SWIM and Horizon 2020 Support Mechanism

Working for a Sustainable Mediterranean, Caring for our Future

SWIM-H2020 SM EFS-EG-1 & 2

Overview of different demand management options and water saving technologies across different sectors, and practical guidelines

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Presentation Outline

- Basic definitions
- Process to be followed when designing demand management options
- Demand management measures (concepts, definitions)
    - Urban sector
    - Agricultural sector
- Increase supply measures - NWRM
- Next steps

Basic Definitions

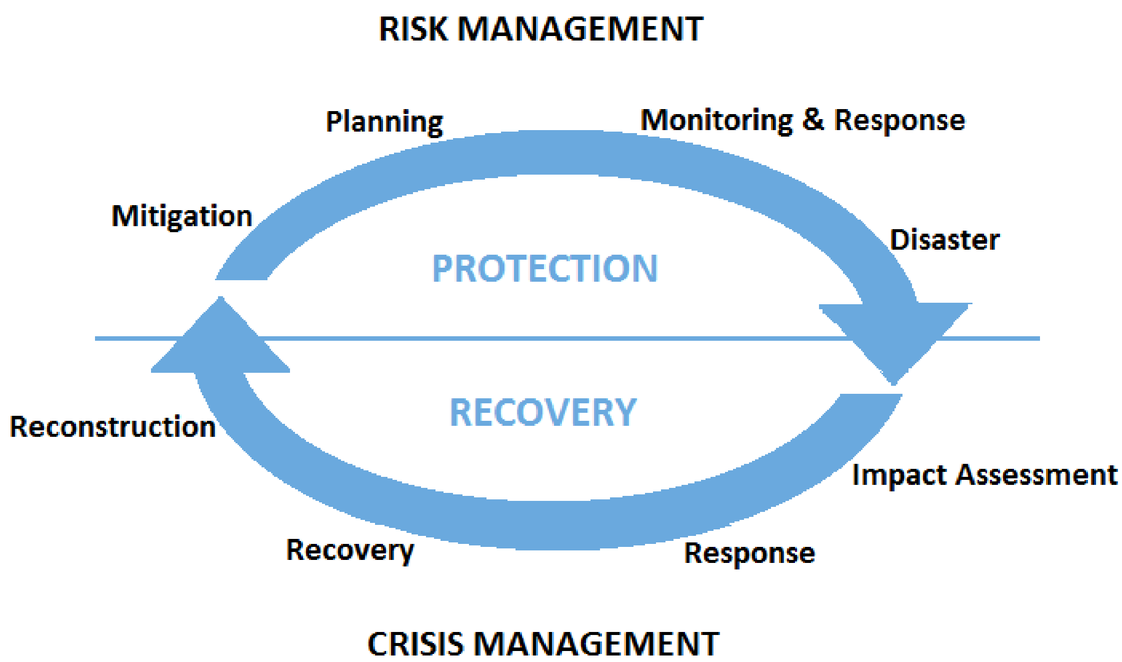
- **Demand management:** adoption of interventions and measures (technological, legislative, regulatory, financial, etc.) to achieve efficient water use by all sectors of the community (urban/ domestic, agricultural, industrial, tourism, etc.)

Demand reduction/ water saving measures:	Measures targeting to reduce demand and/or introduce water conservation *For example*: reduce leakage, install water saving fixtures, increase irrigation conveyance and field application efficiency, create incentives, water tariffs, water markets, taxes, etc.
Increase supply measures:	Measures targeting to increase water supply *For example*: greywater and wastewater reuse, water recycling, desalination, rainwater and stormwater harvesting, natural water retention measures. **** Caution to potential environmental impacts**

Guiding principles when designing demand management schemes

- Develop a Programme of Measures (PoM) to mitigate the problem of unmet demand at the appropriate spatial scale (e.g. river basin)
- Design mitigation measures together with stakeholders to safeguard their relevance and acceptability
- Involve locals, promote ownership and responsibility, and facilitate the internalization of the PoM in development framework
- Link science to the decision and policy-making process
- Promote proactive risk management

Basic Definitions



Crisis management only addresses the symptoms - seriously flawed from the perspective of vulnerability reduction → **Reactive Approach**

Risk management focuses on identifying vulnerabilities and addresses the prevailing risks through implementing mitigation and adaptation measures → **Proactive Approach**

Stepwise process

Step 1 – POLICY ASSESSMENT	Policy relevant **assessment of the water balance and unmet demand** (per sector) in the **area of interest** based on the results of detailed water balance models and calculations
Step 1 – IDENTIFY DM OPTIONS	Identification of **potential demand management (including increase supply) measures** for the most important sectors (e.g. urban and agricultural sector)
Step 1 – DISCUSS OPTIONS, SCREENING	**First dialogue with the stakeholders**: presentation of the measures, discussion on their efficiency and implementability, identification of limitation, agreement on a list of " **candidate measures"**
Step 1 - ASSESS COST-BENEFIT	**Simulation of the performance "candidate measures"** against a physical-based model to assess their **cost-benefit**
Step 1 – PRIORITIZE, SET TARGETS	**Second dialogue with the stakeholders:** presentation of the modeled/ simulation outcomes, agreement and **prioritizartion of measures** based on specified criteria (PoM), **setting of targets**

Which measures?

State-of-the-Art

- Focus on Demand Management Measures which could benchmark an “alternative policy”
- Investigate Increase Supply Measures which do not cause adverse environmental impacts

- Challenge: **Limited knowledge of their actual effectiveness**
- Perform cost-benefit ex-ante assessments (water saved vs. investment cost) prior to decision on the selection of measures
- Perform ex-post assessment based on monitored data after their implementation to evaluate their actual effectiveness
- Socio-economic factors always come into interplay, such as the readiness of the technological solution, the social acceptability, the equitability, constraints related to the implementation of the measures, etc. which can facilitate or impede the uptake and effectiveness of the measure
- People’s behavior is an unpredictable factor, need to increase awareness and motivation

Which measures?

Sectors	Measures for water saving and/or increasing supply
Urban	1. Low water using appliances (low flow taps and shower heads, dual toilet flushes, efficient washing machines, dishwashers, etc.) 2. Domestic Greywater Reuse (GWR) (increase supply) 3. Rainwater Harvesting (RWH) (increase supply) 4. Water pricing reform
Agriculture	1. Replacement of open canals with closed pipes 2. Change of irrigation methods - Switch to drip irrigation and/or sprinklers from furrow irrigation systems - Apply deficit irrigation - Precision agriculture 1. Changing land use/ crops 2. Water pricing reform
Cross-cutting	1. Wastewater treatment and reuse (within or across sectors) 2. Natural Water Retention Measures (NWRM) 3. Water metering 4. Economic Policy Instruments (EPIs), including water pricing reform

At what scales?

Scales	Measures for water saving and/or increasing supply
Micro	Low water using appliances (low flow taps and shower heads, etc.) Domestic Greywater Reuse (GWR) on-site Rainwater Harvesting (RWH) on-site Precision agriculture at the farm level Water metering
Meso	Replacement of open canals with closed pipes Switch to drip irrigation and/or sprinklers from furrow irrigation systems Apply deficit irrigation Precision agriculture Natural Water Retention Measures (NWRM), e.g. retention ponds Rainwater Harvesting (RWH) and storage
Macro	Wastewater treatment and reuse (within or across sectors) Dams Economic Policy Instruments (EPIs), including water pricing reform Changing land use/ crops

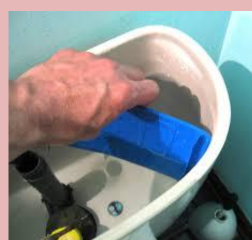
Urban measures

Water saving fixtures & techniques

High Efficient Toilets (WC)

tank bank

toilet dam



Dual-flushing device

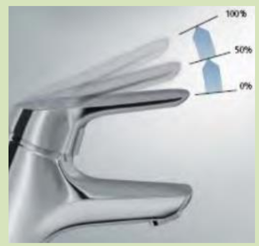
Waterless urinals

Efficient Taps & Mixers

Spray taps

Sensor faucet

Tap with break



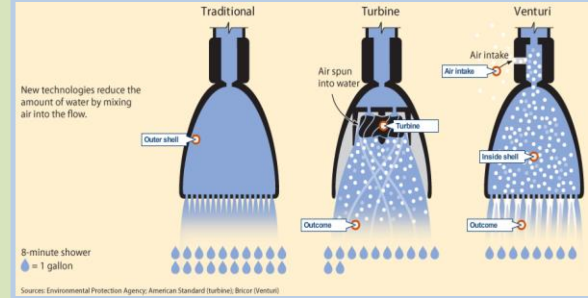
Push-tap

Flow restrictor

Aerators

Eco-button

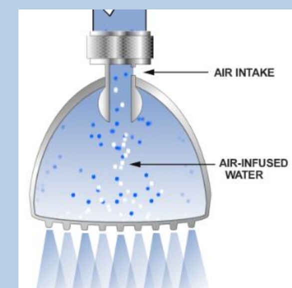
Efficient Showerheads



Laminar flow

Aerating

Low-flow showerhead

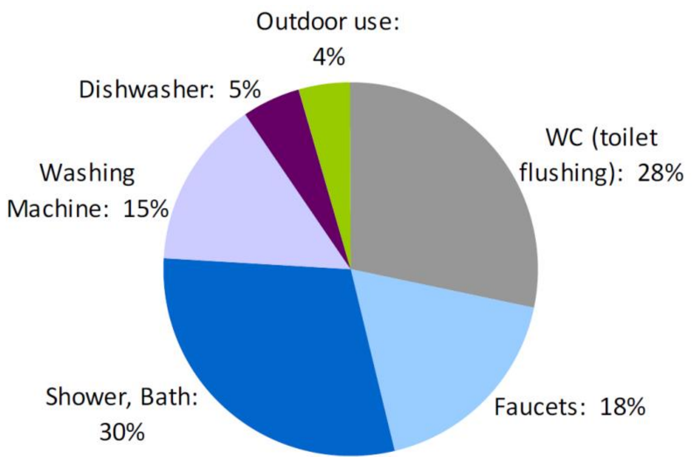


Flow regulator

Urban measures – water saving fixtures

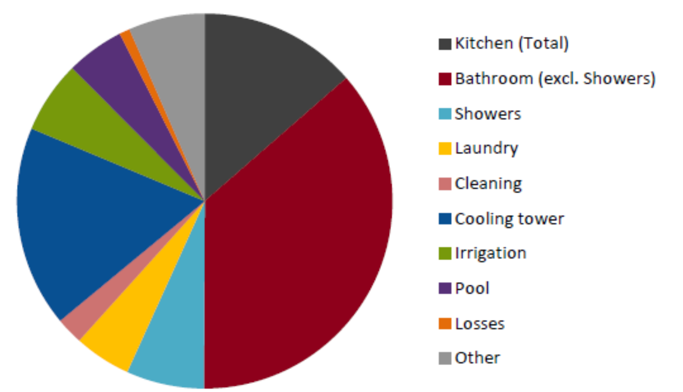
Water Using Product (WuP)	Consumption of “traditional” WuPs (lt/use)	Consumption of “efficient” WuPs (lt/use)	Water Saving Potential (%)
Low flush WC	6-12 lt/flush	3-4,5 lt/flush	30-50%
Showerhead	25 lt/min; 25.7-60 lt/shower	6-14 lt/min	50-70%
Faucet aerator	13.5 lt/min; 2.3-5.8 lt/use	2-5 lt/min	40-65%
Dishwasher, AAA class	21.3-47 lt/load	7-19 lt/load	40-60%
Washing Machines, AAA class	39-117 lt/load	40 lt/load	40%

Average water consumption share of different household micro-components



Micro-components of water use

Average water consumption share in commercial buildings



Option 1 – Water saving fixtures & techniques

Water Saving Measure	Performance (% water saving)	Micro-component targeted	Micro-component water consumption share (%)*	Unit Cost €	AEC €	Expected water saving as % of total consumption
Dual Flush Toilet	40%	WC	25%	170 €	32 €	10%
Showerheads replacement (1 item)	60%	Bath + shower	34%	30 €	11 €	20.4%
Low flow taps (2 items)	50%	Faucets	13%	50 €	19 €	6.5%
Efficient Washing machine	40%	Washing Machine	14%	600 €	111 €	5.6%
Dishwasher	50%	Dishwasher	8%	700 €	130 €	4%

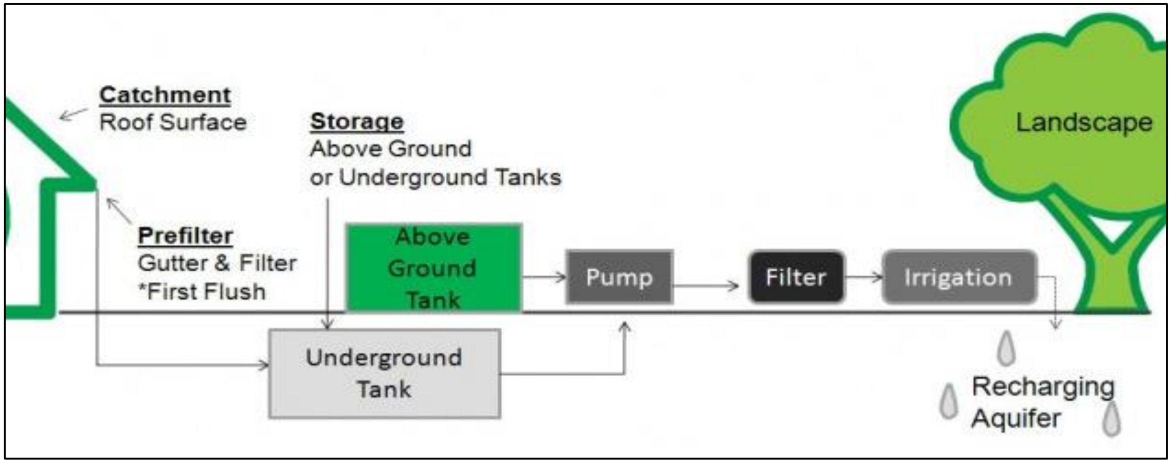
These shares refer to a residential building. Adjustments need to be made according to the building types and micro-components of water use.

Consumption volumes in absolute terms are ambiguous to report, since they depend on the number of employees/occupants in each building, the frequency of use & their habits, existing leakage losses, etc.

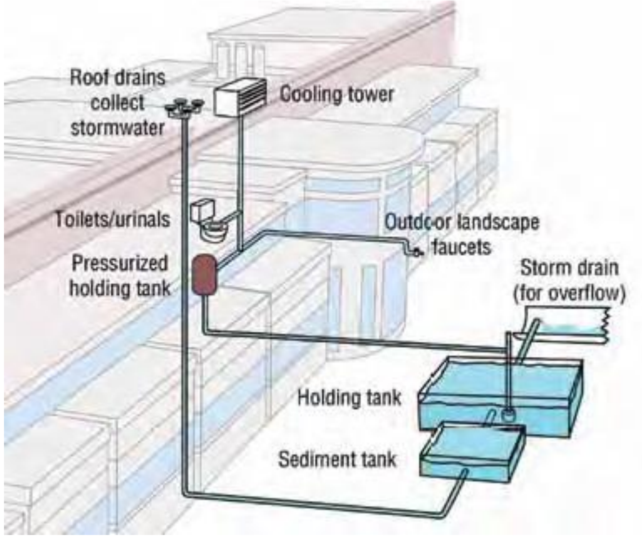
Thus, metering of micro-components prior to decision-making is encouraged

Urban measures – Domestic Rainwater Harvesting (RWH)

- Rainwater harvesting (RWH) is a **decentralized technique** of the collection and storage of rainwater for later use at or near the point where water is needed or used.
- Harvested rain water can be **utilized for several purposes**: washing, gardening, flushing and even drinking.
- Although rainwater is relatively clean and the quality is usually acceptable for many purposes, **filtration** and **disinfection** is usually appropriate
- A **RWH system**, which collects runoff from the roof, generally consists of a catchment area (generally the roof area), a filter, a storage tank, a supply network, pipes and an overflow unit (Environmental Agency 2008).



http://semmesco.com/harvest-time-for-rainwater/



Urban measures – Domestic Rainwater Harvesting (RWH)

Benefits:

- Meet water demand when no other water sources are available
- Reduction of potable water consumption from the mains
- High collection and distribution efficiency
- Self sufficiency (less dependency on distant water courses).
- Reduction of flood risk (reduction of economic losses).
- Enhance rational utilization of water through decentralized systems
- Rain water can also be directed to recharge the aquifer thus increasing the ground water table

1 US gal=3.78 lt

Cost effectiveness:

- Great **variation in capital costs** because of options in terms of size, type of tank, and whether or not a pump is needed.
  - Range: from \$1.50 - \$3.00/gal of storage (for simple systems) to \$3.5 - \$8/gal for more sophisticated systems (EPA,2013)
  - The **storage tank size** is by far the largest factor of the total installation cost.
- Typical payback period is between 2 to 7 years
- The volume of **water that is actually saved depends** on the supply and demand for water.
- The amount of **money saved depends** on the price of water and the maintenance
- Approximately **0.62 gallons of water can be collected per square foot** of collection surface per inch of rainfall (**0.025 m3 per m2**). In practice, however, assume an **efficiency of 80%.** (loses from first flush, evaporation from the roof surface, splash-out from the gutters)
- Annual production potential:

m3= roof area (m2) x annual precipitation (in/yr) × (0.025x 0.8)

Urban measures – Domestic Greywater Reuse (GWR)

- GWR systems can vary significantly from simple, low-cost appliances that harvest greywater and convey it for direct use (e.g. in toilets and gardens), to composite systems integrating specialized treatment processes
- Cost and energy required can also vary, increasing mainly as more and better treatment is involved
- Water saving potential: variable, a reduction of 16-40% of potable water use is expected
- GWR systems are more suitable for new-built developments, as retrofitting existing systems can be more expensive

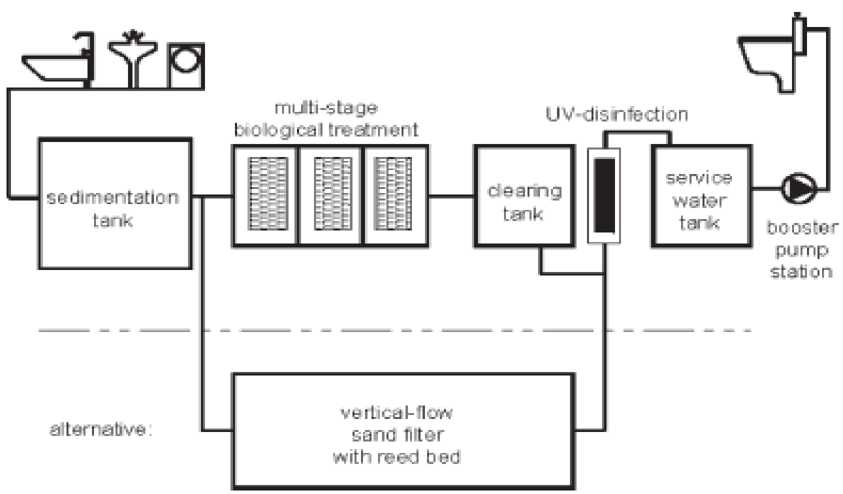


Figure 1 Recommended concept for greywater treatment

Requirements of a GWR for 280 users	
Tank height	1.89 m
Required min. room height	2.39 m
System surface	about 15.0 m2
Installation surface	max. 25.0 m2
Suited for # of users	about 280
Recycling capacity	10,000 lt/day

http://web.stanford.edu/group/narratives/classes/08-09/CEE215/Projects/greendorm/water/GraywaterCD/graywater08/Research%20Articles/WS&T05GryWtrReusGerm.pdf

Urban measures

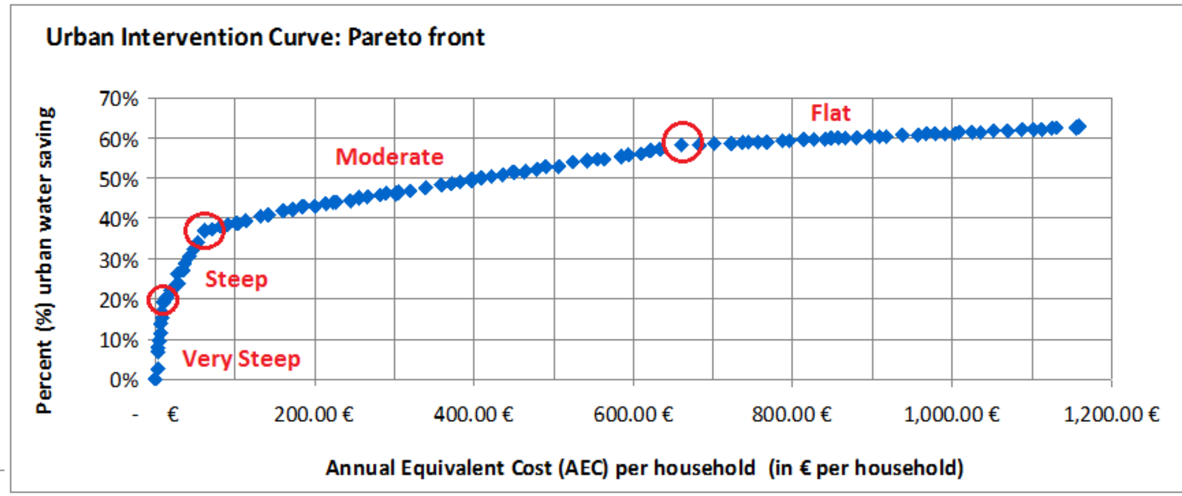
	Water Saving Measure	Performance (% water saving)	HH Micro-component targeted	HH Micro-component share (%)	Unit Cost €	AEC €	Expected water saving as % of total HH consumpt.
Tier #1	Dual Flush Toilet	40 %	WC	25 %	170 €	32 €	10 %
	Showerheads replacement	60 %	Bath + Shower	34 %	30 €	11 €	20.4 %
	Low flow taps (2 items)	50 %	Faucets	13 %	50 €	19 €	6.5 %
	Efficient Washing machine	40 %	Washing Machine	14 %	600 €	111 €	5.6 %
	Dishwasher	50 %	Dishwasher	8 %	700 €	130 €	4 %
			Outdoor use	6%			
Tier #1 TOTAL				100 %	1,550 €	303 €	46.5 %
Tier #2	Rainwater Harvesting[1]	40 % (incl. rainy months)	WC, washing machine, outdoors	29 %	2,500 €	356 €	11.6 %
	Greywater Reuse[2]	22 %	WC , outdoors	21 % (15% WC + 6% outdoors)	3,500 €	498 €	4.6 %
Tier #2 TOTAL				44 %	6,000 €	854 €	16.2 %
GRAND TOTAL					**7,550 €**	**1,158 €**	**62.7 %**

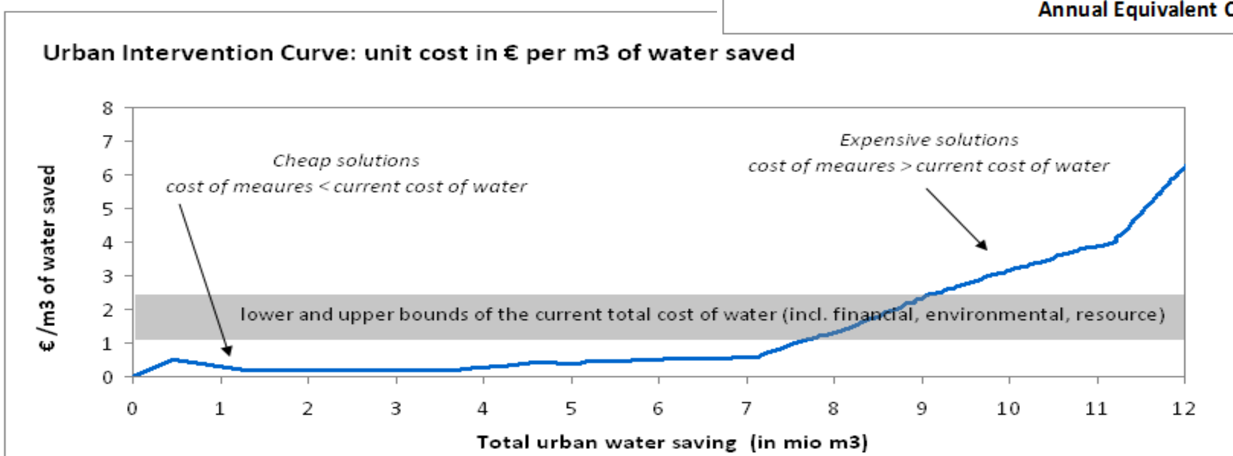
$$AEC = \frac{r(1+r)^n}{(1+r)^n - 1} \times Inv + OMC$$

Urban measures' intervention curves

Water Saving %	AEC per HH €	Total water saving * (mio m³)	Total AEC mio €	€/m³ of water saved	*Penetration (% of the households adapting the measure)*						
					Dual flush toilet	*Shower-heads (1 item)*	*Low flow taps (2 items)*	*Efficient Washing Machine*	*Dish-washer*	*RWH*	*GWR*
7.7 %	4 €	1.49	0.29 €	0.20	0	38%	0	0	0	0	0
20.4 %	15 €	3.93	1.00 €	0.26	13%	94%	0	0	0	0	0
34.0 %	53 €	6.46	3.62 €	0.56	91%	100%	70%	0	0	0	0
39.4 %	115 €	7.59	7.80 €	1.03	100%	100%	100%	37%	9%	0	0
40.7 %	142 €	7.85	9.65 €	1.23	100%	100%	100%	61%	9%	0	0
45.2 %	256 €	8.72	17.43 €	2.00	100%	100%	100%	100%	9%	20%	0
49.6 %	397 €	9.56	26.97 €	2.82	100%	100%	100%	89%	9%	63%	0
54.5 %	541 €	10.51	36.77 €	3.50	100%	100%	100%	100%	9%	100%	0
60.0 %	857 €	11.57	58.22 €	5.03	100%	100%	100%	100%	100%	100%	40%
62.7 %	1,158 €	12.11	78.73 €	6.50	100%	100%	100%	100%	100%	100%	100%

- Easy and low cost to achieve conservation up to 34% (53 €/hh AEC)
- Above that level, the cost is increasing rapidly (introduction of relatively expensive measures of tier 2, and washing machines)

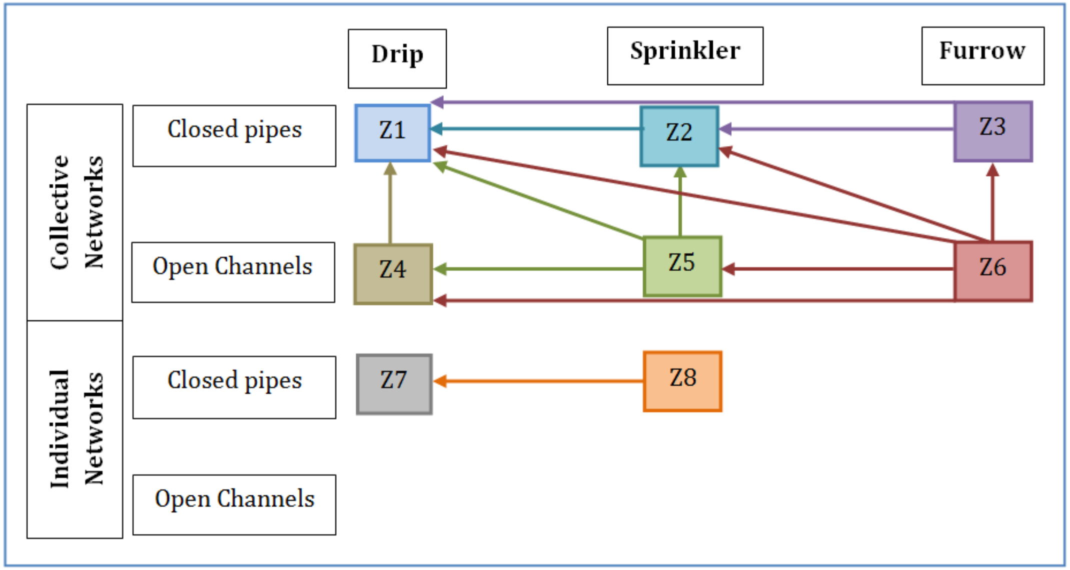




Agricultural measures – Increase irrigation efficiency

- Different options to improve conveyance efficiency and/or field application efficiency

Schematic representation of the optimization process



Aggregated values for irrigation efficiency (conveyance and field application)

Irrigation Efficiency		Drip	Sprinkler	Furrow
Closed Pipes	Collective Networks	76.0%	68.0%	52.0%
	Small individual networks	90.3%	80.8%	61.8%
Open Channels	Collective Networks	57.0%	51.0%	39.0%
	Small individual networks	-	-	-

Agricultural measures – Precision Agriculture

- **Precision Agriculture (PA)**

Soil moisture sensors, watering based on specific needs/ schedule

Costs associated with implementing Precision Agriculture (PA)

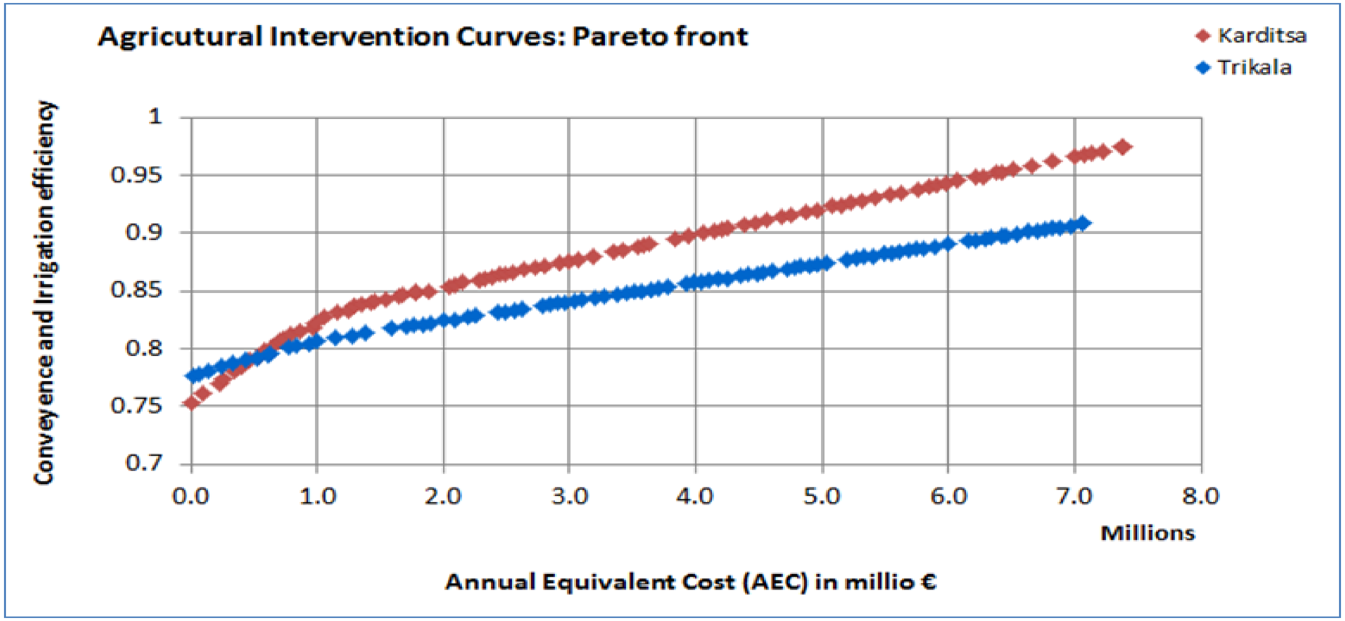
Cost items	Unit price (€)	Cost for 100 ha (€)	Cost per hectare (€/ha)
Yield monitor (1 item per 100 ha)	7,000	7,000	70
Soil moisture sensor (160 items per 100 ha)	35	5,600	56
Data logger (10 items per 100 ha)	200	2,000	20
Atmometer (10 items per 100 ha)	350	3,500	35
Sum of equipment cost		18,100	181
Drip irrigation modernization			650
Total cost for implementing PA			831
AEC (for a useful life n=5 years, and r=0.07)			202.67
Savings from reduced fertilisers' use (~30 kg N/ha)			-39
Savings from energy bills (reduced pumping)			-8
Net total cost for implementing PA (suggested for the Matlab model)			**156 €/ha**

- **Deficit Irrigation (DI):** Application of water below the ET requirement

It is based on the concept that in areas where water is the most limiting factor, maximizing Crop Water Productivity (CWP) may be economically more profitable for the farmer than maximizing yields

$$\text{Market Value} = Y_a * \text{Area} * \text{Price}$$

Agricultural measures' intervention curve



Cost items inserted in the MATLAB model	Cost per hectare
converting from open channels to closed pipes	390 €/ha
converting from furrow to sprinkler irrigation	155 €/ha
converting to drip irrigation	347 €/ha
implementing Precision Agriculture (PA)	156 €/ha

An example from Greece, Thessaly
Trikala: AEC ~400,000€ for each 1% efficiency gain.
Karditsa: for efficiencies <~82% an AEC of 100,000€ for each 1% increase ; >82% an AEC 250,000€

Water Metering

You can’t manage what you don’t measure!!

- Average consumption volumes in absolute terms are ambiguous to report, since dependent on the number occupants (or employees) in each building, frequency of use & habits, existing leakage losses, etc.
- Metering of micro-components prior to decision-making is encouraged
- Meters and submeters can be integrated into a centralized building management system, making it easy to **track usage** and implement **water saving measures**
- They can also detect and **trigger alerts** for leaks or other operational anomalies

Water Metering

1. Determine **what to meter** and submeter
2. Determine **the type** of meters

   - positive displacement (PD): suitable for small CIF, because they have high accuracy rates at low flows and can precisely measure peak flows.
   - compound meters: suitable for large CIF because they accurately measure low flows and high flows with their multiple-measuring chamber design.
   - turbine and propeller meters: suitable for continuous, high-flow applications, inaccurate at low flows. Not recommended for CIF
3. Select the **appropriate size** of the meter (min/max flow rates) ~ building's size, function, fixture types, usage occupancy, peak population
4. **Installation**: place meters in a secure and accessible location to allow for reading and repair. Ensure uniform flow entering → do not install it near pipe bends (*General Rule: upstream straight pipe length = 5 x diameter, downstream 10x)*
5. **Maintenance**: install an inline strainer on the meter's inlet to collect debris, test for accuracy and calibrate on regular basis
6. Consider installing a **water meter Data Management System (DMS)** with remote communication capabilities

PD meter

Compound

Turbine

American Water Works Association (AWWA), 2004. Sizing Water Service Lines and Meters (AWWA Manual M22, 2nd Edition).

Economic Policy Instruments (EPIs)

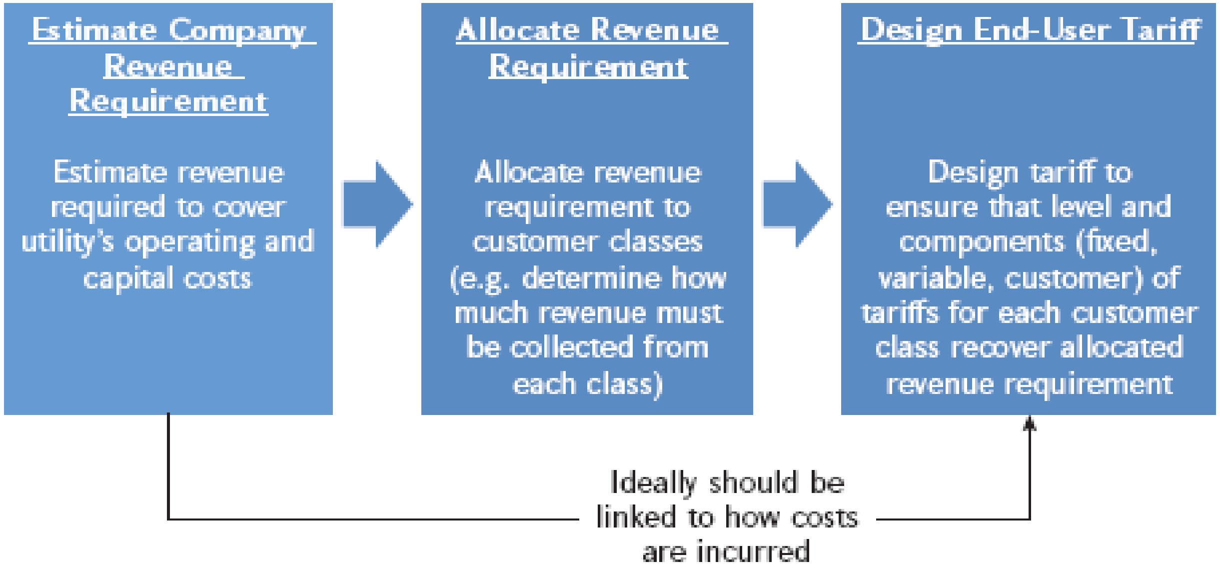
EPIs are tools based on incentives ad disincentives; they change conditions to enable economic transactions or reduce risk, aiming at delivering environmental and economic benefits

EPIs related to PRICING

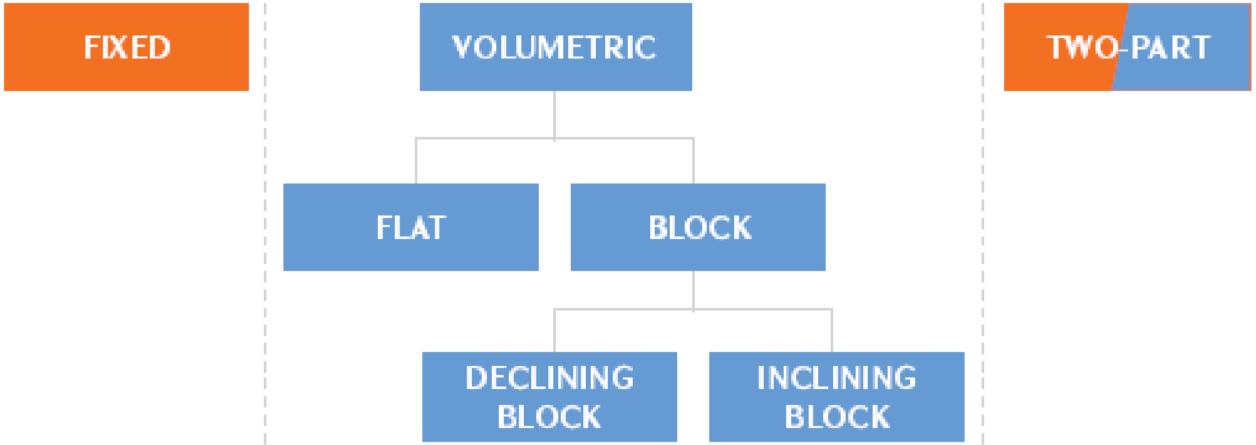
EPI	Definition	What can the EPI deliver?
Tariffs	Price to be paid by a user for a given quantity of water or sanitation service	Encouraging technological improvements or changes in behaviour, leading to a reduction in water consumption or discharge of pollutants. They generate revenues for water services/infrastructures.
Taxes	Compulsory payment to the fiscal authority for a behaviour that leads to the degradation of the water environment.	Encouraging alternative behaviour to the one targeted by the tax, for example the use of less-polluting techniques and products.
Charges (or fees)	Compulsory payment to the competent body (environmental or water services regulator) for a service directly or indirectly associated with the degradation of the water environment.	Discouraging the use of a service. For example, using charges in a licensing scheme may discourage users to apply for a permit.
Subsidies on products	Payments from government bodies to producers with the objective of influencing their levels of production, their prices or other factors.	Leading to a reduction in the price of more water-friendly products, resulting in a competitive advantage with comparable products.
Subsidies on practices	Payments from government bodies to producers to encourage the adoption of specific production processes.	Leading to the adoption of production methods that limit negative impacts, or produce positive impacts, on the water environment.

Water Pricing

Steps Required To Set Tariffs



Overview of Common Tariff Options



Economic Policy Instruments (EPIs)

EPIs related to TRADING

EPI	Definition	What can the EPI deliver?
Trading of permits for using water	The exchange of rights or entitlements to consume, abstract and discharge water.	Encouraging the adoption of more water efficient technologies. May improve the allocation of water amongst water users.
Trading of permits for polluting water	The exchange of rights or entitlements to pollute the water environment through the discharge of pollutants or wastewater.	Encouraging the adoption of less water polluting technologies. Improve the allocation of abatement costs amongst water users

EPIs related to COOPERATION

EPI	Definition	What can the EPI deliver?
Cooperation agreements	Negotiated voluntary arrangement between parties to adopt agreed practices often linked to subsidies or offset schemes.	Encouraging the adoption of more water-friendly practices.

EPIs related to RISK MANAGEMENT

EPI	Definition	What can the EPI deliver?
Insurance	Payment of a premium in order to be protected in the event of a loss.	Water users' aversion to risk and willingness to pay for income stabilisation. Insurance premiums can discourage behaviours that increase risk or exposure
Liability	Offsetting schemes where liability for env. degradation leads to payments of compensation for environmental damage.	Liability as a means to incentivise long-term investments in water efficient devices.

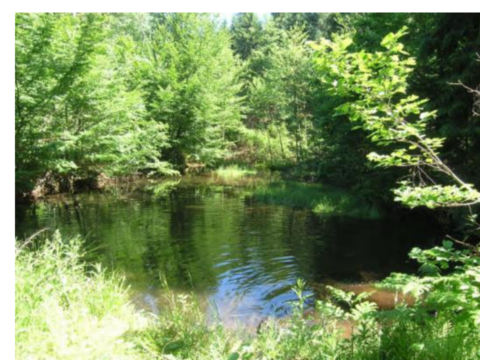
Increase supply – Natural Water Retention Measures (NWRM)

http://nwrm.eu/

Basins and ponds require a large accessible area that is relatively flat and with an appropriatelysized drainage catchment. They can be installed in any type of area (urban, forest, agricultural...).
Account should be taken of natural features that could be used to form the basin and/or provide additional storage areas in order to minimise the need for artificial landscaping

Detention & Retention basins temporarily store runoff, then releasing it at a slower rate downstream, e.g. in to a receiving watercourse. The capacity to store runoff is dependent on the design of the basin, which can be sized to accommodate any size of rainfall event. Typical construction costs in range from $20 to $40 per m3 of storage.

Biophysical Impacts		Rating	Evidence
Slowing & Storing Runoff	Store Runoff	High	Volume of runoff storage: Total volume of the basin/volume available in the pond (total volume minus the volume of water already there before the rain event). No long term storage for the basins. For the pond, the potential storage is equal to the total volume of the pond. Peak flow reduction estimated to be between 15-30% for the Northumberland (Rural runoff attenuation in the Belford catchment, UK) project
	Slow Runoff	High	
	Store River Water	None	Storing of surface runoff only (system not connected to a river)
	Slow River Water	None	Storing of surface runoff only (system not connected to a river)



Increase supply – Wastewater reuse

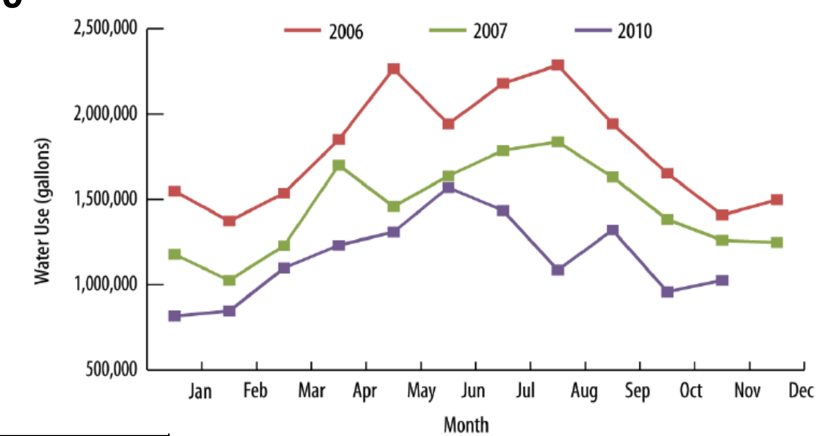
Large scale
Collect wastewater from the basin
Treat and Reuse

Location !!!!
Potential to serve other users, downstream

Case Studies

Case Study 1: Hotel Installs Water-Efficient Sanitary Fixtures

- **Location:** Holiday Inn Hotel, San Antonio International Airport, Texas, USA
- **Technology/ practice:** retrofitting **397 hotel guestroom bathrooms** with water saving fixtures (high-efficiency toilets, faucet aerators, and showerheads)
- **Water saving:** 7 million gallons of water per year **(~ 26,500 m3/yr**).
- **Energy saving:** much of the water saved is hot water, thus the hotel also saves energy. Estimated electrical energy savings 330,000 kWh/y.
- **Economic benefits:** approximately $35,000 saved each year in water and sewer bills from reducing the water use, and an additional $33,000 per year in energy savings. i.e. Total = **$68,000** per year
- **Investment cost:** the utility spent approximately **$100,000**
- **Payback period:** less than **2 years**
- **Miscellaneous**: The hotel has also reported that it no longer receives calls for maintenance of the new fixtures or fittings, compared to the 1-2 calls received each day in the past.

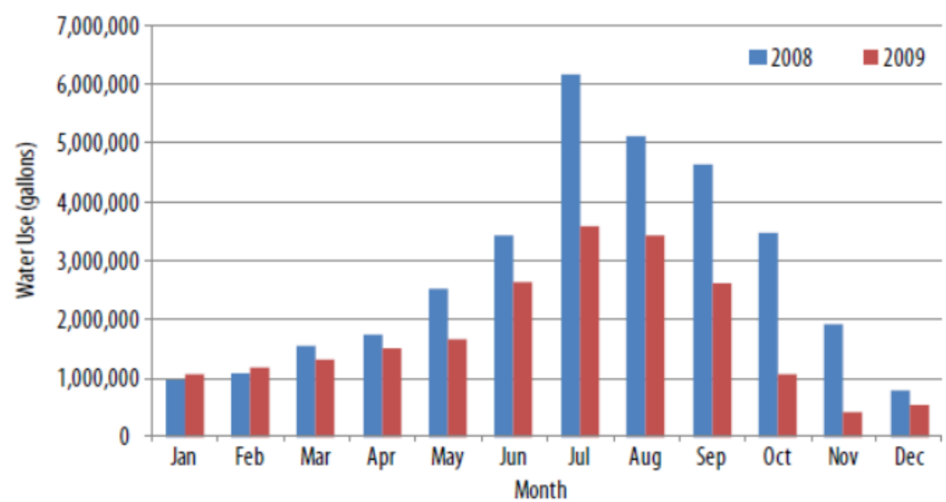


Fixture/Fitting Replaced	Original Efficiency	Retrofit Efficiency	Number of Units Replaced
Toilets	3.5 gallons per flush (gpf)	1.1 gpf	297
Toilets	5.0 gpf	1.1 gpf	100
Faucet Aerators	2.2 gpm	1.5 gpm	397
Showerheads	2.5 gpm	1.75 gpm	397

Case Study 2: Office Complex reduces outdoor water use

- **Location:** Granite Park office complex in Plano, Texas, USA – 35,000 m2 in size
- **Technology/ practice:** Following an irrigation audit, the irrigation efficiency was improved by:
  - ✓ installing **weather-based irrigation controller** (which analyzes local weather data and landscape conditions to program watering schedules based on plants' needs)
  - ✓ installing **rain sensor** and **freeze sensor** (to prevent watering at unnecessary times)
  - ✓ replacing broken sprinkler heads;
  - ✓ positioning sprinkler heads to ensure adequate coverage
  - ✓ Installing pressure regulating nozzles to increase the uniformity of water applied

- **Water saving:** 12.5 million gallons in 2009 (~**47,300 m3/yr**)
- **Economic benefits:** $47,000 in 2009
- **Investment cost:** ~ $66,000
- **Payback period:** **Less than 1.5 years**



Case Study 3: Greywater Recycling and Reuse in Hotel - Dead Sea, Jordan

- **Location**: Jordan
- **Aim**: Conservation of water
- **Climate Risk Addressed in the area**: Water scarcity and drought
- **Old system:**
  - ✓ During peak season the hotel had to hire private water suppliers to fill the hotel's water tank up to 10 times/day
  - ✓ Public water supply is available at a significantly lower price, but it cannot meet the needs of this four-star hotel.
- **Potential of recycled water**: Approximately 80% of the wastewater generated daily by each hotel room of the facility takes the form of grey water
- Project size: The system can recycle 15 m3/day, collected from showers and bathroom sinks, thus 60% of water consumed for toilet flushing in the hotel can be saved
- Saving costs: 20.000€ per year

The Dead Sea Spa Hotel

The Greywater recycling system

Summary results of greywater recycling at the hotel

Saving potential	17% of the total water consumption in the hotel
Investment in the greywater system	US $ 80,000
Approaches used	High quility greywater treatment and reuse
Key success factors	Investment costs can be minimised if integrated in early planning

SWIM and Horizon 2020 Support Mechanism

Working for a Sustainable Mediterranean, Caring for our Future

Thank you!

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