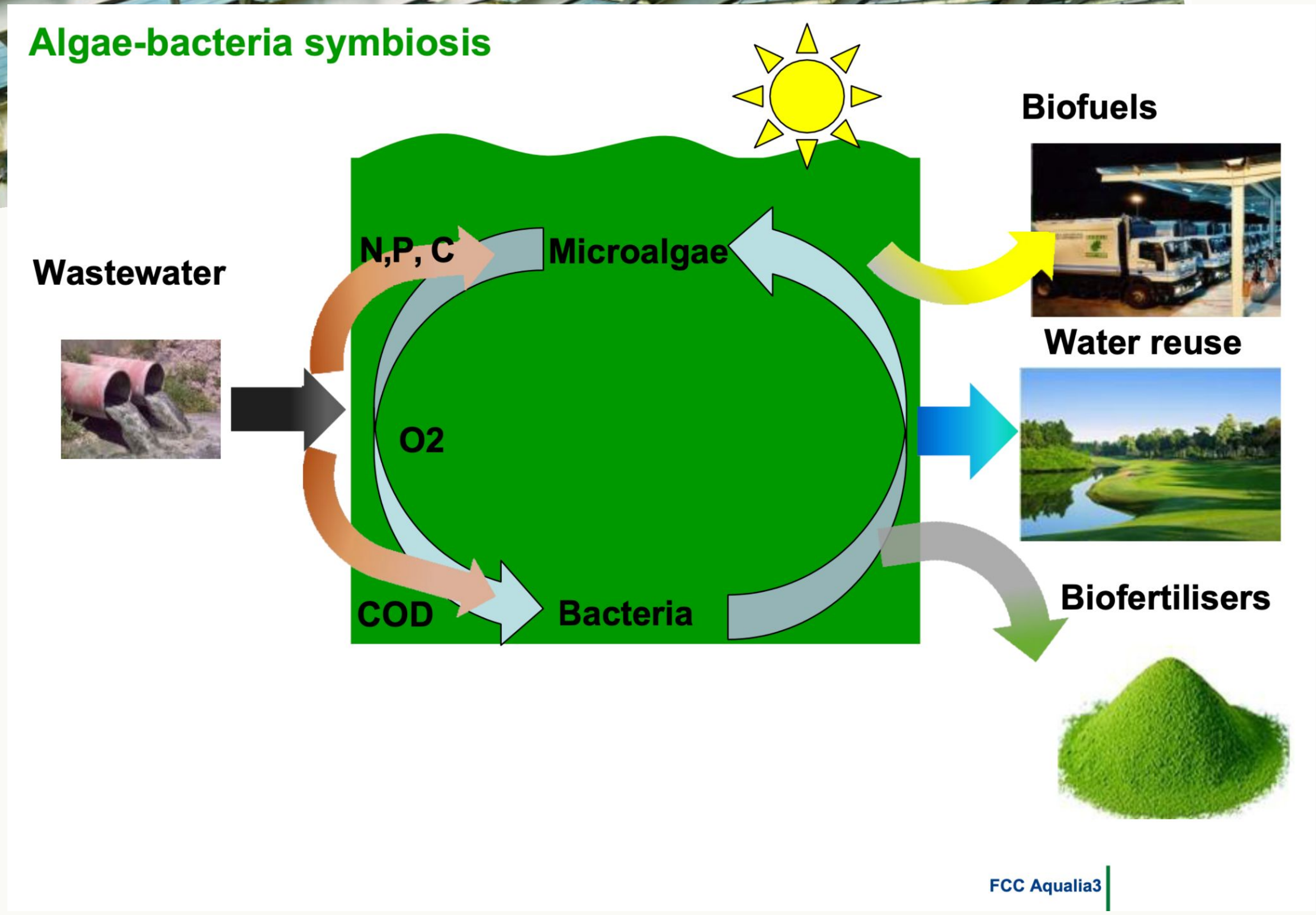
Our Transfer Project





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1 Task

Town with existing waste water ponds should get algae treatment inspired by Motetema and Brandwacht project - serves around 1 560 households

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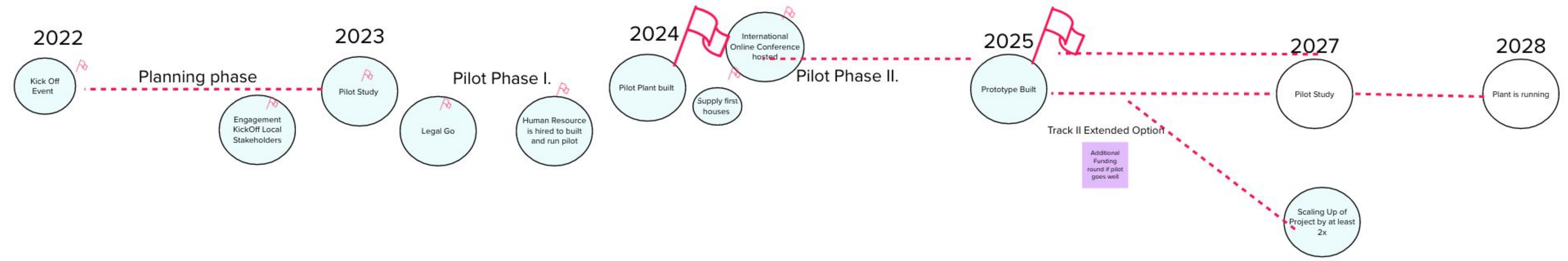
2 Goal for this project

Supplying a local population with recycled water from their town to potentially use in their domestic, industrial and agricultural endeavours and becoming more independent from fluctuations from freshwater supply.

Our vision for this project:

reusing water that is already in the system (our location)
building longlasting infrastructure
improve existent waste water treatment system (local infrastructure)
sustainable and efficient technique
enable participation of local community
leading the way in waste water treatment solutions

4 Project Timeline



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5 Advantage/Disadvantage (consequences)

	Advantage	Disadvantage
social	• can contribute to water justice • can contribute to SDGs like "clean water for all" • water infrastructure can trigger development in the area and improve quality of life in the area	• low acceptance rate of treated waste water can trigger conflict • if scaled up, land is needed
economic	• low electricity consumption --> low costs • establishment. of work places	• low acceptance rate of treated waste water can trigger conflict • algae is more innovative kind of water treatment, and therefore research might be costly
ecological	• environmentally friendly: - zero land fill - also other positive side effects, such as • energy recovery as biomethane; • microalgeae als biofertiliser	• potential spillover

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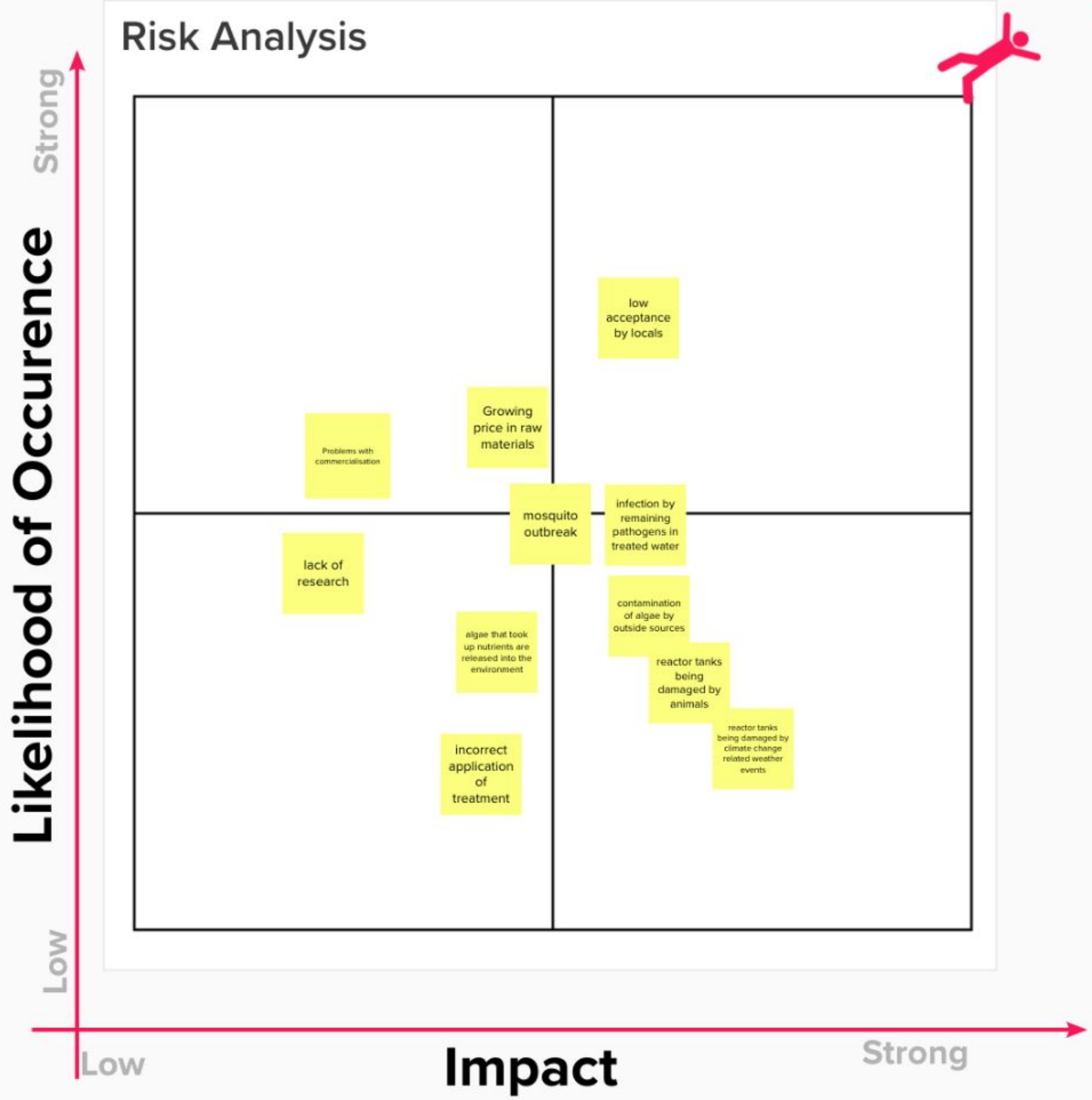
What could block us?

6

Risk Analysis

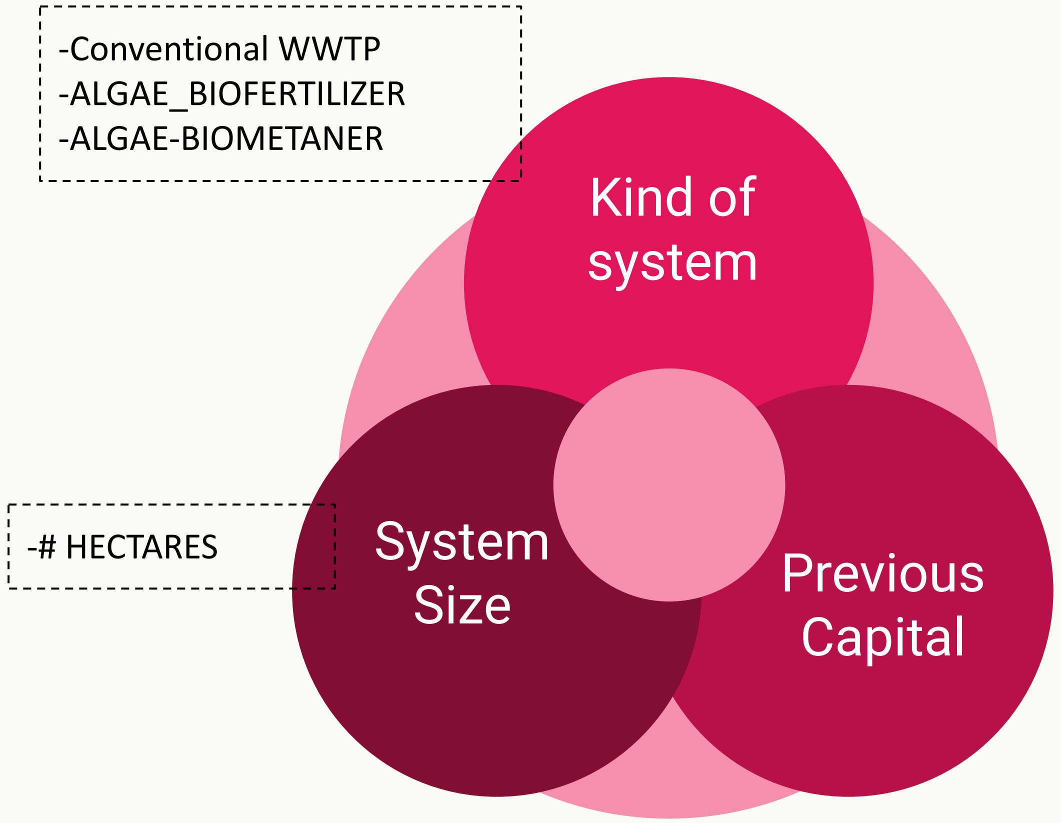


7 Mitigation of known risks

low acceptance by locals	big interactive knowledge and capacity building campaign, especially around the mechanism of the cleaning process, starting in school
incorrect application of treatment	make the maintenence of the facility integrated task of importance (via education), stay in contact with other communities having done that case study
mosquito outbreak	having ponds with a depth of more than 1 meter and steep/vertical walls, regularly check for larvae
algae that took up nutrients are released into the environment	monitoring algae concentration, using durable materials
tanks being damaged by animals reactor tanks being damaged by climate change related weather events	using resilient materials
lack of research	Initiating an international network / annual conference for algae based water reuse systems
infection by remaining pathogens in treated water	removing bottom sludge before wetting; water should be designated to non direct contact with people
contamination of algae by outside sources	shielding algae in reactor tanks from outside influences; costant monitoring

8 What will this cost?

Allocated: 10.000.000 €		
1. System		
Implementation COSTs / CAPEX	**€ (850 h.e.)**	**€ (30.000 h.e.)**
		(Differents tech: It's Biometaner)
Civil works and auxiliary installations	93.500,00 €	
Mechanical and electrical installations	65.000,00 €	
Pre-treatment	23.000,00 €	
Algae lagoons	15.000,00 €	
Algae harvesting	45.500,00 €	
Sub Total	**242.000**	**4.650.000**
Operation COST (OPEX)	(medium flow)	0 (- 1.450.000)
Fixed cost: Laubor, maintenance, electrical power	5.200	
Variable costs: Electricity, regents, Algal biomass disposal, CO2 addition etc.	1.800	
Subtotal	**7.000**	**0**
Land costs (rent/buy)	*Dependent on method*	
2. Education and Communication		
Lecturers, Talkers, Materials, certification	100.000	100.000
Communication Strategies	50.000	50.000
Sub Total	**150.000**	**150.000**
3. Project Adminsitration		
Labour, documentation, and another system operation	80.000	80.000
Savings for unpredictables.	200.000	200.000
Sub Total	**280.000**	**280.000**
Total per year	**680.000**	**5.080.000.00**



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