Session 2: Estimation of biomass availability for lignocellulosic biomass

Assessment of the cropping potential and the development of dedicated crops database

Presenters

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Outline

- Overview: main objectives
- Approach and data used
- Crop yield estimation for whole of Europe
- Land suitability for dedicated cropping
- Land availability for dedicated cropping
- Conclusions

S2Biom Project

Aim of the project:

To support the sustainable delivery of **non-food lignocellulosic biomass** at local, regional and pan European level through developing **strategies, and roadmaps** that will be informed by a **toolset** with updated harmonized datasets

Main objectives:

- to estimate the DM biomass yield of perennials crops in whole EU
- to identify the most suitable crop mix for every location in Europe (Nuts 3 level)
- to make an estimate of the dedicated biomass cropping potential in Europe

The modelled crops are

Annual and perennial crops

Miscanthus

Switchgrass

Giant reed

Reed canary grass

Cardoon

Sorghum

SRC

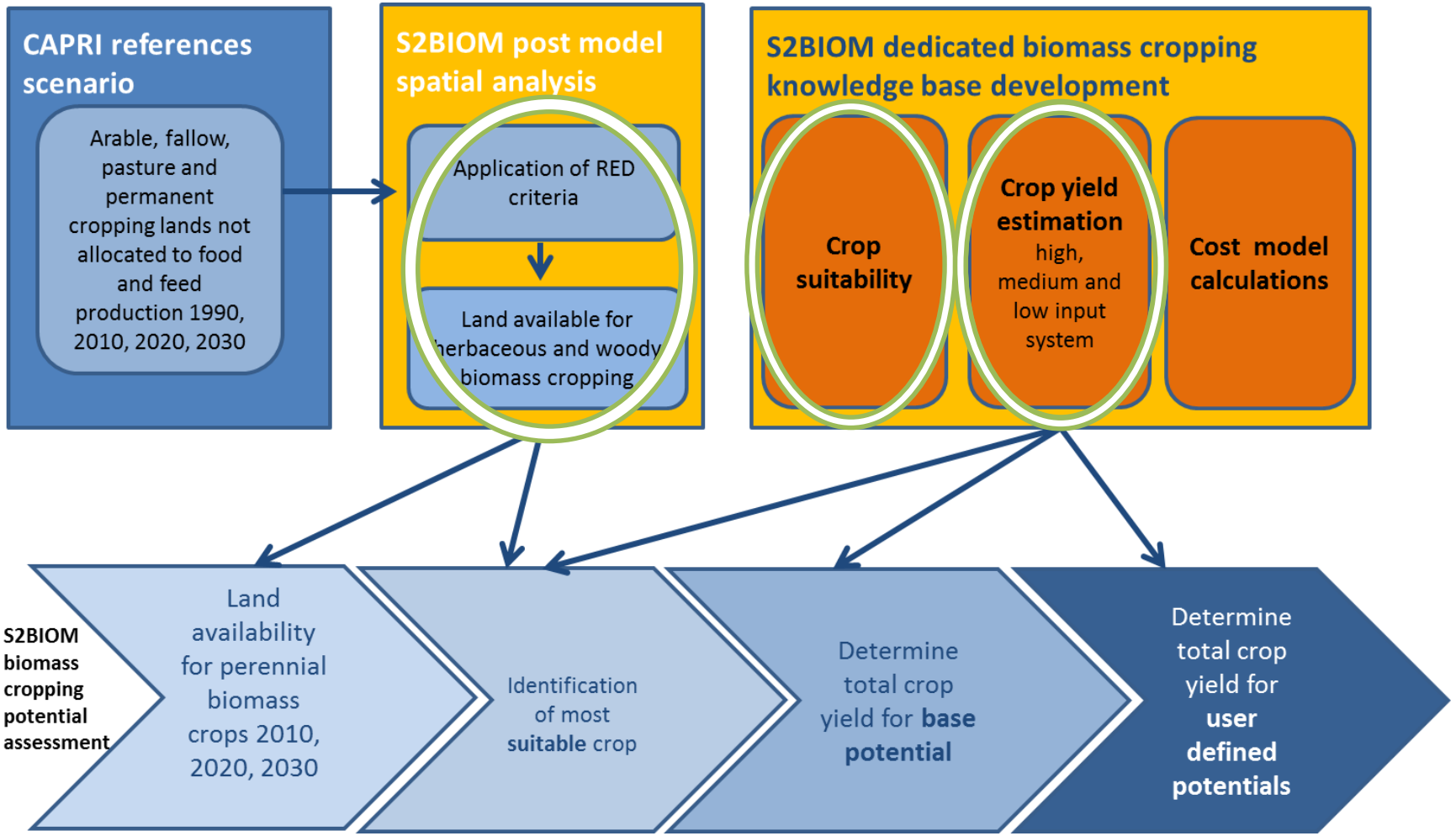
Poplar

Willow

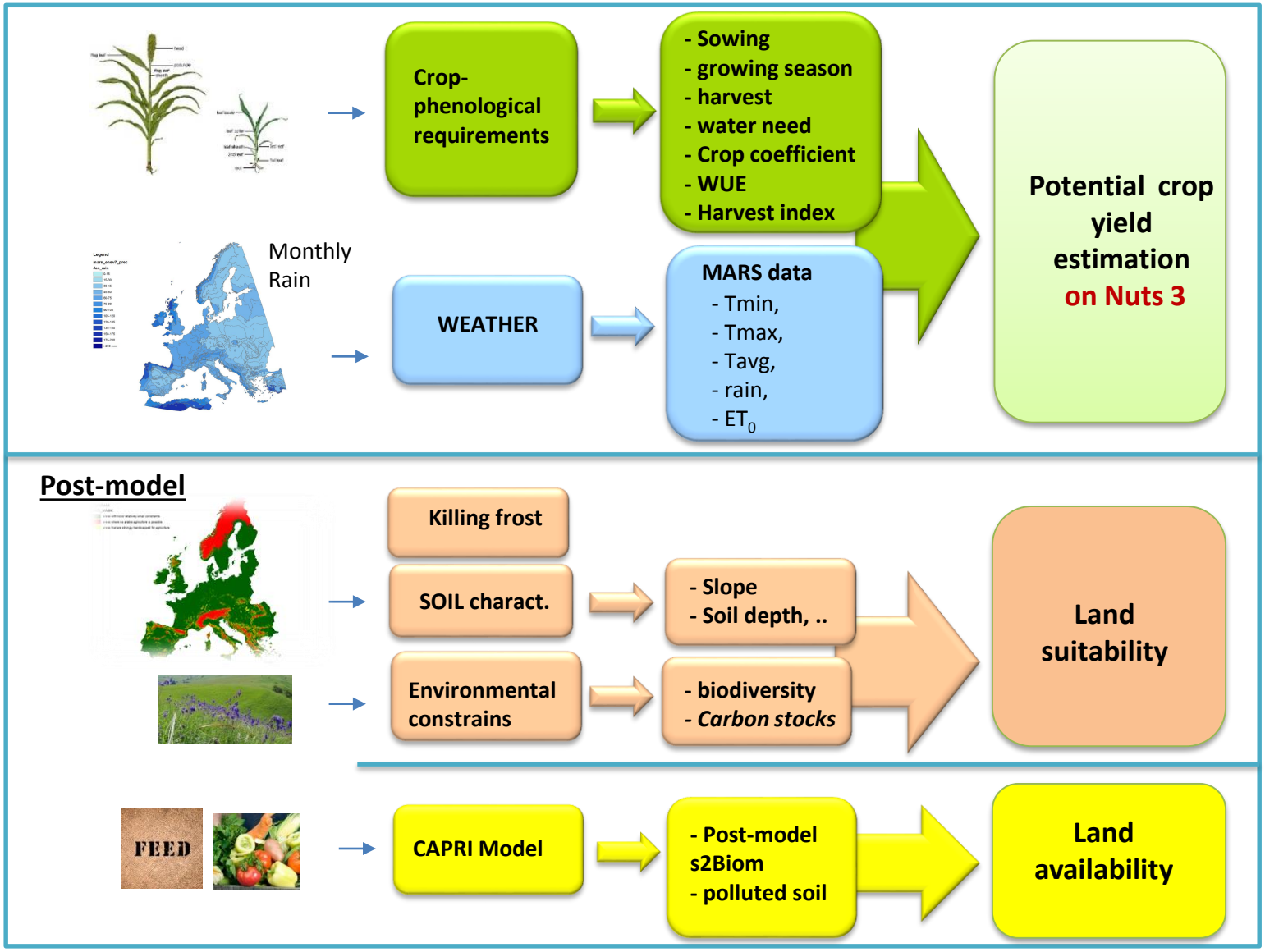
Eucalyptus

Approach

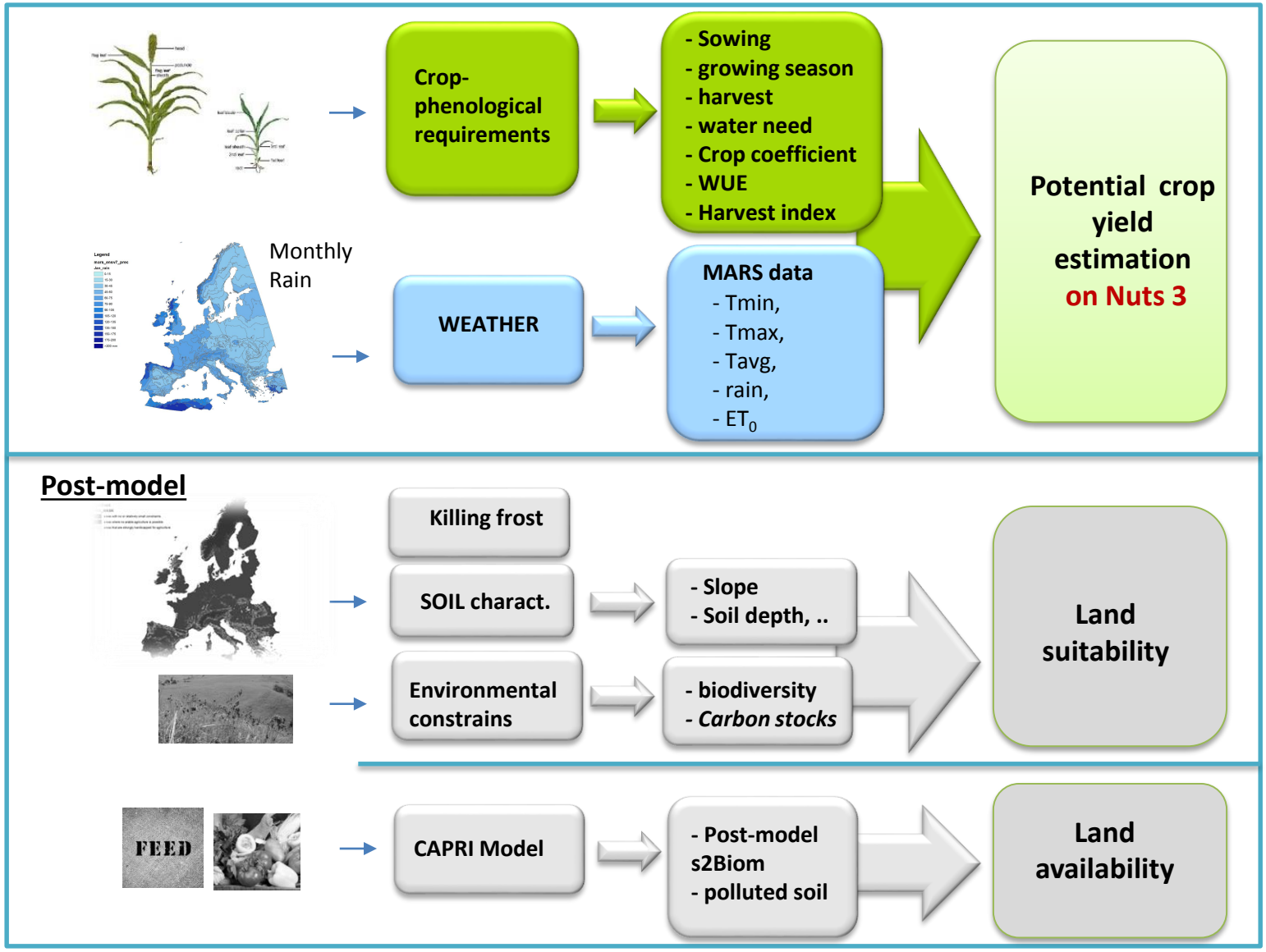
Integration of CAPRI land availability for dedicated biomass crops with S2BIOM yield and cost level assessments to estimate herbaceous and woody biomass cropping potentials



Crop yield estimation for whole of Europe


Crop-phenological requirements
- Sowing
- growing season
- harvest
- water need
- Crop coefficient
- WUE
- Harvest index
Monthly Rain
WEATHER
MARS data
- Tmin,
- Tmax,
- Tavg,
- rain,
- ET0
Potential crop yield estimation on Nuts 3
Post-model
Killing frost
SOIL charact.
- Slope
- Soil depth, ..
Environmental constrains
- biodiversity
- Carbon stocks
Land suitability
FEED
CAPRI Model
- Post-model s2Biom
- polluted soil
Land availability

Crop yield estimation for whole of Europe



Crop yield estimation

Methodology

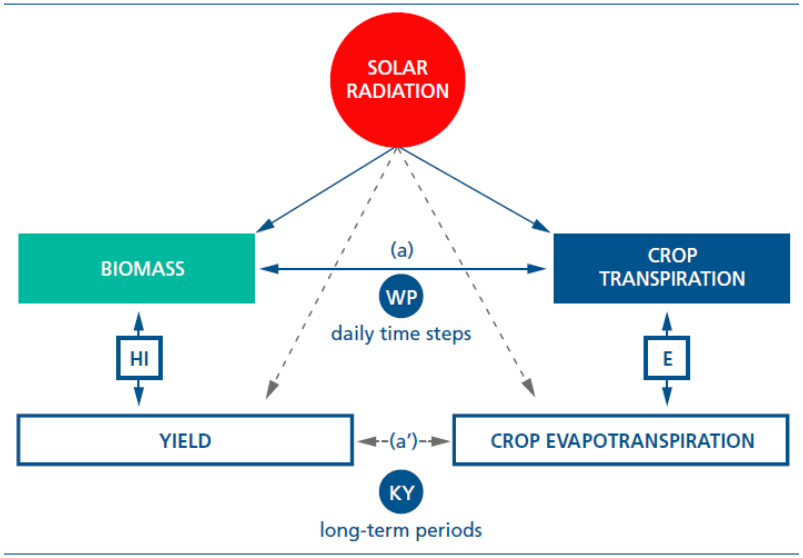
- The biomass yield depends on very site-specific conditions such as soil, temperature and water availability. A direct relation exists between biomass production and water consumed through transpiration.

Maintaining the original concept of a direct link between crop water use and crop yield, in this study we use the *AquaCrop Model* evolved from the FAO.

$$B = WP \bullet \Sigma Tr$$

For all crops, only part of the biomass produced is partitioned to the harvested biomass parts to give yield (Y) and the below ground plant part. Hence, the ratio of yield to biomass is known as harvest index (HI).

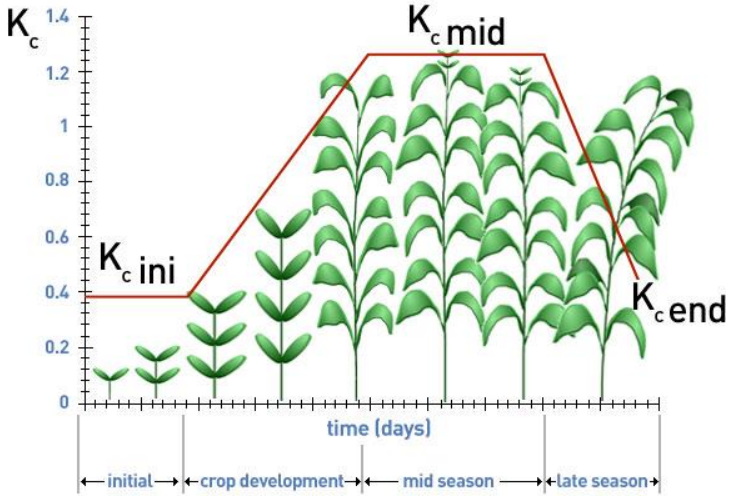
$$Y = HI \bullet B$$



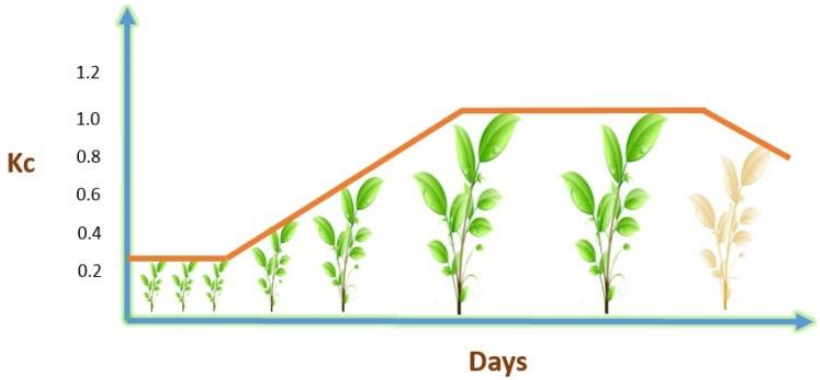
- **B**, biomass produced cumulatively (kg per m^2)
- **Tr**, crop transpiration(either mm or m^3 per unit surface) with the summation over the time period in witch the biomass is produced
- **WP** is the water productivity parameter (either kg of biomass per m^2) and per mm, or kg of biomass per m^3 of water transpired)
- **Y**, yield
- **HI**, Harvest index

Crops specific parameters

Length growing season (Lgs)



Crop coefficient (Kc)



Water Use Efficiency (WUE)

$$WUE = \frac{\text{Crop yield (kg)}}{\text{Water consumption } (m^3)}$$

Harvest index (HI)

Cutting miscanthus

Agronomic table

Factors	Miscanthus	Switchgrass	Giant Reed	Reed canary grass	Cardoon	Sweet Sorghum	Willow	Poplar	Eucalyptus
Latin name	Miscanthus spp.	Panicum virgatum L.	Arundo donax L.	Phalaris arundinacea L.	Cynara cardunculus L.	Sorghum bicolour L. Moench	Salix spp.	Populus spp.	Eucalyptus spp.
Photosynthetic system	C4	C4	C3	C3	C3	C4	C3	C3	C3
Propagation	rhizomes, micropropagated plants	seed	rhizomes, micropropagated plants	seed	seed	seed	cuttings	cuttings	Cuttings
Harvest period	Annually fall or spring	Annually fall or spring	Annually fall or spring	Autumn / early spring	Late summer	Annually fall	harvested on 3–4 years rotation Winter	harvested on 3–7 years rotation Winter	harvested on 6–15 years rotation Winter
Growing minimum (°C)	10	10	10	7	5	10	5	7,5	10
Growing maximum (°C)	40	35	35	30	35	40	30	30	35
Water requirement (mm)	High	Medium	Low	High	Low	Medium	High	Medium	Medium
Fertilizer input (N) (kg ha/N/year)	50 - 100	50 - 100	50 - 100	50 - 140	100 - 150	100 - 200	80 - 150	112 - 450	60 - 125
Dry biomass (t dm/ha)	12 - 25	8 - 15	12 - 30	5 - 20	4 - 8	15 - 25	10 - 30	7 - 28	10 - 26
Tolerance to dry conditions	High	High	high	Medium	high	high	Low	Medium	Medium

Weather: MARS database

Climate data are available from the JRC-MARS data base on a 25x25 km grid.

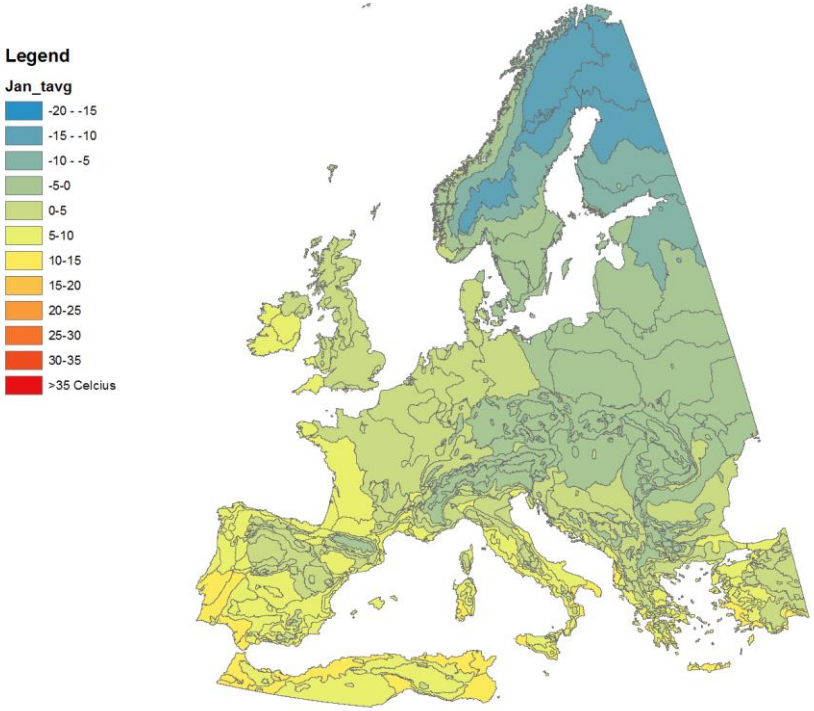
MARS-weather interpolated data have been collected, representing the long term average for each day of the year for the following variables:

- tmin minimum day temperature
- tmax maximum day temperature
- tavg average day temperature
- rain daily rainfall
- ET0 daily evapotranspiration for reference crop

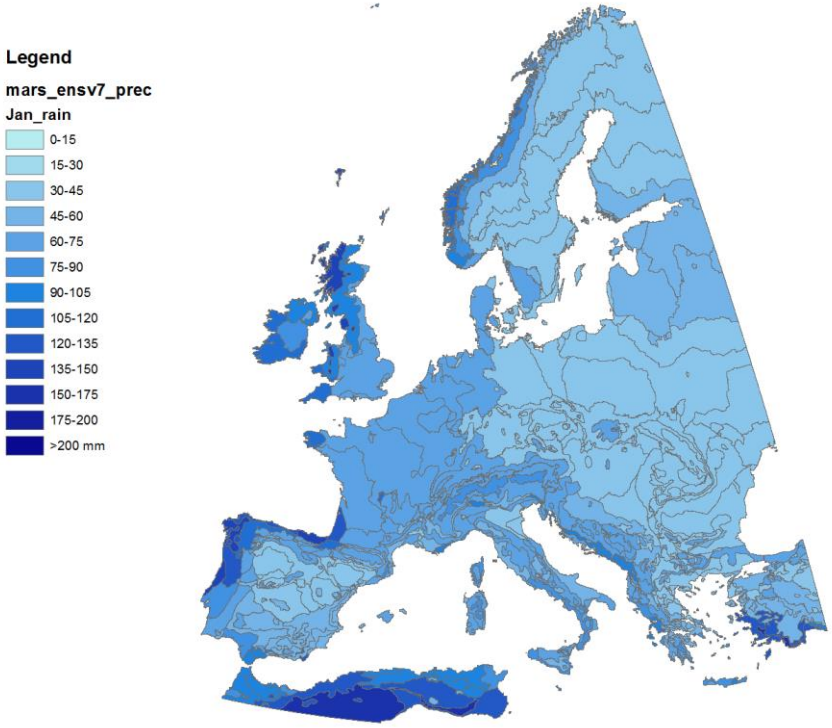
Reference evapotranspiration (ET0)
for every location in Europe was determined from the Penman-Monteith equation recommended by FAO.

Climatic characteristic

Monthly Average Temperature (C°)



Monthly Rain (mm)



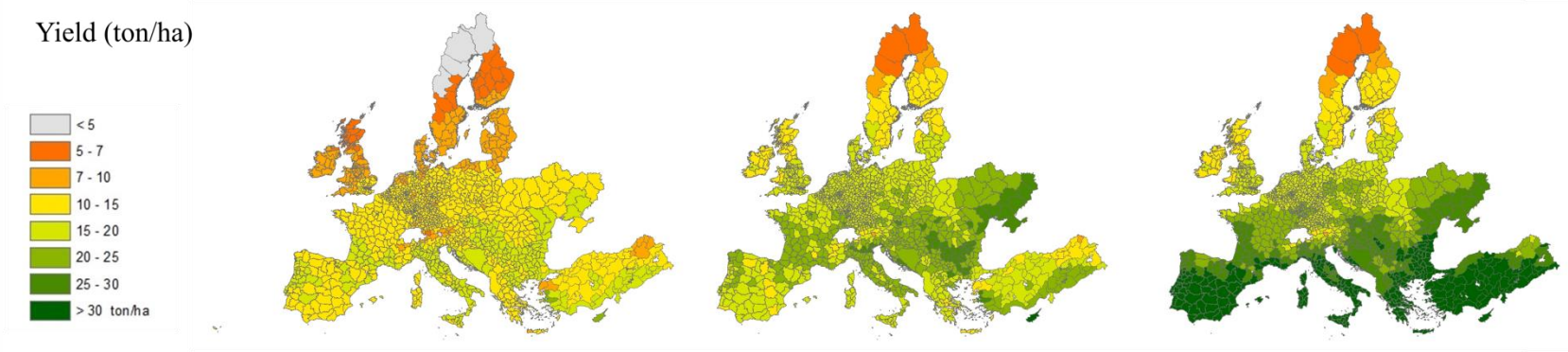
http://mars.jrc.ec.europa.eu/mars/About-us/AGRI4CAST

Crops yield estimation for whole EU

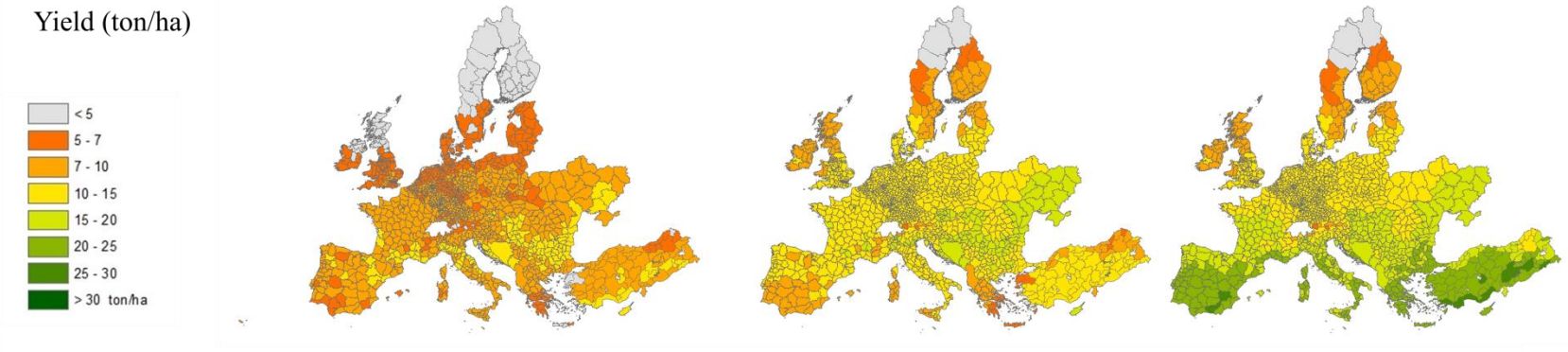
Level	description
L1	low input, rain fed
L2	medium input, rain fed
L3	high input, irrigation applied where needed

Results: crop yield estimation (vers 1.3)

GIANT REED	L1 (low input/no irrigation)	L2 (medium input/no irrigation)	L3 (high input/ irrigation)

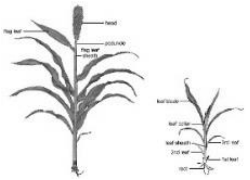


MISCANTHUS	L1 (low input/no irrigation)	L2 (medium input/no irrigation)	L3 (high input/ irrigation)



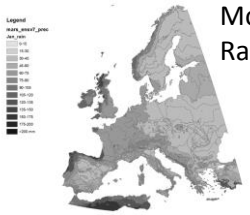
Land suitability for dedicated crops

Land suitability



Crop-phenological requirements

- Sowing
- growing season
- harvest
- water need
- Crop coefficient
- WUE
- Harvest index



Monthly Rain

WEATHER

MARS data
- Tmin,
- Tmax,
- Tavg,
- rain,
- ET_0

Potential crop yield estimation on Nuts 3

Post-model

Killing frost

SOIL charact.

- Slope
- Soil depth, ..

Environmental constrains

- biodiversity
- *Carbon stocks*

Land suitability

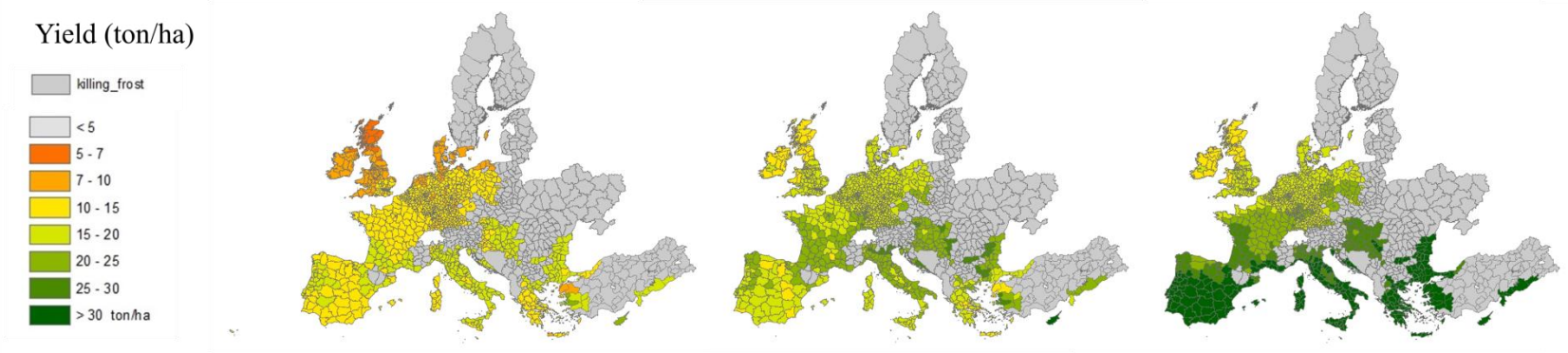
CAPRI Model

- Post-model s2Biom
- polluted soil

Land availability

Results: crop yield estimation + killing frost (vers 1.4)

GIANT REED	L1 (low input/no irrigation)	L2 (medium input/no irrigation)	L3 (high input/ irrigation)



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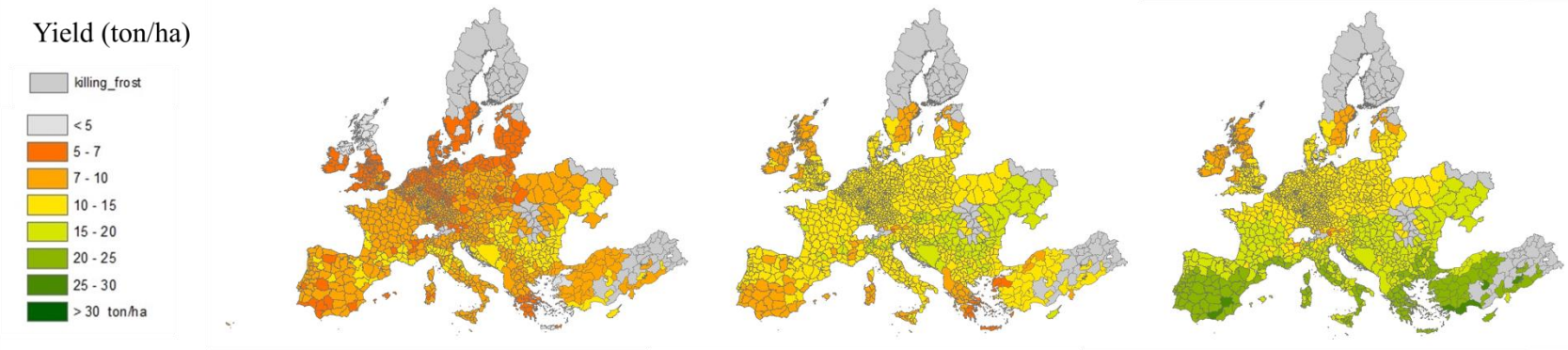


Soil characteristic

Criteria & classification	Misc.	Switch.	Giant r.	Card.	RCG	Willow	Poplar	Eucalyp.
Slope								
0-8% slope	S	S	S	S	S	S	S	S
8%-16% slope	MS	MS	MS	MS	MS	LS	LS	LS
>16% slope	NS	LS	NS	LS	NS	NS	NS	NS
Texture								
Sand (coarse)	MS	MS	MS	LS	PS	LS	MS	MS
Loam (medium-medium fine)	VS	VS	VS	VS	VS	VS	VS	VS
Clay (fine)	LS	MS	S	MS	MS	MS	LS	MS
Heavy clay (very fine)	PS	NS	MS	NS	PS	NS	NS	MS
Peat (no mineral texture)	NS	NS	NS	NS	NS	NS	NS	NS
Soil depth								
Shallow (< 40 cm)	NS	NS	NS	NS	NS	NS	NS	NS
Moderate (40 - 80 cm)	PS /MS	PS /MS	PS / MS	PS /MS	LS /MS	PS / MS	PS / MS	PS \/MS
Deep (80 - 120 cm)	S	S	MS / S	MS / S	S	MS / S	MS \/S	MS / S
Very Deep (> 120 cm)	VS	VS	VS	VS	VS	VS	VS	VS
pH soil								
0 - 4	NS	NS	NS	NS	NS	NS	NS	NS
4 - 5	LS	LS	LS	PS	PS	PS	PS	PS
5 - 6	S	MS	MS	MS	S	MS	MS	MS
6 - 7	VS	VS	VS	VS	VS	VS	VS	VS
7 - 8	MS	LS	S	S	MS	S	S	S

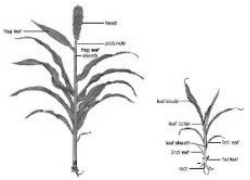
Environmental Constrains

- *Nature 2000*
- *Biodiversity*
- *Carbon stock*

S: Suitable/MS: medium suitable/LS: Low Suitable/NS: Not suitable (poorly suitable: PS, very suitable: VS)

Land availability for dedicated crops

Land availability



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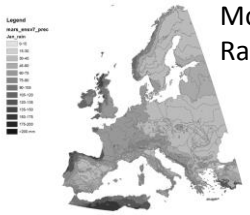

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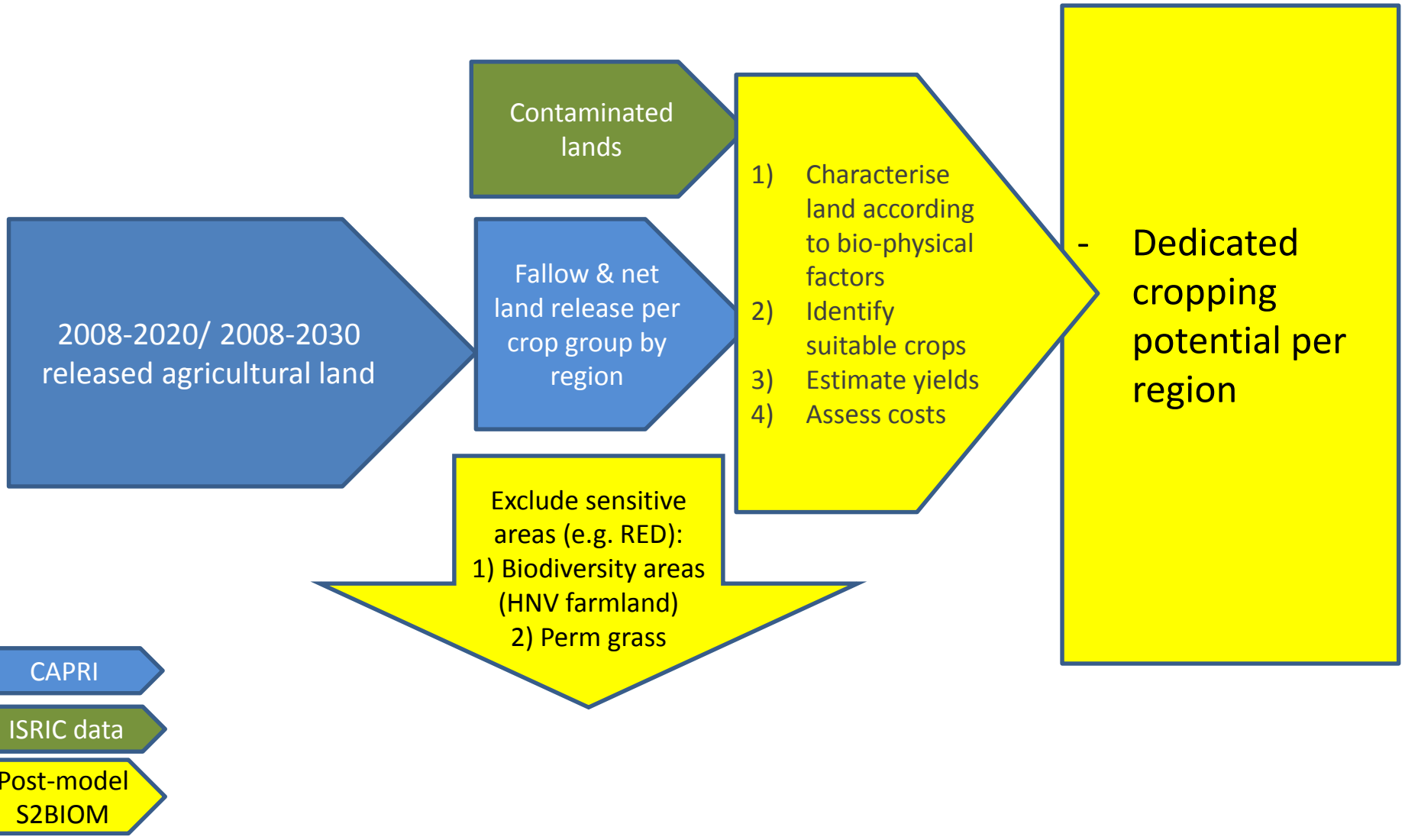
Land availability

Land availability for dedicated crops



CONCLUSION

output of this assessment are:

a. Dedicated cropping database for Europe providing information per crop per region (nuts 3) on

   i. Yield (water limited and maximum yield)
   ii. Water use
   iii. Cost in different management systems
   iv. Estimated land area available per region available for dedicated cropping in 2020 and 2030

b. Total dedicated biomass cropping potential per region

limitations of our approach:

a. Crop yield simulation is challenging because
   i. Lack of breeding experience with all these novel crops
   ii. Many different cultivars per crop
   iii. Lack of crop phenological information for these novel crops
   iv. Now we take main crop factors and combine with detailed climate data. But soil and management factors can make large difference

b. Identifying land available can only be done through statistical information and modelling. But whether the mobilisation of dedicated cropping will take place demands omn many other factors that cannot be captured in model and statistics.

Thank you for your attention !!

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S2biom *consortium*

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