Using Dynamic Adaptive Policy Pathways and hydrological modelling to co-create water resource adaptation policies for climate change

A practical example for southern Portugal

Institutions:

Ciências ULisboa
FCiências.ID
CCIAM Centre for Climate Change Impacts Adaptation & Modelling
cE3c centre for ecology, evolution and environmental changes
IRD Institut de Recherche pour le Développement FRANCE
AMAL Comunidade Intermunicipal do Algarve

Funding:

PORTUGAL 2020 POSEUR
POCH PROGRAMA OPERACIONAL POTENCIAL HUMANO
EUROPEAN UNION
Cohesion Fund
European Social Fund
FCT Fundação para a Ciência e a Tecnologia
IF INVESTIGADOR FCT

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Sciences – University of **LISBON** – Portugal

Presentation Summary

Co-creating water resource adaptation policies for climate change in southern Portugal

Introduction

Water is a scarce resource in the Algarve, southern Portugal

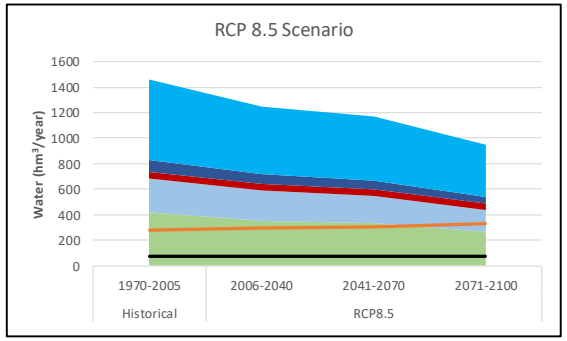
- Essential for irrigated agriculture (2/3^{rds} use)
- Essential for population and tourism (1/3rd use)
- Current demands are 43% of available resources
  severe water stress

The climate is dry and is getting drier

- Recurrent droughts already create scarcity and water use conflicts
- Climate change should worsen this problem

What are the best solutions to adapt to drought under current and future climate?

Climate Change Impacts and Adaptation Options



Water availability

- Groundwater
- Reservoirs
- Wastewater
- Planned reservoirs
- Undammed streams

Water demand

- Municipal supply
- Irrigation

Water Exploitation Index

<20%	No Stress	20-40%	Moderate Stress
40-70%	Severe Stress	>70%	Scarcity

Adaptation solution	Water Exploitation Index in 2100 (RCP 8.5)	Joint assessment by stakeholders and researchers
TARGET	43%	Decided by stakeholders: keep WEI at current levels
None	78%	Water scarcity – not acceptable
1) Improve Water Use Efficiency	74%	Region is already drought aware; irrigation is efficient
2) 1 + Decrease Irrigation Needs	~~53%~~	Already tried in the past; not socially acceptable
3) 1 + Wastewater recycling	66%	Not much wastewater to recycle; costly to distribute
4) 3 + Build new reservoirs	60%	The best places for dams already have them
5) 4 + Landscape water retention	Scalable until ~45%	Improve traditional water conservation; many small-scale works
6) Desalination	Scalable until <20%	Costly and energy-intensive now, but this could go down in time

Algarve Climate Change Adaptation Plan

Led by **Stakeholders**

- Funded by local governments
- + water utilities, farmer associations…
- Define the scope of the problem
- Assess the feasibility of solutions

Developed by **Researchers**

- Climatologists, hydrologists, sociologists…
- Calculate the potential impacts of climate change
- Assess the effectiveness of solutions

Climaaa
Plano Intermunicipal Adaptação às Alterações Climáticas do Algarve

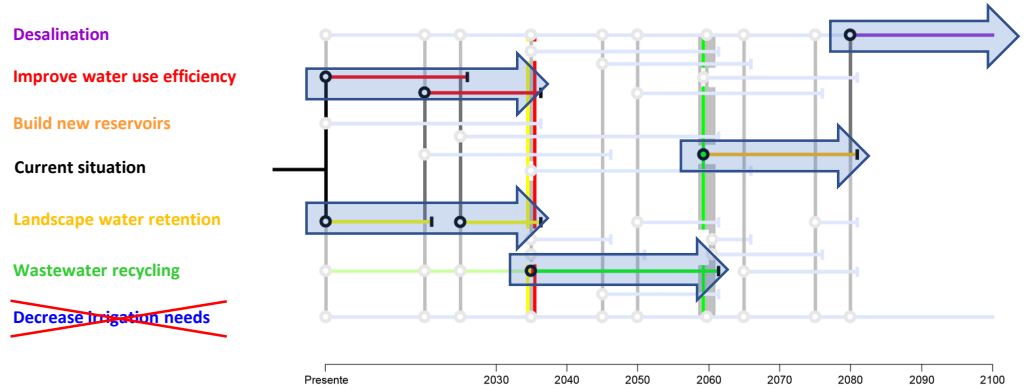
www.climaaa.com

AMAL Comunidade Intermunicipal do Algarve
Ciências ULisboa

Co-created during joint discussions

- Joint assessment of adaptation options
- Adaptation timeline using DAPPs

Making an Adaptation Plan with Dynamic Adaptive Policy Pathways



DAPP for RCP 8.5

ADAPTATION MEASURES

Near future:
Improve water use efficiency
Landscape water retention

Mid-term: Wastewater recycling

Long-term: Build new reservoirs

If all else fails: Desalination

Do not decrease irrigation needs
-> further social debate required

Climate change in southern Portugal – the Algarve

- The Algarve is **especially vulnerable** to climate change
  - Climate is already dry; water resources in severe water stress
  - Climate change should significantly worsen these conditions
  - Adapting water resources to these scenarios is a top concern

- Climaaa: climate change adaptation plan for the Algarve
  - Contracted by **AMAL** – Algarve Intermunicipal Community
  - Multi-stakeholder approach to design an adaptation plan
  - **Researchers**: hydrologists, social scientists
  - **Local government**: politicians, technicians
  - **Other stakeholders**: farmers, water utilities

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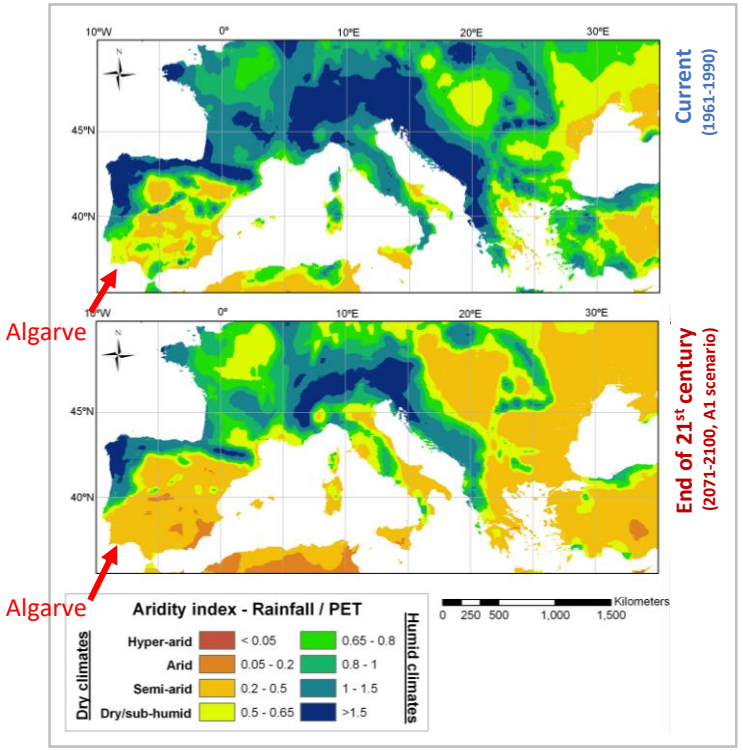

Nunes 2008
(PhD thesis: NOVA University of Lisbon)

Impacts of climate change on climatic aridity in southern Europe
Top: present day
Bottom: end of 21st century

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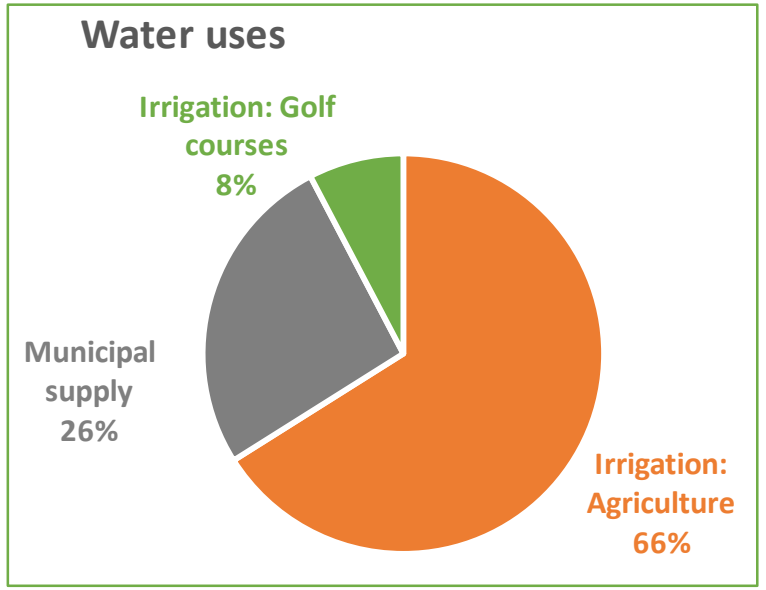
Water resources in the Algarve today

- Dry climate with recurrent droughts
- Available water resources:
  - Intermittent rivers with torrential flow, with dams in the largest
  - Large and productive coastal aquifers, some are contaminated
- Water requirements:
  - Irrigation: orange trees: ~2/3rd
  - Domestic use and tourism: ~1/3rd
- Water requirements are 43% of available resources
  - Threshold of severe water stress



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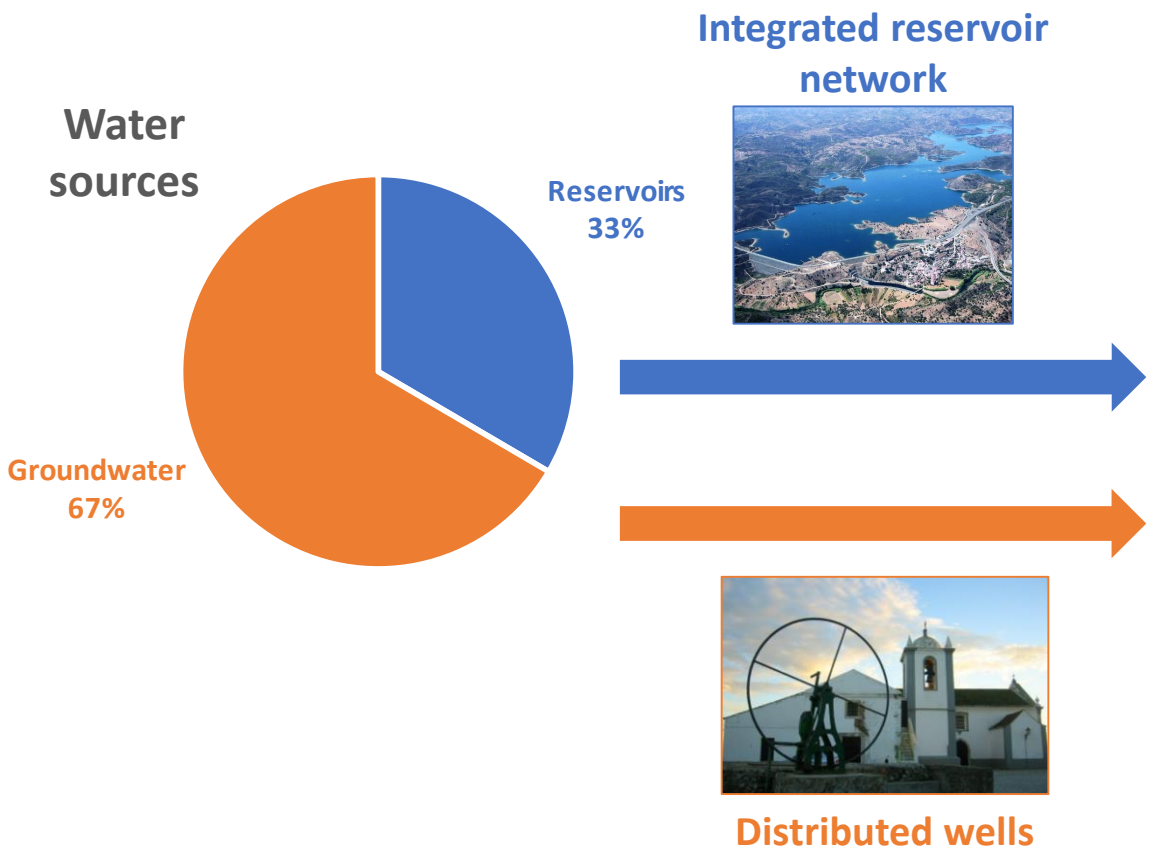
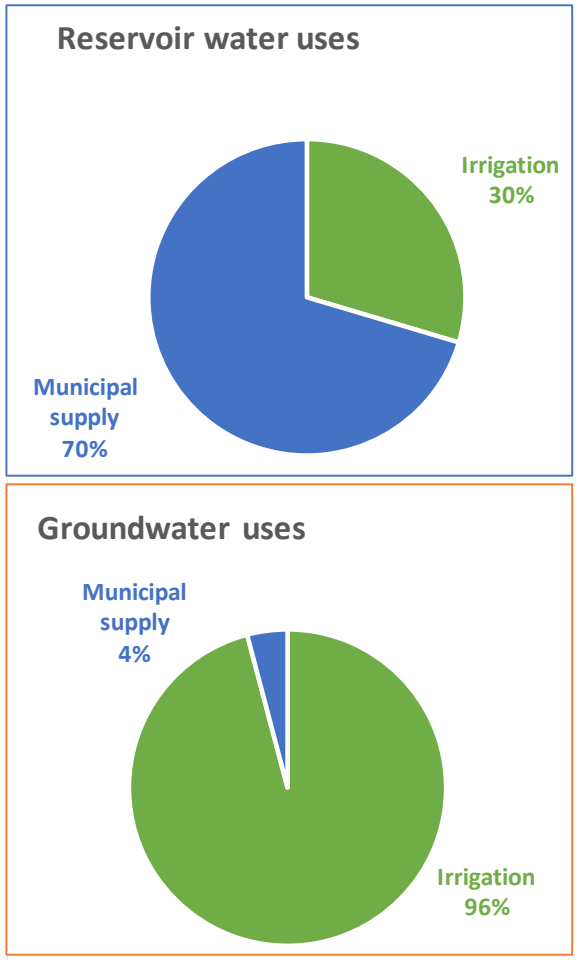
Water supply network in the Algarve





Reservoirs:

- Interconnected network
- Municipal supply
- Water for public, large-scale irrigation networks

Wells:

- Distributed over multiple aquifers
- Water for private, small-scale irrigation networks
- Municipal supply reserve in case of extreme drought

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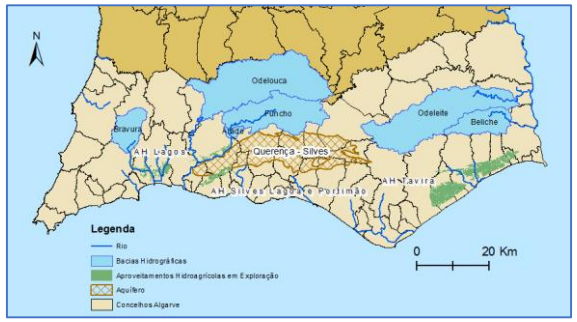
Methods: modelling climate change impacts

1. Hydrological modelling of major water assets

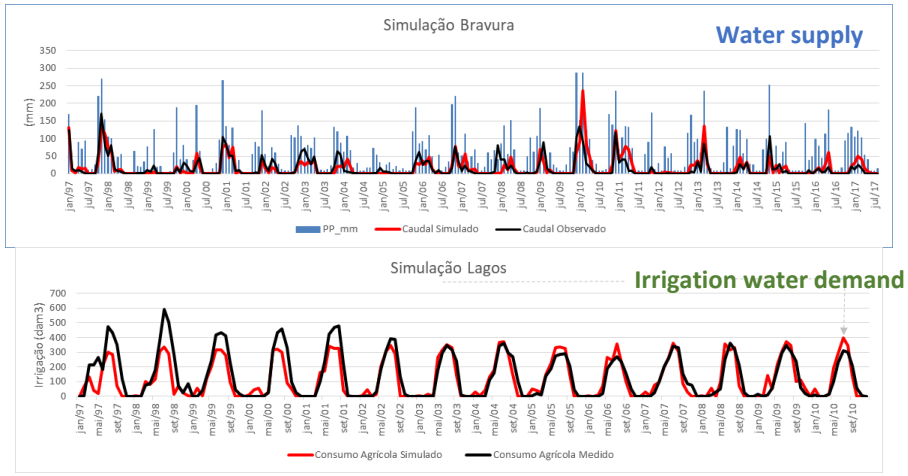


- 6 main reservoirs
- 1 major aquifer
- 3 main irrigation perimeters

- Simple water balance modelling

Stigter et al 2014
(Reg Environ Change 14)

Model calibration:



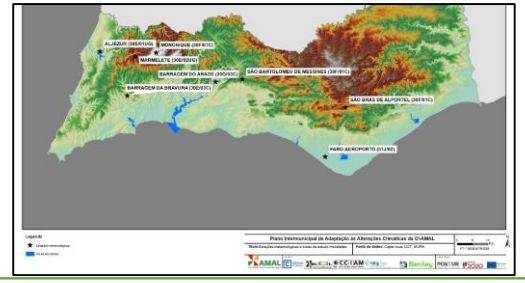
2. Hydrological modelling of future vulnerabilities

- Model the impacts of future climate scenarios
- Multiple CORDEX models
- RCP 4.5 and RCP 8.5 until 2100

- Impacts on water supplies
- Impacts on irrigation demands

3. Extrapolation for the Algarve

- Based on water availability and requirements per land-use
- Test adaptation options where feasible: new reservoirs, changes to crops…



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Methods: selecting adaptation solutions

Stakeholders

- Municipal technicians
- Water utilities
- Regional water authorities
- Farmer associations
- Business associations
- Environmentalists

- Can assess present-day vulnerabilities
- Can estimate feasibility and social acceptability of adaptation solutions

Iterative solution analysis

Interaction 1: initial engagement

Researchers present the "big picture" and main climate change impacts

Stakeholders determine the main water resource vulnerabilities to impacts

Researchers model climate change impacts

Interaction 2: major impacts

Researchers present climate change impacts on main vulnerabilities

Stakeholders propose adaptation solutions for these impacts

Researchers model proposed solutions

Interaction 3: selecting adaptation solutions

Researchers present effectiveness of solutions and propose alternatives

Select the best solutions

Most effective
Lowest economic and social costs
Dynamic Adaptive Policy Pathways

Researchers

- Hydrologists
- Climatologists
- Geographers
- Economists
- Anthropologists

- Can predict climate change impacts
- Can assess effectiveness of adaptation solutions

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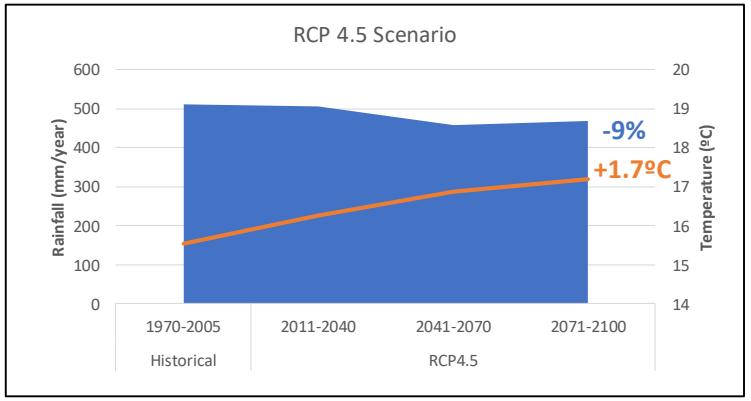
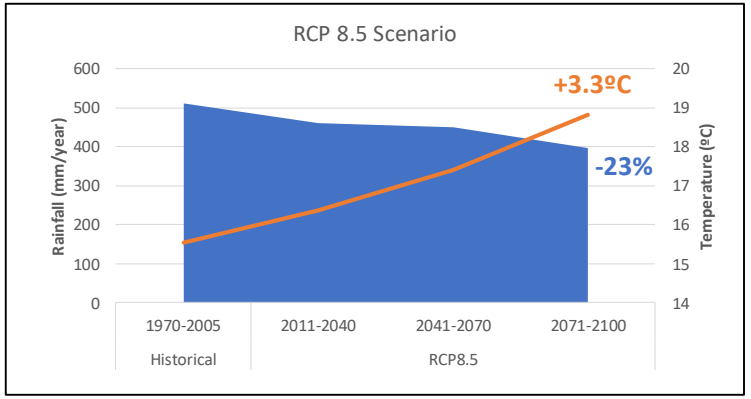
Results: climate change impacts on water resources

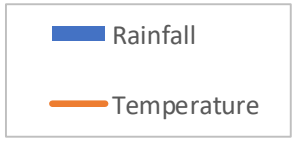
Evolution from the 1970s until the end of the 21st century

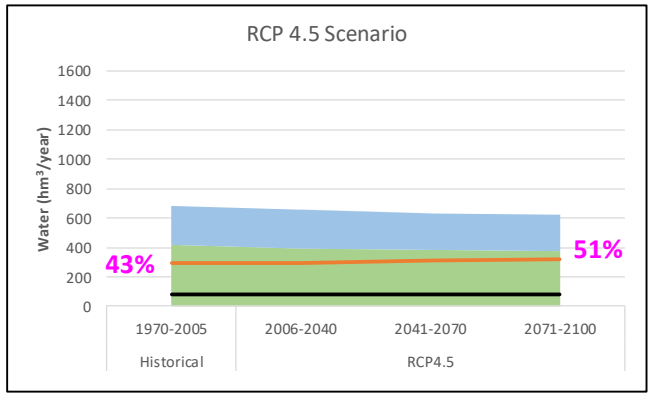
- Average 30-year annual rainfall and temperature
- Median of predictions by 11 Regional Climate Models (CORDEX)

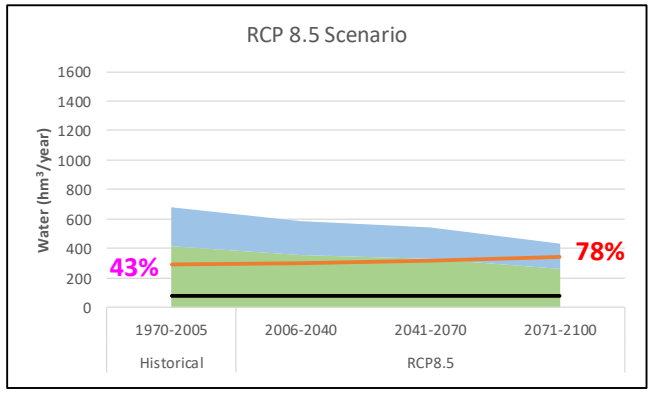




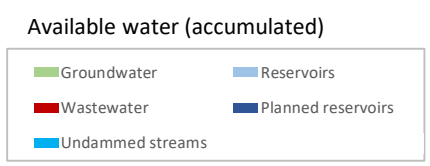
Climate scenarios

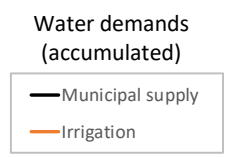






- Average 30-year annual water availability and demands
- Numbers show Water Exploitation Index
- Median of 11 hydrological model runs, one per Regional Climate Model





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Co-creating water resource adaptation policies for climate change in southern Portugal

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Adaptation options: decrease consumption

Evolution from the 1970s until the end of the 21st century

Improve water use efficiency

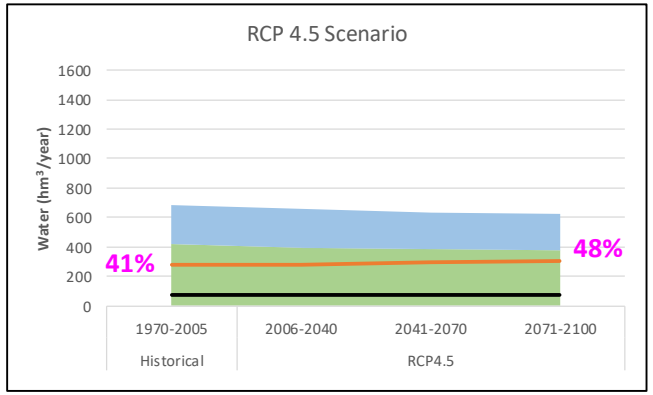
Stakeholder proposal:

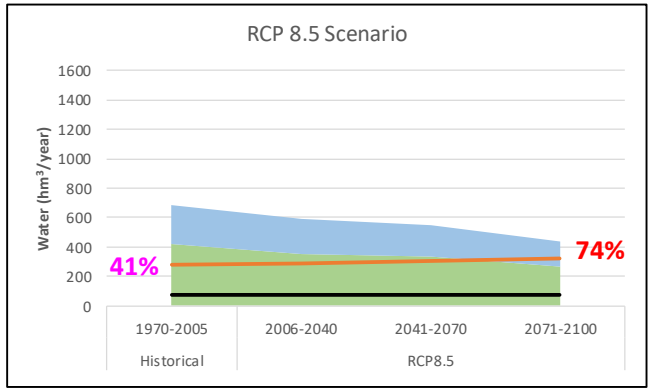
- Distribution systems have losses
- Water use is excessive for requirements
- Promotes personal responsibility of the public
- Best use of existing resources: efficient and morally correct

Effectiveness analysis:

- The 2005 drought led to large improvements in water use efficiency, largely unreported

- Little room for improvement: 5% less water use
  - Transmission losses: 10-15%
  - Best practices already used in irrigation
  - Population is drought-aware





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- Numbers show Water Exploitation Index
- Extrapolated from hydrological model runs

Available water (accumulated)

Groundwater | Reservoirs
Wastewater | Planned reservoirs
Undammed streams

Water demands (accumulated)

Municipal supply
Irrigation

Water Exploitation Index

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Decrease irrigation use

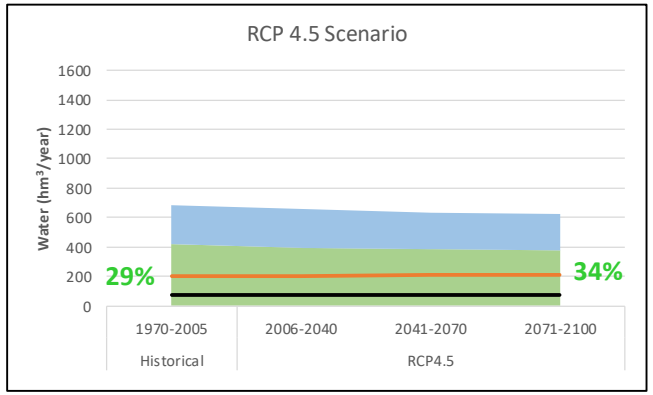
Researcher proposal:

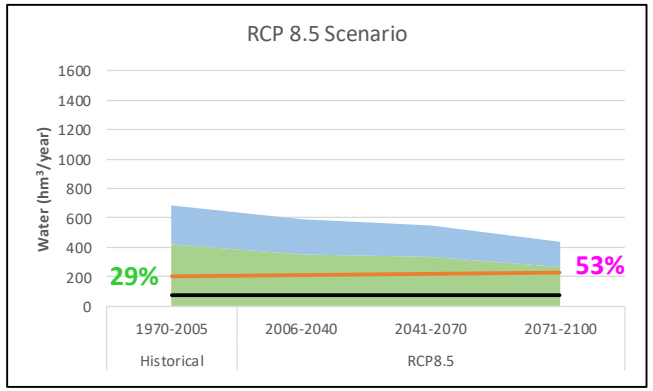
- Currently irrigated crops – orange trees – are not drought adapted and consume a lot of water
- Replace with traditional crops: almond trees, olive trees, carob trees…

- Large improvement: 30-40% less water use

Feasibility analysis:

- Solution already tested in the past
- Replacement crops would be less profitable
- Political issue: cut water from local farmers to supply tourism (municipal use)?
- Not socially feasible





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Adaptation options: technology

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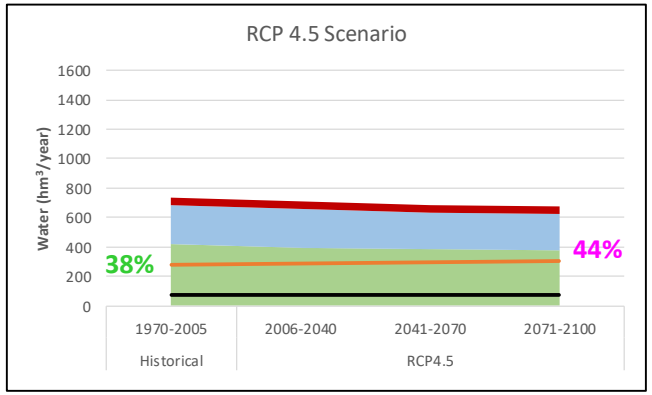
Wastewater recycling

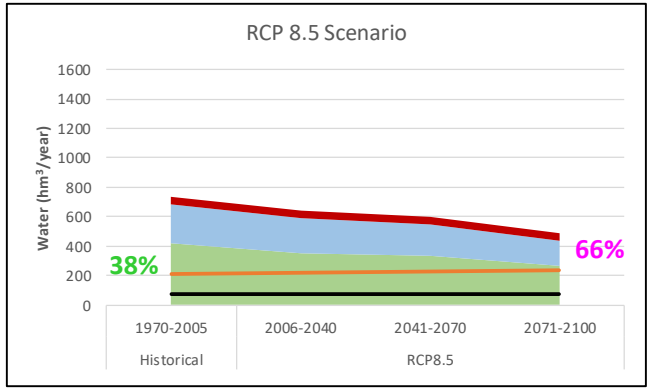
Stakeholder proposal:

- Fashionable, but with a lot of negative issues
- Available wastewater is small compared with water requirements
- Coastal wastewater treatment plans: would require new distribution networks

Effectiveness analysis:

- Agree on all points
- Small improvement: 8-12% more water





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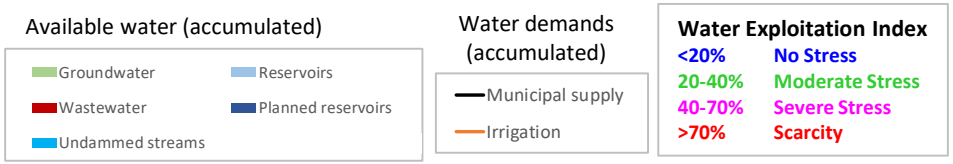

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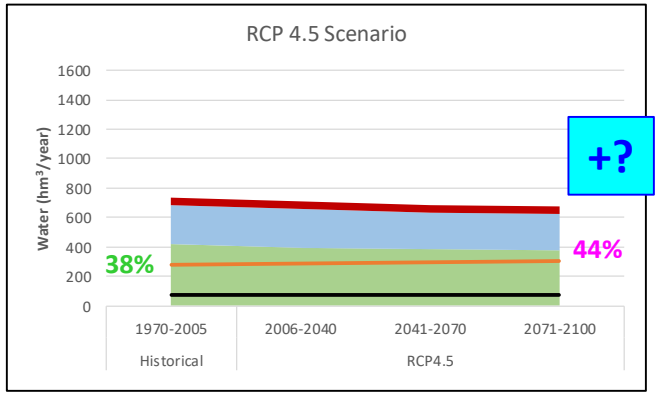
Desalination

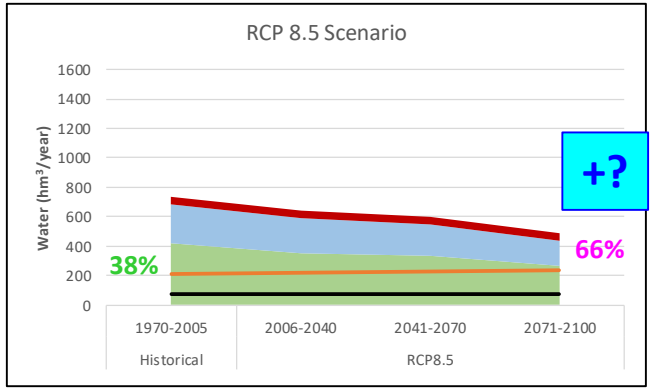
Researcher proposal:

- Good conditions: coastal area, solar energy
- High costs/impacts but very large supply
- Can solve the problem
  - Can supply all current water needs

Feasibility analysis:

- Agreed on effectiveness
- Large-scale work would be difficult to implement, politically
- Time will decrease costs and impacts
- Re-assess in the future, if all else fails





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Adaptation options: increase water collection

Evolution from the 1970s until the end of the 21st century

Build new reservoirs

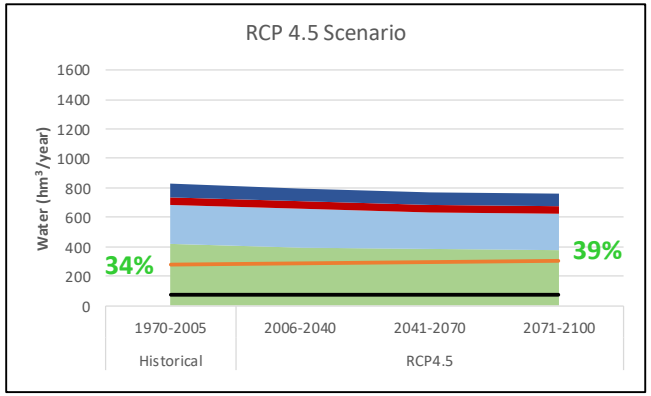
Stakeholder proposal:

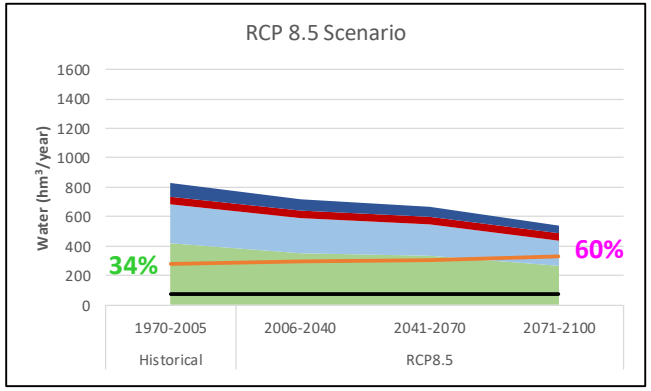
- Reservoirs have increased available water resources in recent years – proven solution
- Many streams are still undammed

Effectiveness analysis:

- Most large streams are dammed
- Remaining rivers: too small, too flat, over porous bedrock…
- Only one feasible site remains for a new dam

- Small improvement: 12-14% more water





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Landscape water retention

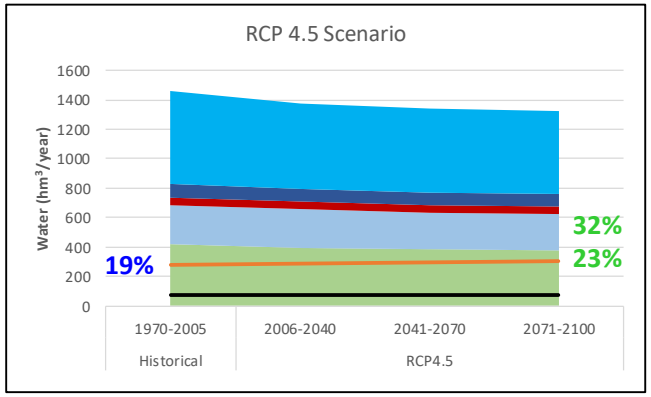
Researcher proposal:

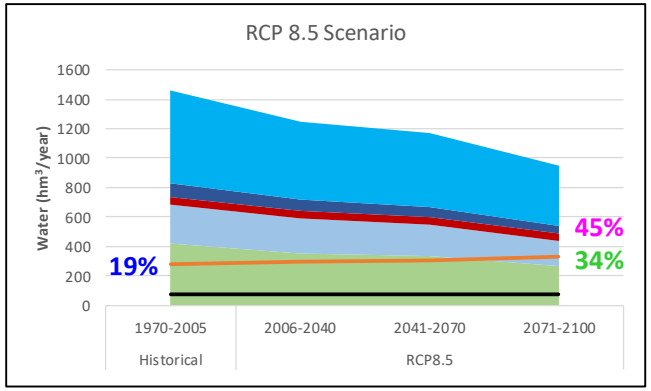
- Promote infiltration and aquifer recharge
- Spatially distributed: many small works
- Traditional approaches improved by technology

- Moderate improvement: at least 20% more water

Feasibility analysis:

- An improvements on traditional methods: politically easier to implement
- Small works: scalable, easy to adjust to funding and effectiveness
- Best short-term solution





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Likely WEI
Best possible WEI

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Methods: DAAP – Dynamic Adaptive Policy Pathways

- DAAP: a method to
  - Identify an **adaptation objective** and select possible **adaptation measures**
  - Determine the effectiveness of each measure – how long will it work to maintain the objective?
  - Identify "tipping points" when one measure becomes insufficient and new ones must be adopted
  - Order measures sequentially in time, adopting a new one after each "tipping point"

Hasnoot et al 2013
(Global Env Change 23)

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Desalination

Improve water use efficiency

Build new reservoirs

Current situation

Landscape water retention

Wastewater recycling

Decrease irrigation needs

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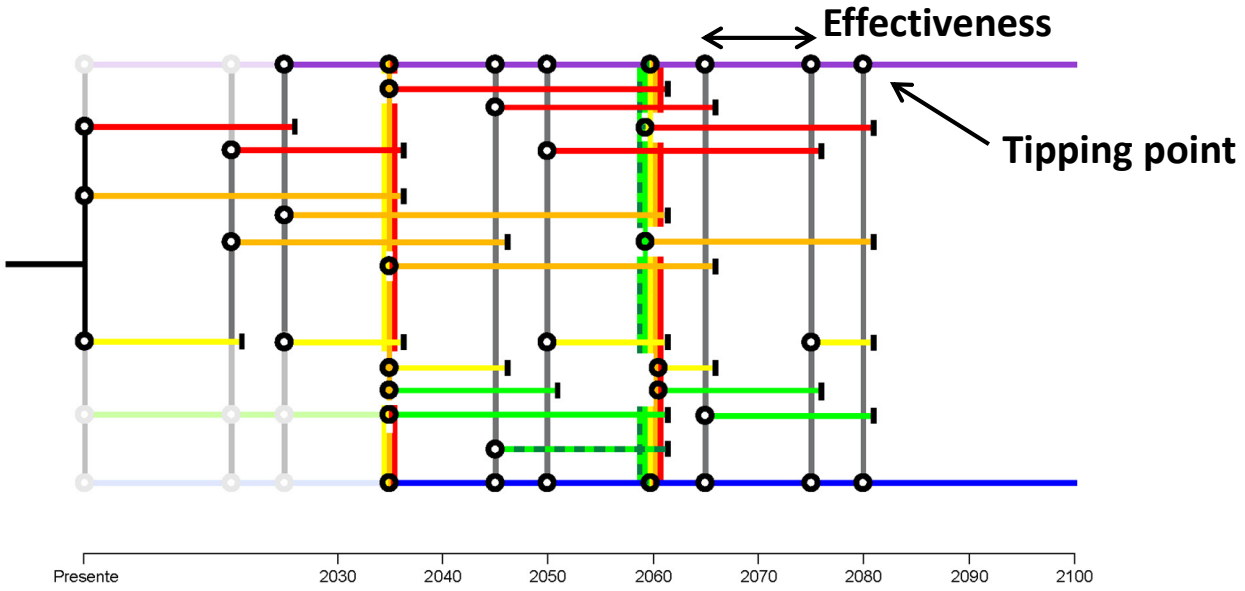
(Global Env Change 23)

DAPP
for
RCP 8.5



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Methods: DAAP – Dynamic Adaptive Policy Pathways

- DAAP: a method to
  - Identify an **adaptation objective** and select possible **adaptation measures**
  - Determine the effectiveness of each measure – how long will it work to maintain the objective?
  - Identify "tipping points" when one measure becomes insufficient and new ones must be adopted
  - Order measures sequentially in time, adopting a new one after each "tipping point"

Hasnoot et al 2013
(Global Env Change 23)

DAPP
for
RCP 8.5

Desalination

Improve water use efficiency

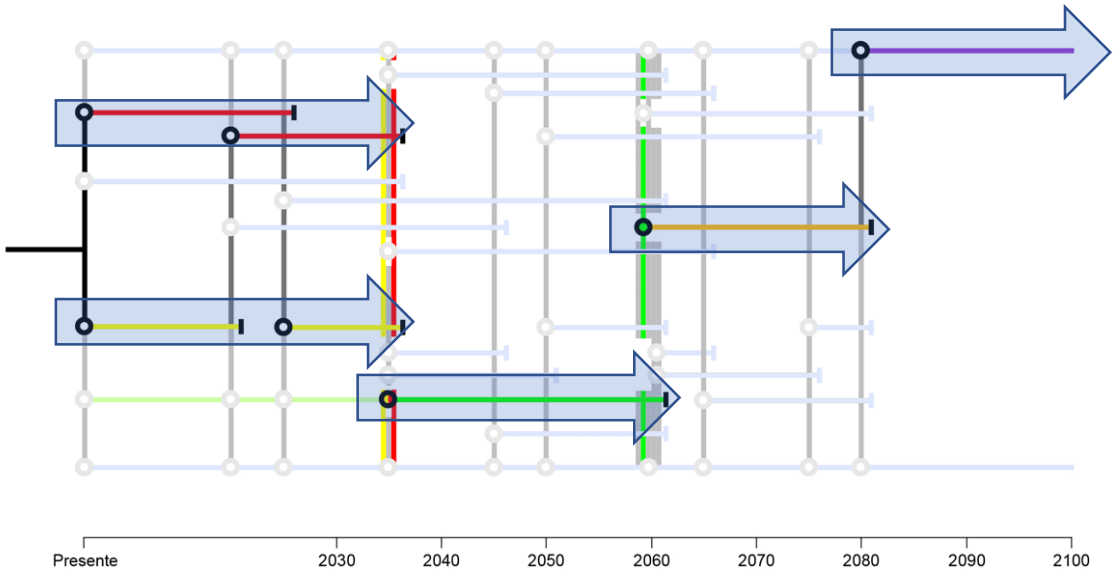
Build new reservoirs

Current situation

Landscape water retention

Wastewater recycling

~~**Decrease irrigation needs**~~



Near future:
Improve water use efficiency
Landscape water retention

Mid-term: Wastewater recycling

Long-term: Build new reservoirs

If all else fails: Desalination

Do not decrease irrigation needs
-> further social debate required

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Conclusions

- Water resources in southern Portugal are vulnerable to a future drier climate
- Several adaptation options have different efficiencies and costs: resources, environmental, social…
- Adaptation solutions can be build from the interaction between researchers and stakeholders
  - Researchers: quantify impacts and solution effectiveness
  - Stakeholders: decide adaptation goals, assess solution feasibility
- Another advantage: stakeholder buy-in will help the implementation of the Algarve climate change adaptation plan

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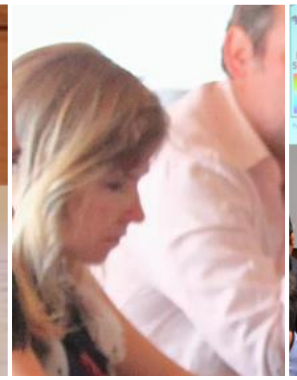
Thank you for your attention!



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