Water for All
Conserve, Value, Enjoy

PUB

Non Conventional Water Source – A Strategic Resources for Singapore Sustainable Water Supply

Puah Aik Num
PUB Singapore

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Water for All: Conserve, Value, Enjoy

OUTLINES

- 1. Water Challenges - Climate change, population growth and migration, urbanisations, limitation of resources-energy
- 2. Look beyond conventional sources of water - recycling, desalination, etc.
- 3. Perception- water is gift of nature, water tariffs, education, outreach, partnership
- 4. Leveraging on technology

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Water Resource Challenges

Rising Energy Prices

Rise of Megacities

Population Growth

No Pristine Water Sources

Stringent Regulations & Public Expectations

Climate Change

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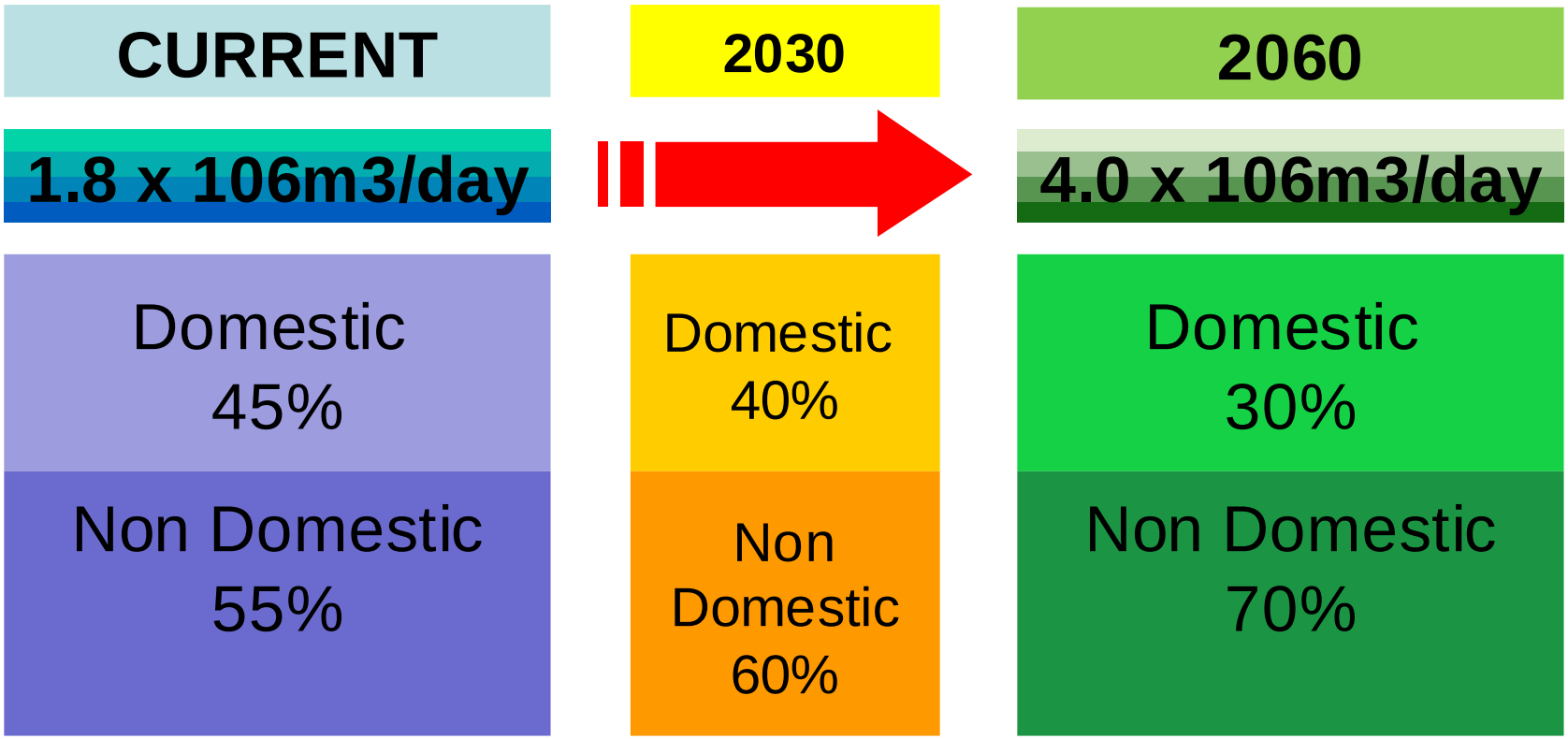
Singapore

Land Area: 710km2
Population: 5.4million
Average Annual Rainfall: 2400mm
Average Water Demand: 1.8mil m3/day (400mgd)

PUB *is a statutory board under the Ministry of Environment and Water Resources, and is the national water agency of Singapore*

Singapore Water Demand



Integrated Water Resource Management

4 National Taps

Local catchment

Imported water

NEWater

Desalinated water

"Water for All"

3P Approach

"Conserve Water"

"Value Our Water"

"Enjoy Our Waters"

"Conserve, Value, Enjoy"

Supply-Side Policy Instruments

FOUR NATIONAL TAPS

Water for All : Conserve, Value, Enjoy

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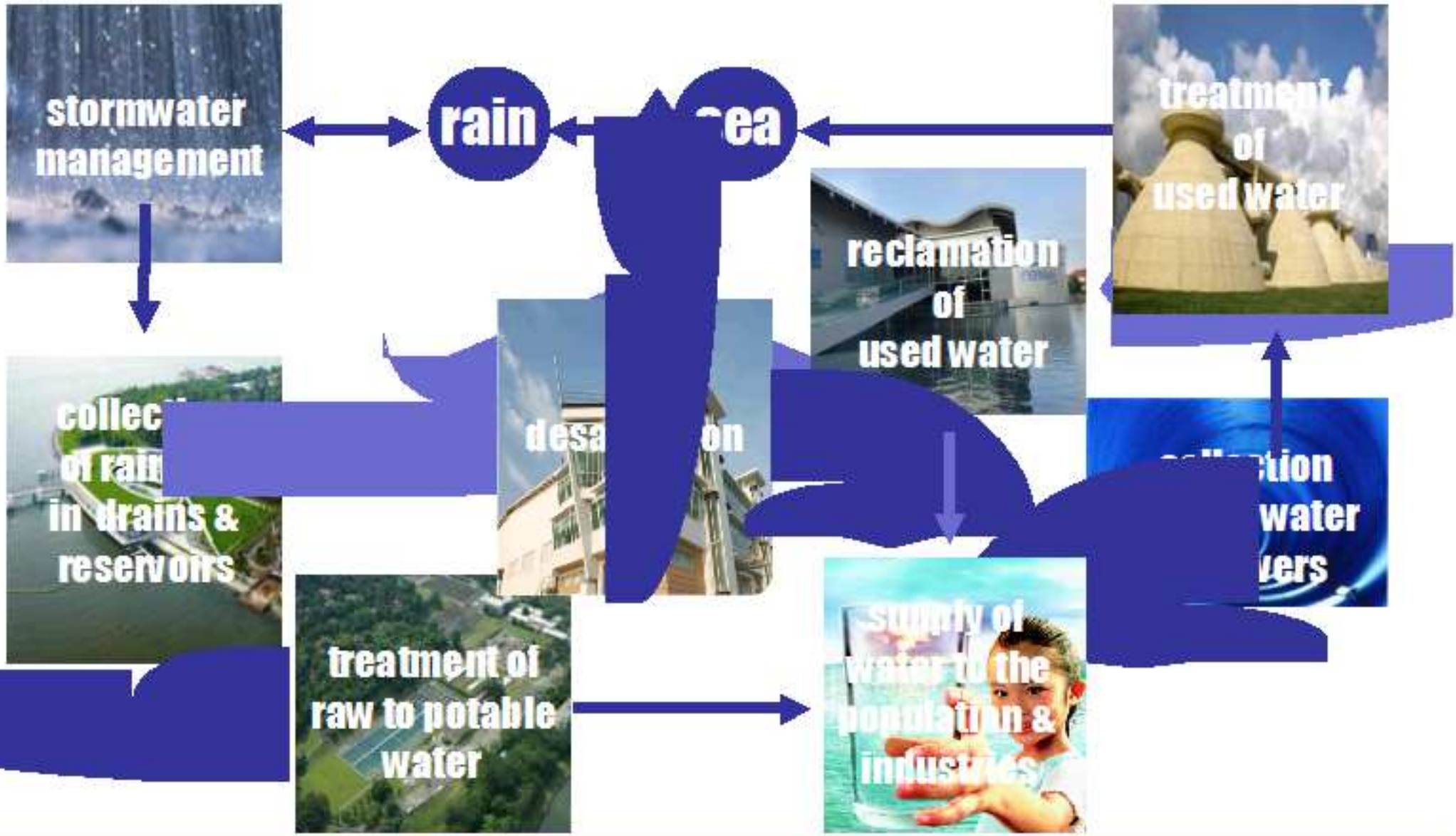
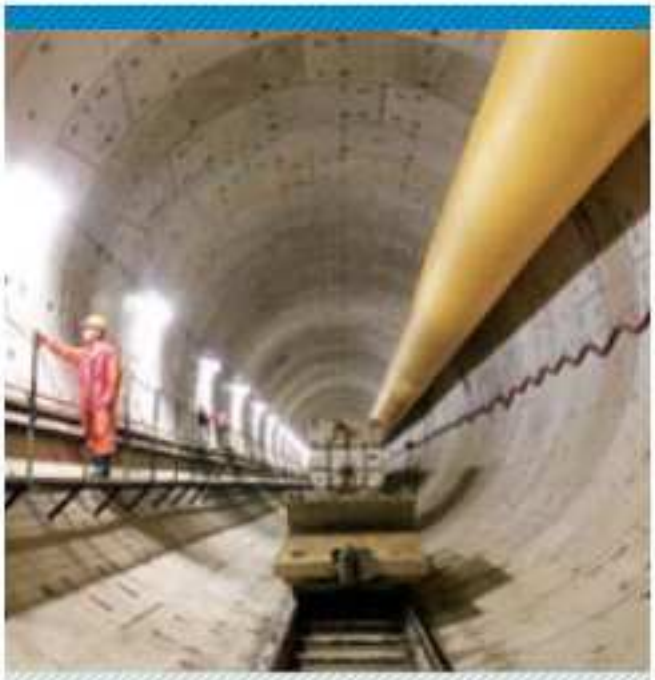
Managing water cycle as a whole



Principles for sustainable water supply

to collect every drop of rain that falls on Singapore



to collect every drop of used water

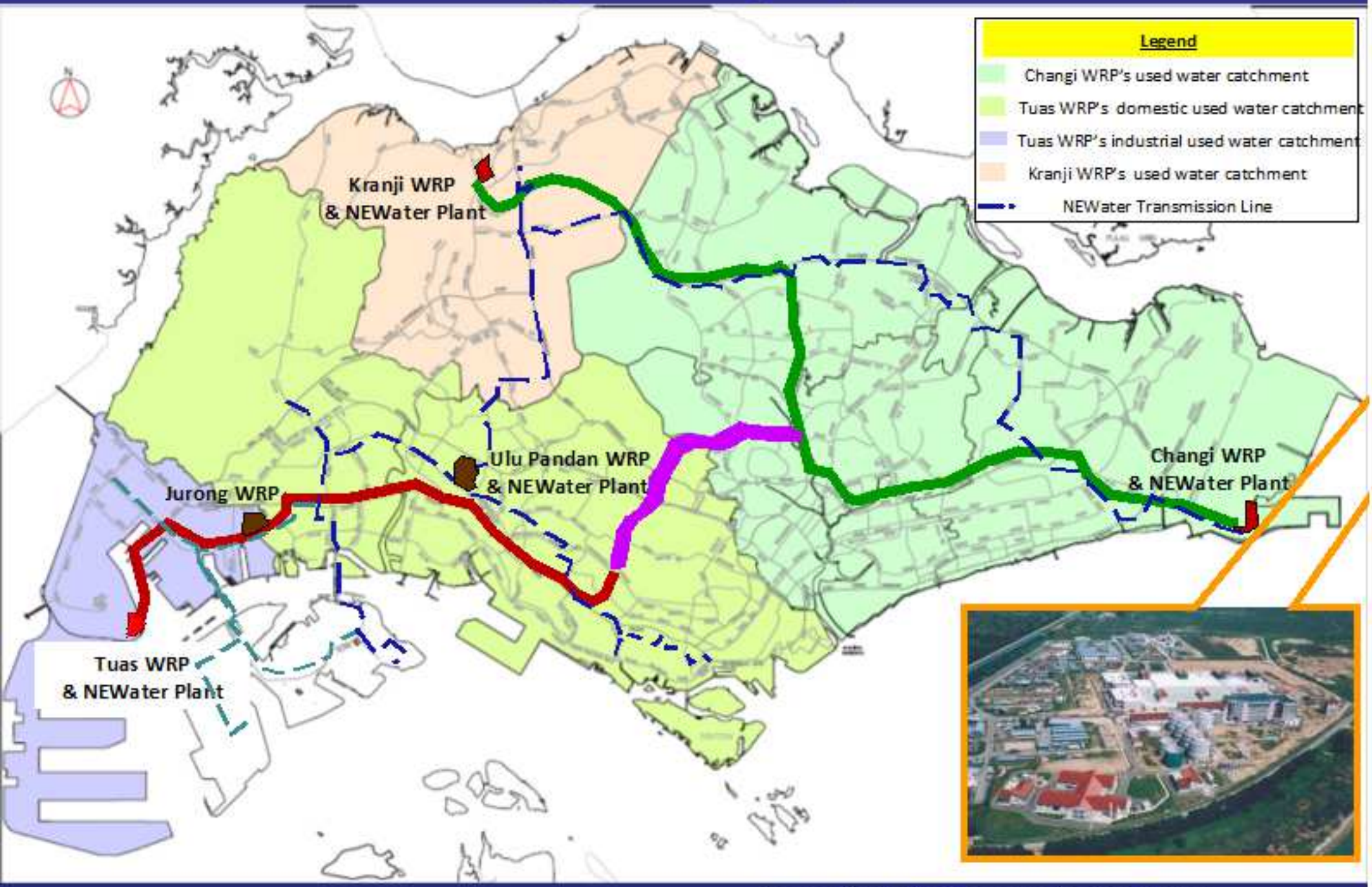
to recycle every drop of water more than once

Collecting Every Drop

Water Catchment Map

- **Two-thirds of Singapore** is already water catchment with **17 reservoirs**

Collecting Back Every Drop Used



Re-Use Every Drop of Water More Than Once - NEWater

Generate New Drops - Desalinated Water

- Desalination Plants by Hyflux
- PPP approach:
  - 25 year contracts
  - Optimises technology configuration

Benefits and Challenges

NEWater – High grade recycled water

- Better suited for industrial use for semicon, boiler, ultrapure facilities, etc.
- No need RO process at factory end
- Less replacement for boiler water
- IPU – drought resilient

Desalinated Seawater

- Infinite source
- Drought resilient

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“Water for All”

3P Approach

“Conserve Water”

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“Conserve, Value, Enjoy”

“Conserve, Value and Enjoy”

“Conserve Water”

“Value Our Water”

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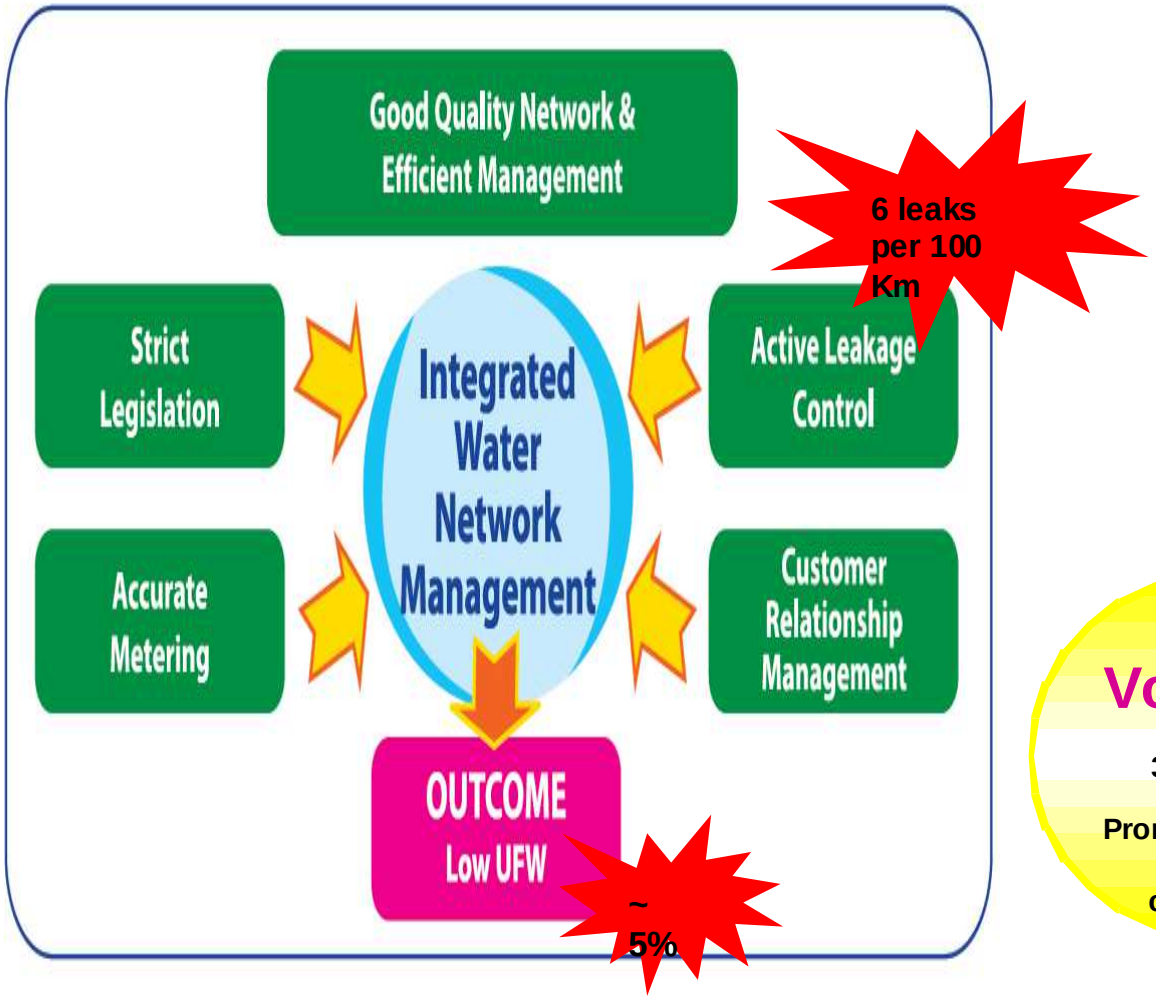
NEWater Visitor Centre

Marina Barrage

Activities in Reservoirs and

Water Demand Management

UFW Control via Integrated Network Management



Water Conservation

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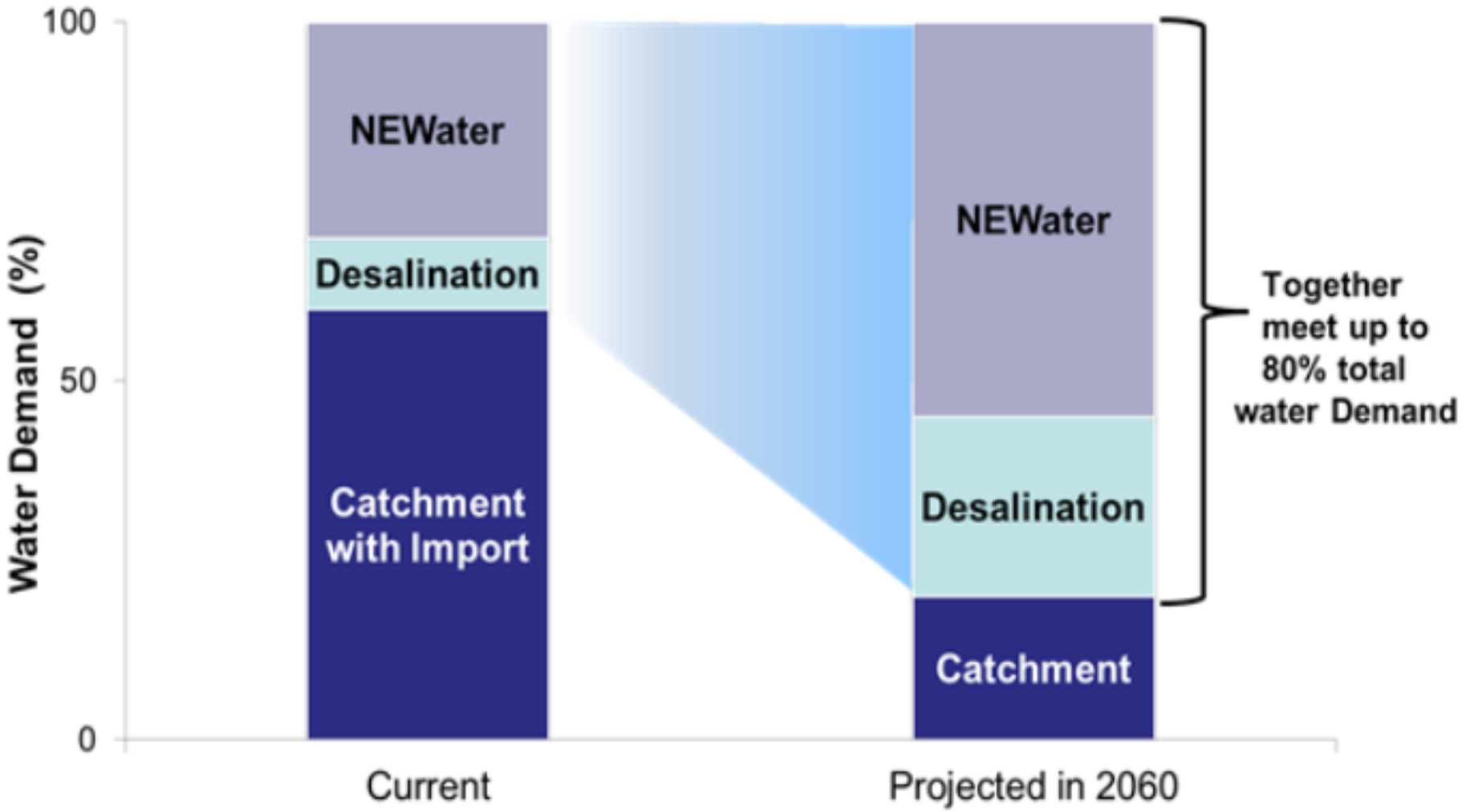
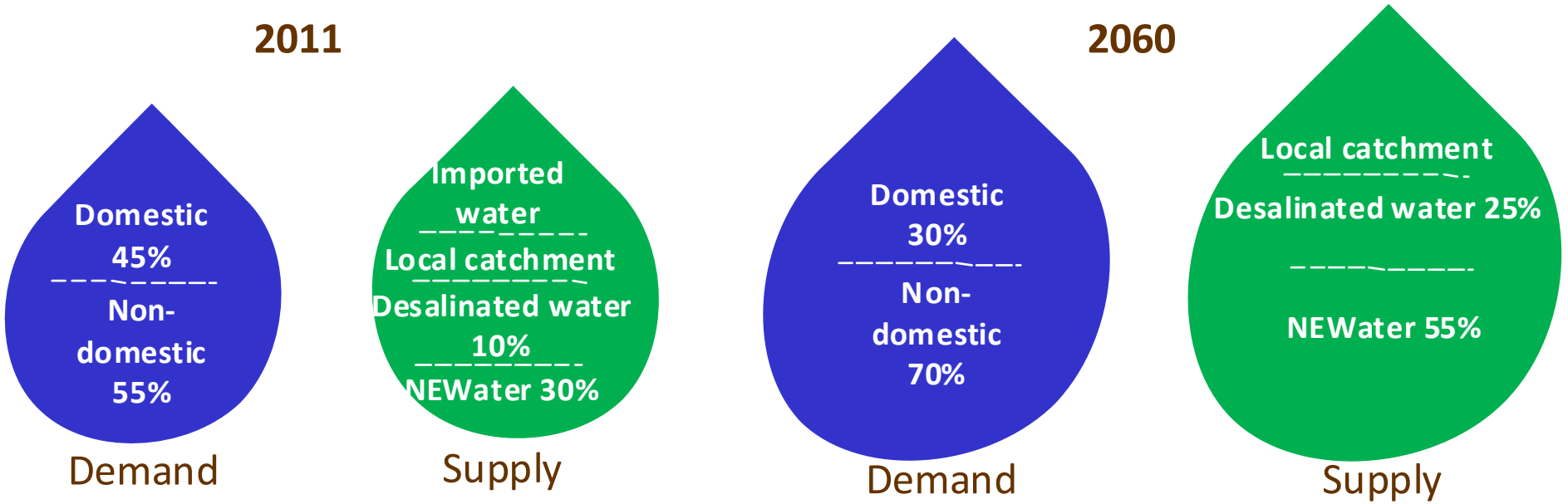
Projected composition of water demand in 2060



Singapore Water Challenges



Projected Water demand in 2060 = 2 x Water demand in 2011

Leveraging on Research & Technology

Systematic investment in research and technology has helped secure water supply sustainability for Singapore.

NEWater

Reclaimed water for industrial and indirect potable use to close the water loop

Membranes

Large-scale use of membrane for water production

Desalination

PPP approach to seawater desalination

Deep Tunnel Sewerage System

Awarded 'Water Project of the Year' at Global Water Awards 2009 in Zurich, Switzerland

Marina Barrage

First reservoir in the city with 3-in-1 function which will also supply more than 10% of Singapore's water demand

Desalination Technology Roadmap

Improving Energy Efficiency

Current ~ 3.5 kWh/m3

Variable Salinity Plant: 1.7 kWh/m3

Membrane Distillation: 1.0 kWh/m3 (with waste heat)

Electrochemical Desalting: 1.5 kWh/m3

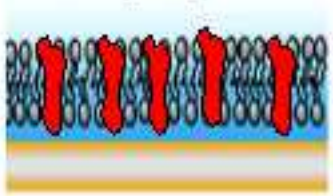
Short-term ≤ 1.5 kWh/m3

Breakthrough R&D

Long- term ≤ 1 kWh/m3

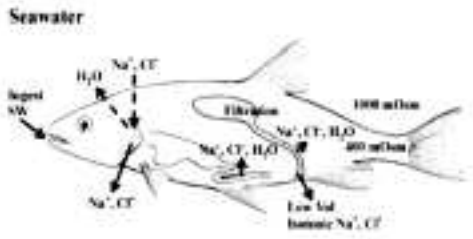
Systems approach with breakthrough technologies

Aquaporins

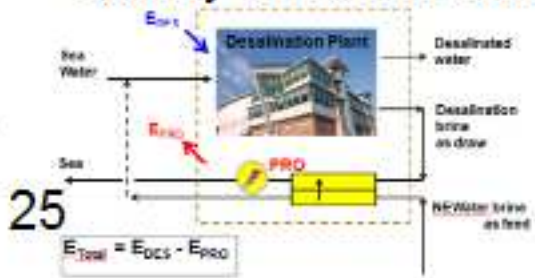


Mangrove

Euryhaline Fish



Salinity Gradient Power



SWRO: Seawater Reverse Osmosis

Summary of ED Development

Project Start
Matching EWI Grant
Singapore + USA

White Paper

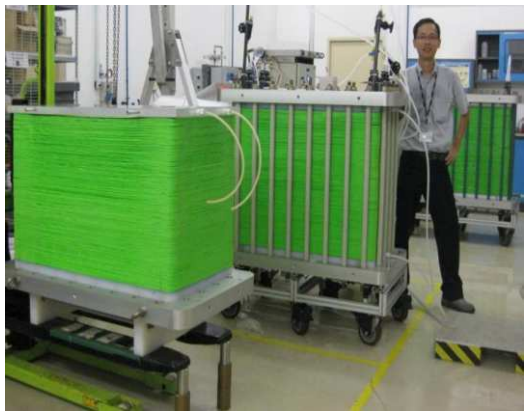
Prototype ED

Beta 3

85% Membrane Utilisation
6 x Lower Footprint
Molded commercial components
Automation in assembly

Oct 2007 | Oct 2008 | Oct 2009 | Oct 2010 | Oct 2011 | Oct 2012 | 2014

Lab ED

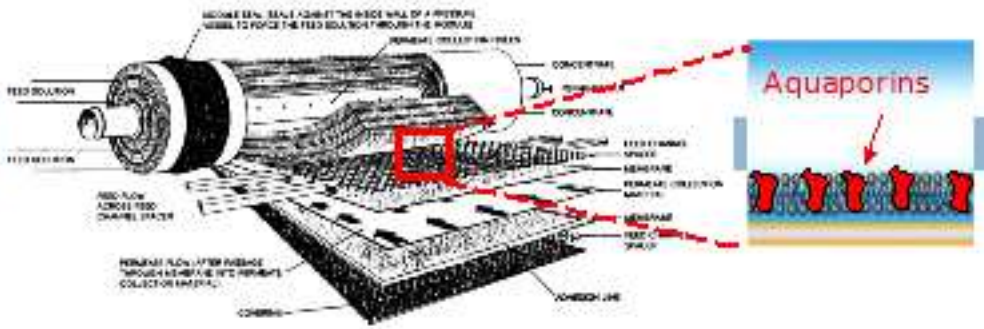


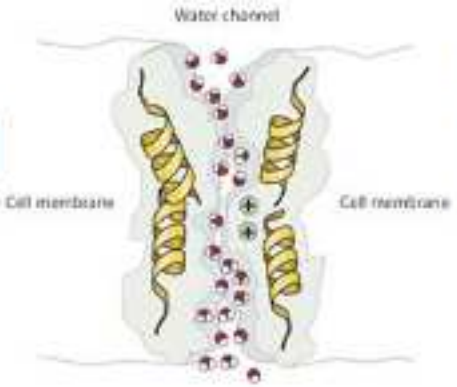
EWI Demo

Commercial ED Design

Prepare for the Future

Biomimetic Membranes: Low Energy Desalination

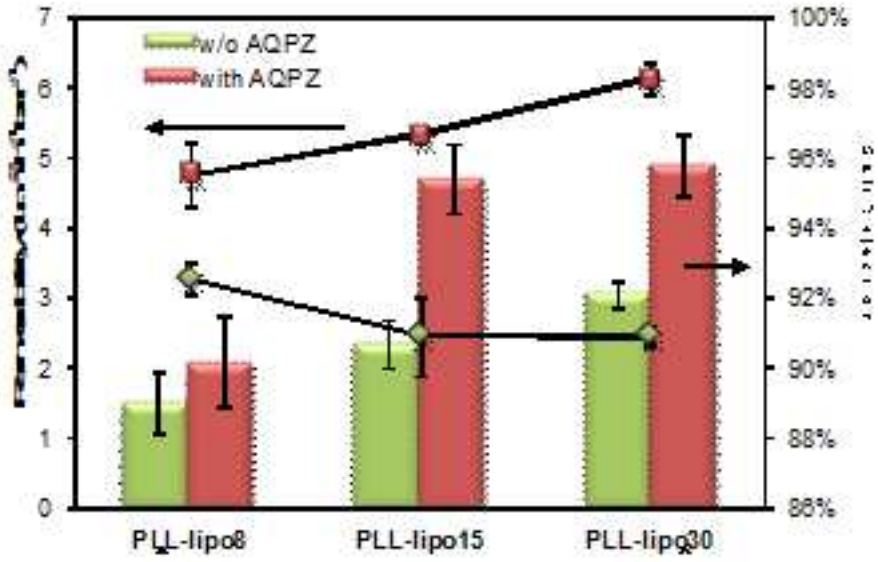




Aquaporins

- ✓ High water flux
- ✓ Quantitative rejection of Na+ and Cl- ions

Technology core: **Aquaporins** (*water channels proteins with selective functions*): Found through cell walls of living things and serve to selectively transport water molecules across cell membrane wall. Other small molecules are restricted by narrow channels and electrochemical properties.



Aquaporin Inside™ Technology: Impregnation of aquaporins into p
p
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Biomimetic desalination

Successful embedment of the aquaporin proteins onto FS polymer membranes, leading to better membrane performance: ***Higher water permeability (>200% higher than commercial NF and ~40% higher than commercial brackish water RO) with comparable salt rejection of 95-97%.***

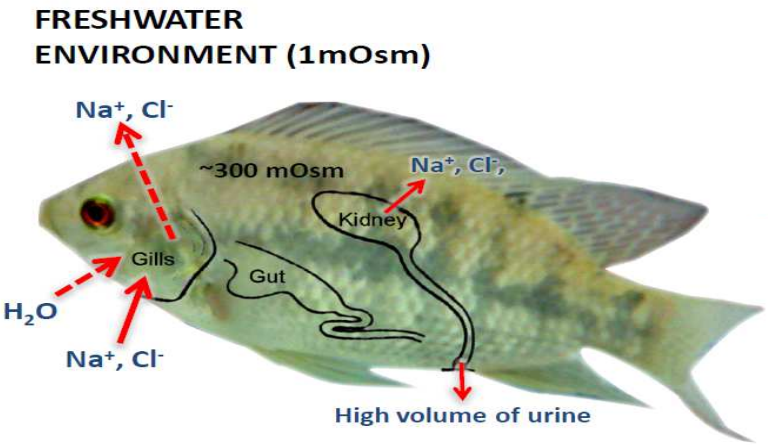
Biomimicry Research

Objective: To identify proteins and genes responsible for the desalting mechanism, and to express/replicate the salt pumps, aquaporins and ion-channels/transporters.

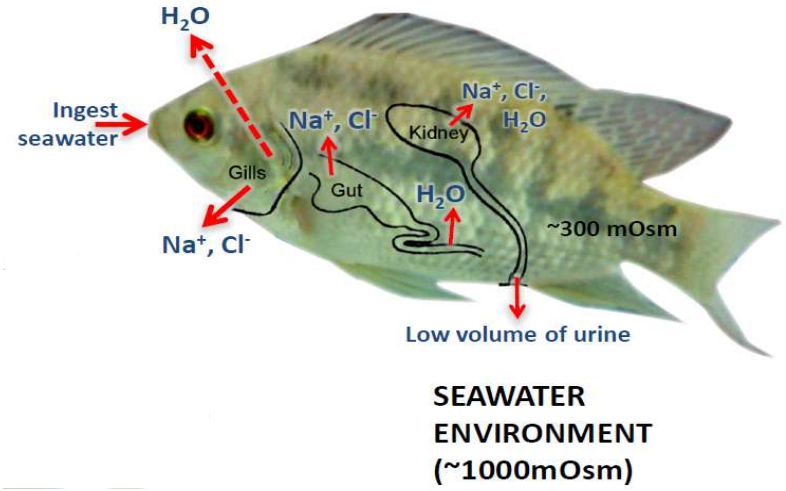
1. Molecular and structural characterization of the desalination mechanisms in euryhaline fish (tilapia and climbing perch) for the mimicry of seawater desalination.

1. Desalination in Mangrove Plants: Mechanistic Study of the Salt Gland and its Implications.

Cellular Remodelling of Euryhaline Fish

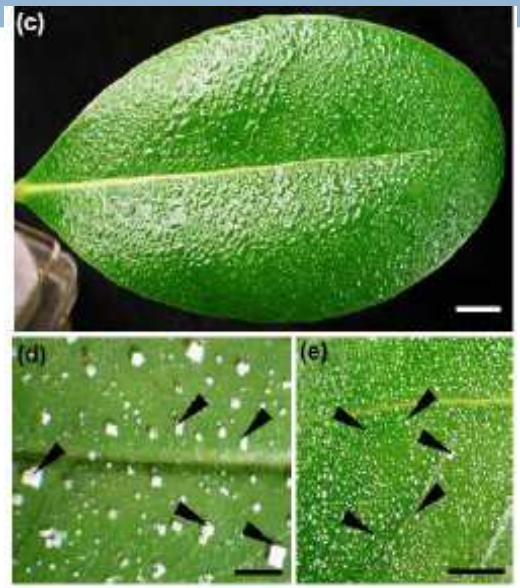


Under different salinity environments, cellular remodelling occurs. This change in cell types results in a change in the expression of genes and proteins in the fish.



Desalination Mechanisms of Mangroves

1. Salt secretion in leaves



Major ions secreted from the leaf surfaces of *Avicennia officinalis* were similar to that of seawater.

2. Salt filtration in roots

Water for All
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Thank You

Stockholm Industry Water Award 2007

SINGAPORE QUALITY AWARD for business excellence 2006 WINNER

INNOVATION EXCELLENCE AWARD 2006 WINNER