Integrated Climate Risk Assessment in Agriculture & Food - Trade M

Parallel Session

Economics in modelling climate change

Chair: Floor Brouwer

The economic impact of changes in climate variability on milk production in the area of Grana Padano

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Thursday 9th April 2015

Objectives…

…of our work

to assess the ECONOMIC impact of Climate Change (CC) at short medium term on dairy cattle farms of **Grana Padano** (GP) region

HOW

MULTIDISCIPILINAR APPROACH:
integration of Climatological, Livestock, Agronomic and Economic modelling.

FARM-SCALE resolution, with projecion of modeling results at REGIONAL scale, based on territorial representativeness of sample farms.

…of this presentation

to present the approach, the area, the model and its main results …… with some weakness we are working on

Climate Variability in the Economic Modelling

Meteorological Variability is intrinsic in each climate, with different *states of nature* that may occur both in Present and in Future climate. CC modifies representative values and probability of these *states*, affecting achievable economic results

A **Discrete Stochastic Programming** model represents management choices in the GP area at **representative dairy farms level ,** under the uncertainty conditions generated by this variability (Dono et al., 2013)

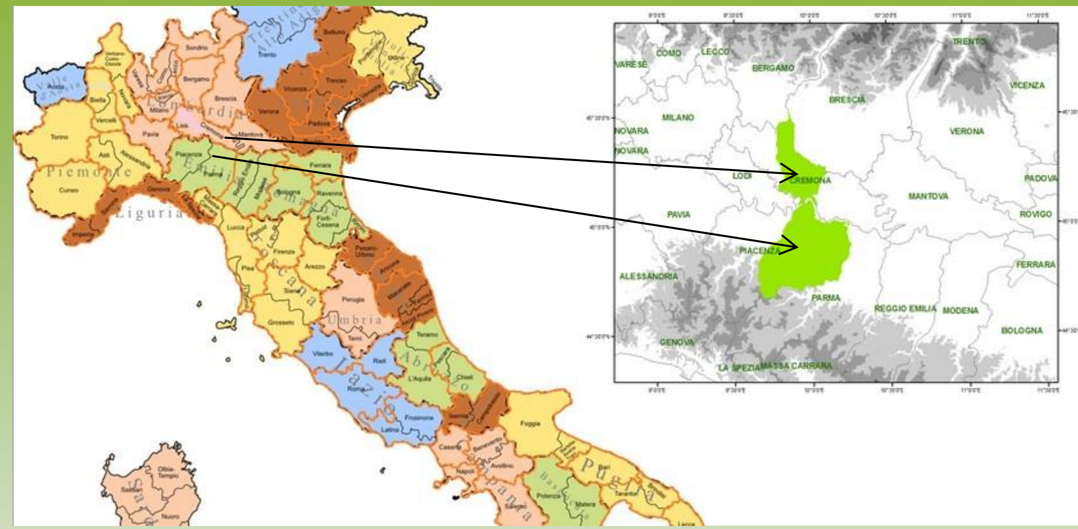
Uncertainty affects yields and water needs of crops, and nutritional needs of cattle: these can be managed by farmers through **Corrective Actions (CA)**, like additional water pumping and feed purchasing.

Impacts on milk productivity and quality traits are also considered, but cannot be mitigated by CA.

Study area

- Po Valley
  (Northern Italy)

6,868 dairy farms, producing PDO milk in the 13 Provinces where GP is produced



- 2 Provinces (NUTS3) as representative of the entire GP area
  - Cremona
  - Piacenza

→ 24% of GP produced in 2014 (CLAL, 2015)

where 1,014 dairy farms operate

Source: ISTAT 2010, 6 th Agricultural Census

Main differences:

- Structure and productive dimension
- Productivity

Tab.2: Weighted averages of productivity indicators

	Cremona	Piacenza
LUs × UAA^{-1}	3.3	2.8
Milk (t) × LU^{-1}	5.1	3.8
LEUs × LU^{-1}	70.9	46.0
Income per LEUf (.000 €)*	155.6	63.6
Return On Equity (ROE) (%)**	6.3	6.5

* Compensating Farm-owned capital at 1.5 % rate

** Remunerating L.E.f. with 32.500 €×$Year^{-1}$

More intensive cropping schemes and breeding techniques in Cremona than in Piacenza

Tab.1: Weighted averages of representative farms charachteristics

	Cremona	Piacenza
Utilized Agricultural Area (UAA, Ha)	90.5	46.1
For farm re-use (Ha)	*78.8*	*85.7*
% alfa-alfa	*18.7*	*39.9*
% silage maize	*62.2*	*27.8*
% grain crops	*6.7*	*14.8*
Livestock Units (LUs)	298	129
Annual milk production (tons)	1,509	495
Equity (.000 €)	4,261	1,194
Labour Employ Units (LEUs, 2200 h×y^{-1})	4.2	2.8
Family Labour (LEUf)	*39.3*	*69.4*
Revenues from sales (.000 €)	1,080	333
% from milk sale	*61.4*	*69.6*
% CAP contribution	*6.8*	*7.7*
Gross Income (.000 €)	506	163
Net Income (.000 €)	321	141

Climatological datasets

a. Regional Atmospheric Modelling System simulates local climate at DAILY time-scale for:

2000-2010 → Present scenario (Ps)

2020-2030 → Future scenario (Fs)

b. 2 synthetic time series of 150 years each are generated with WXGEN

Livestock modelling relevance
- Air Temperature (T_{min}, T_{mean}, T_{max})
- Relative Humidity (RH_{min}, RH_{mean}, RH_{max})
- Wind Speed (WS_{mean})

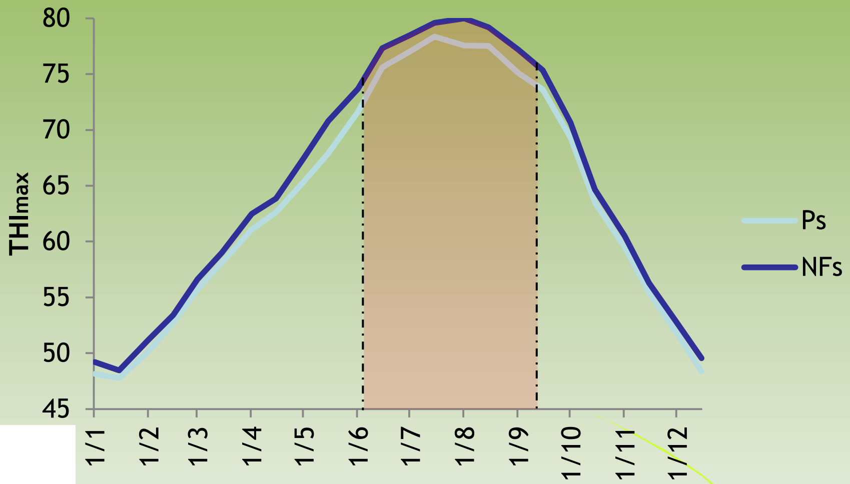
Agronomic modelling relevance
- Daily precipitation
- Net Radiation

c. THI_{max}, ET_n, crop yield, irrigation needs are computed

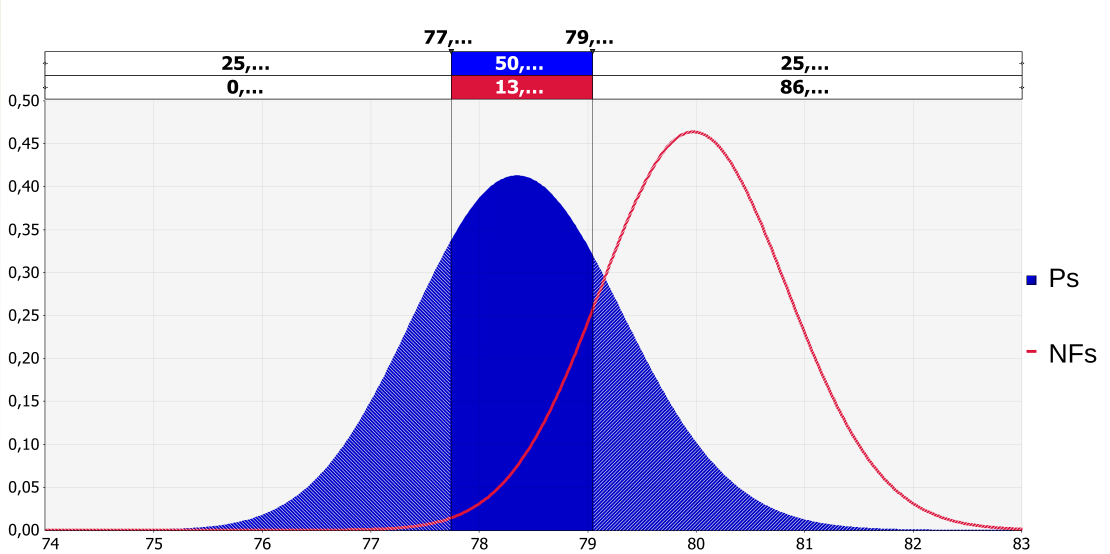
d. Probability Distribution Functions (PDFs) of these variables are fitted

Climate Change and THImax distributions

Daily values of THImax for 150-year series of Ps and Fs to identify the annual period of incidence of heat stress: quarter June-August



PDFs estimated on these data through a maximum likelyhood algorithm: PDF of Future THI shifts towards higher values



Present and future PDFs of THImax divided in 3 *states of nature*: Low, Intermediate and High with 25%, 50%, 25% probability of occurrence

Climate scenarios: states of nature

Scenarios			Present			Future (Δ% on Present)		
			Low	Intermediate	High	Low	Intermediate	High
Ryegrass			8.4	8.9	9.4	5.0	3.7	3.3
Yield ($t\ ha^{-1}$ d.m.)	Corn silage	*long cycle*	25.0	26.2	27.4	1.4	2.3	3.0
		short cycle 1	20.4	21.6	22.7	-3.0	-2.3	-1.9
		short cycle 2	12.5	13.4	14.1	-7.8	-6.7	-4.6
THI (June-August)			75.9	76.8	77.7	2.2	2.3	2.3

The DSP model can be compactly written as follows:

$$\max_{x_{n,j},ca_{t_{n,s}}} z = \sum_n \sum_j \sum_s P_s * (GI_{n,j,s} * x_{n,j} - C_{ca} * ca_{t_{n,s}}) + Pm_n * Qm_n + VE_n * NE_n \quad (1)$$

subject to

$$\sum_j A_{n,j} * x_{n,j} \leq B_n \qquad \forall\, n \qquad (2)$$

$$\sum_j N_j * Y_{t_{n,j,s}} * x_{n,j} + ca_{t_{n,s}} \geq R_{t_{n,s}} \qquad \forall\, n,s \qquad (3)$$

$$x_{n,j} \geq 0 \; and \; ca_{t_{n,s}} \geq 0 \qquad \forall\, n,j,s \qquad (4)$$

Decision-making on *t* stages, *s* states of nature for uncertain variables, with land allocation $x_{n,j}$ in the *n* farms for each *j* crop activity and corrective action $ca_{t_{n,s}}$. OF (1), expected gross income *z*, weights values and probabilities P_s in the states of nature. Uncertainty involves gross margins $GI_{n,j,s}$ and corrective actions $ca_{t_{n,s}}$. Pm_n and Qm_n are price and quantity of milk. VE_n and NE_n are unitary values and entitlements for Single Payment of CAP. (2) restrains availability of resources B_n and technology matrix $A_{n,j}$ of activities. (3) affects animal feeding: N_j, $R_{t_{n,s}}$, $Y_{t_{n,j,s}}$ are unitary contributions of nutritional elements, nutritional needs of cattle categories and crop yields. Corrective actions $ca_{t_{n,s}}$ can be done at stage *t* for state *s*.

Model results: land and input uses

	Present	Future % Δ on Present
corn silage for feed	31,744	-1.3
corn silage for biogas	5,286	+20.2
grain maize	4,246	+16.2
alfalfa	14,479	-10.5
ryegrass	1,311	+28.3
soybean	443	+4.7
tomato processing	7,834	-2.8
nitrogen (tons)	8,450	+3.3
water (000 m3)	275,637	+8.3
feeds (tons)	573,590	-6.8

Model results: economic variables

	Present	Future % Δ on Present
Total revenues	532,901	-0.8
milk and meat	*503,563*	*-1.5*
Direct payments	52,050	0.0
Costs	224,153	0.5
fertilizers, pesticides, seeds	*12,607*	***6.3***
water	*4,169*	*1.0*
extra labour	*33,474*	*-0.2*
animal feeds	*116,977*	***-6.4***
Net income	**240,783**	**-2.1**

Economic results: typologies of farms ordered by intensity of CC impact

Present Net Income (NI)	Future NI % Δ on Present	Represented		NI per		hectares per farm	% in the Piacenza province
		farms	hectares	farm	hectare		
32,704,946	**-3.9**	284	21,289	115,234	1,536	75.0	78
85,666,959	**-2.1**	213	19,291	401,990	4,441	90.5	17
122,410,748	**-1.7**	359	24,274	341,124	5,043	67.6	14

Smaller and less intensive farms in the Piacenza province suffer a stronger impact of the CC

Conclusions

A major intensification impact in the use of inputs and water, and reduced purchases of feed

however

The model ignores market effects of this variation in the demand of the inputs in the entire area of the GP

Milk production appreciably decreases in the summer, when it is already low

however

The model ignores the effects on the dairy sector, which in the summer might have difficulty even to make cheese

Different effects by farm typology, with the suffering of the less intensive

however

Types to be better defined.
A three years FADN average reduces the sample and requests to widen the representative area: this requires climatic and agronomic data from other GP territories

For further information
please visit: www.macsur.eu