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Monetizing the impacts of climate change on river uses towards effective adaptation strategies

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Climate trends in Italy

- The drought trend in South Europe (Mediterranean)
- In particular, in Italy a 14% decrease in precipitation, between 1951 and 1996, has been reported throughout the country
- According to IPCC scenarios and especially under A2 scenario, a drop in precipitation is predicted for the near future (2031-2060)
- An approximate 10% decrease in precipitation is anticipated for the northern part and 20% decrease in the southern part

Objectives

- Economic impacts of climate change on different services of the Piave River in Treviso, Italy
- Willingness to pay for adaptation interventions to climate change
- Cost Benefit Analysis to evaluate costs against the estimated benefits
- Guide policy making towards efficient adaptation strategies

Case Study

- The Piave River basin
- The study site is located at the southern foothills of the eastern Dolomiti's region at the province of Treviso (Pederobba municipality)
- It is anticipated a reduction of precipitation about 0.5 mm / day towards the end of the century for the broader region
- The recharge of the study aquifer will be affected showing at least 10% of recharge reduction, by the end of the century

Deterioration of the services provided from the Piave River

Piave River main uses

- Irrigation of 1000 ha of the plain area
- Rafting in efficient river flow 7 months per year
- Electricity production of $17*10^3$ MWh per year
- Good ecological state of the Piave River (2000/60/EU)

Climate change pressures on the Piave River uses

20% Anticipated decrease of river discharge

- Irrigation: 30% reduction in the irrigated area
- Rafting: dropped to 4 months
- Electricity: 25% decrease in the production
- Ecological state: The decrease in water provision will degrade the ecological state

River uses and their alterations as a Choice Experiment matrix

Attribute	Levels
Attr1: Irrigated Area (in hectares)	700, 900, 1000
Attr2: Rafting period (in months)	4, 6, 7
Attr3: Electricity production (percentage decrease)	25%, 10%, 0%
Attr4: Ecological state	poor, fair, good
Price: Monthly payment for 10 years	0, 2€, 5€, 10€, 15€, 20€

Survey-Design

- 8 verions of 6 choice sets each plus a hold out task
- Face to face interviews to the resindents of Pederobba municipality
- 300 complete questionnaires, 12% opt outs
- Utility function: $U_{nit} = \beta_j ASC_j + \beta_{Ir}\ IrrigationArea_{nit} + \beta_{Raf}\ RaftingPeriod_{nit} + \beta_{EI}\ ElectricityProduction_{nit} + \beta_{EC}\ EcologicalStatus_{nit} + \beta_P\ Price_{nit} + \varepsilon_{nit}$

Econometric Simulation

Conditional Logit Model

Variable	CL Model
Irrigation area	0.1085***(0.0254)
Rafting period	-0.0631*(0.0254)
Hydroelectricity production	0.0231***(0.0031)
Ecological state	0.5789***(0.0407)
Price	-0.0429***(0.0056)
ASC	0.4476***(0.1167)
Summary statistics	
Log-Likelihood	-1662.481
R^2	0.1593
AIC	3336.962
BIC	1688.263
Observations	5400
Sample Size	300

Note: standard errors in parentheses *:p<0.1,**:p<0.05 and ***:p<0.01

All river attributes are significant determinants of choice

Econometric Simulation

Random Parameter Logit Model

Variable	RPL Model
Irrigation area	0.2874**(0.1416)
Rafting period	-0.386**(0.1822)
Hydroelectricity production	0.0842**(0.0334)
Ecological state	2.070***(0.7907)
Price	-0.1476***(0.0570)
ASC	1.5906**(0.6833)
Standard deviations parameters	
σ(Irrigation)	1.7244**(0.7067)
σ(Rafting Period)	1.7836**(0.7278)
σ(Electr. Production)	0.0136 (0.0963)
σ(Ecological State)	2.4162**(1.1815)
Summary statistics	
Log-Likelihood	-1646.863
R^2	0.1672
AIC	3313.726
BIC	1689.834
Observations	5400
Sample Size	300

Note: standard errors in parentheses *:p<0.1,**:p<0.05 and ***:p<0.01

Interacted Random Parameters Logit Model

Variable	Extended RPL model
Irrigation area	0.18***(0.0639)
Rafting period	-0.207***(0.0796)
Hydroelectricity production	0.0482***(0.0128)
Ecological state	0.8799***(0.2641)
Price	-0.087***(0.0221)
ASC	1.4714**(0.6494)
Additional variables interacted	
Age*ASC	-0.024***(0.0083)
Sex*ASC	1.1707***(0.3037)
River*ASC	0.2429*(0.1242)
Inf*ASC	1.0415***(0.3013)
Futur*ASC	-0.6046***(0.2245)
Inc*ECST	0.0788*(0.0422)
Standard deviations parameters	
σ(Irrigation)	0.9146***(0.2879)
σ(Rafting Period)	0.9255***(0.2999)
σ(Electr. Production)	0.0048 (0.0355)
σ(Ecological State)	1.2447***(0.4553)
Summary statistics	
Log-Likelihood	-1616.799
R^2	0.1824
AIC	3265.568
BIC	1682.552
Observations	5400
Sample Size	300

Welfare Analysis

- Marginal WTP for the Choice Experiment attributes

$$WTP = -\frac{\beta_j}{\beta^{Pr}}$$

Attribute	CL model	RPL model	Extended RPL model
Irrigation area	2.53 €	1.95 €	2.07 €
Rafting period	-1.47 €	-2.61 €	-2.38 €
Hydroelectricity production	0.54 €	0.57 €	0.55 €
Ecological state	13.51 €	14.02 €	10.11 €

- Compensating surplus $CV = -\frac{1}{\beta^{Pr}}(V^1 - V^0)$

-Scenario 0: the 'do-nothing' case

-Scenario 1: moderate adaptation policy

-Scenario 2: strong adaptation policy

Scenario	RPL model	Extended RPL model
Scenario 1	32 €/month	33 €/month
Scenario 2	51 €/month	50 €/month

Alternative Adaptation Scenarios

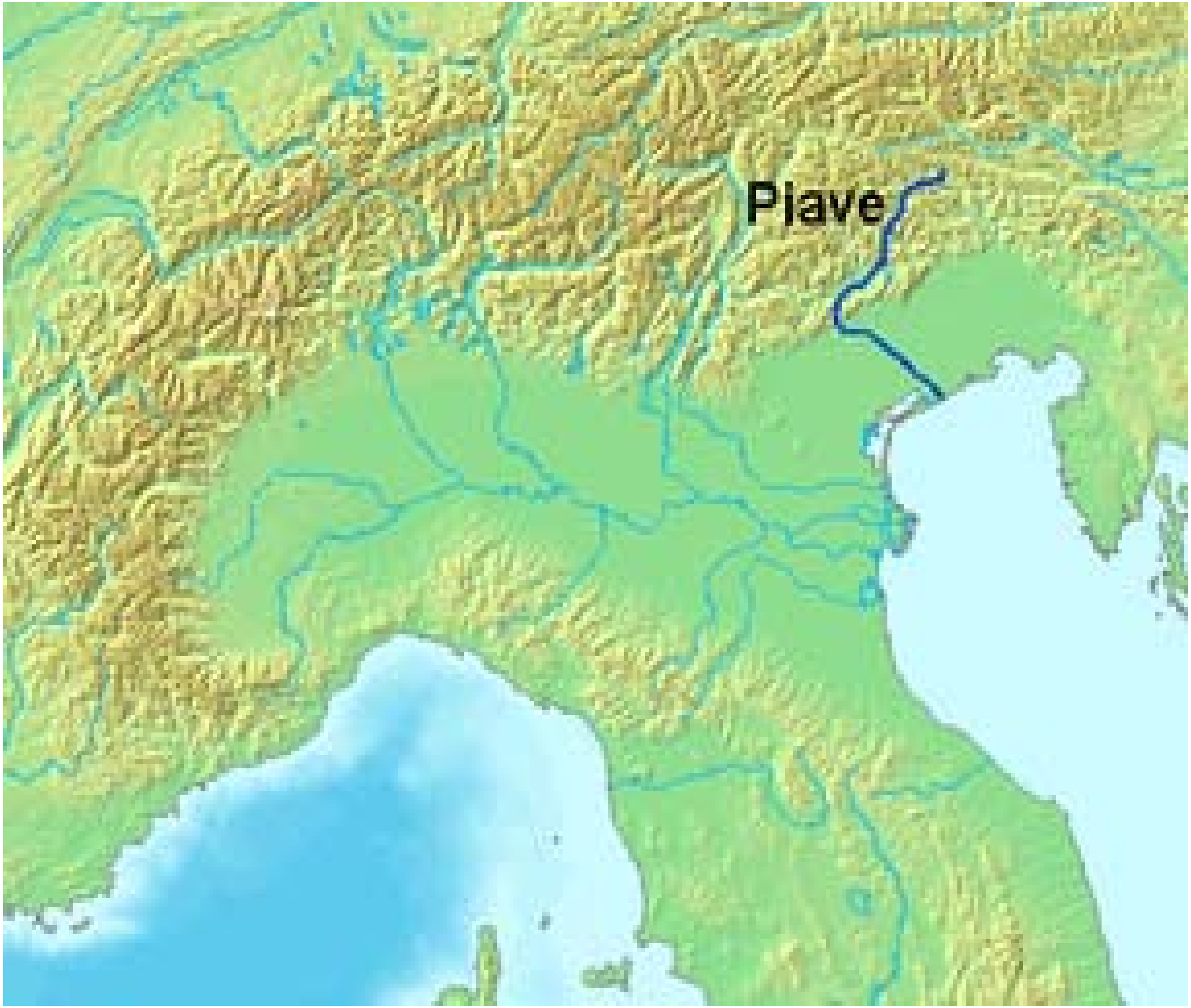
	Do Nothing	Moderate Adaptation	Strong Adaptation
Irrigated Area	700 ha	900 ha	1000 ha
Rafting period (in months)	4 months	6 months	7 months
Electricity production	Decrease by 25%	Decrease by 10%	No decrease
Ecological state	poor	fair	good

Policy Implications

- Deterioration of the river services leads to utility losses
- The 'Ecological state' among the river attributes was ranked high
- The negative sign of 'Rafting activity'
- Respondents are willing to pay to move away from the 'do-nothing' situation
- Individual related characteristics and heterogeneity influence choice preferences

This approach will help mountainous communities to integrate strategies towards adaptation

Thank you for your attention!



The economic model

- The theory of utility maximization (Adamowicz et al., 1998)
- Lancaster theory of value
  - Goods are made up of attributes
  - Part-worths / Part utilities
  - Choices are determined by particular combinations of product attributes
- Utility function $U_{jn} = U(x_{jn}, p_{jn}, Z)$

$$(j \mid C) = U_{jn} > U_{in}$$

The econometric model

- Random utility theory
  - Deterministic part
  - Stochastic part

$U_{jn} = V_{jn} + \varepsilon_{jn}$

Prob (j | C) = Prob ($U_{jn} > U_{in}$) $\Rightarrow$

Prob ($V_{jn}+\varepsilon_{jn} > V_{in}+\varepsilon_{in}$) $\Rightarrow$

Prob ($V_{jn}-V_{in} > \varepsilon_{jn}-\varepsilon_{in}$)

Logit models: Modelling the relation between a choice and many parameters

Hausman Test for IIA

Sample	Statistic	Significance level
Without alternative A	59.95	0.0000
Without alternative B	73.94	0.0000

Violation of the Independence of Irrelevant Alternatives condition