12th International Conference on Renewable Resources & Biorefineries
30 – 31 May & 1 June, 2016, Ghent, Belgium

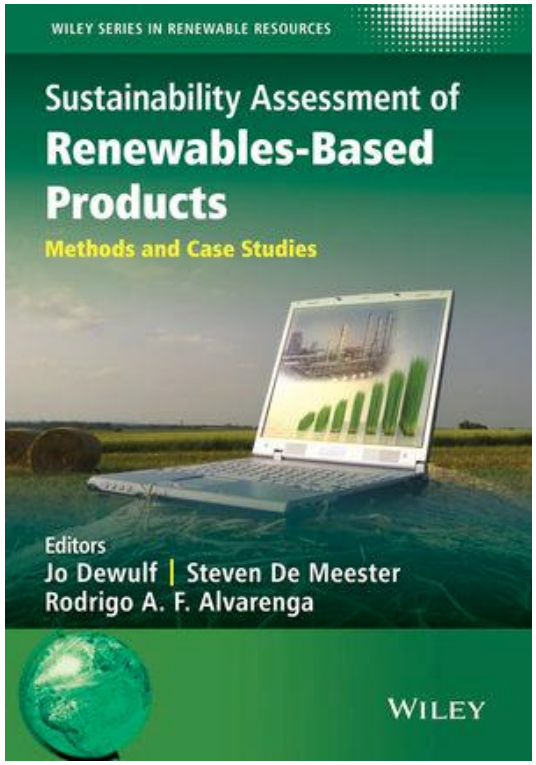
# MEASURING SUSTAINABLE PRODUCTION AND USE OF RENEWABLES-BASED PRODUCTS

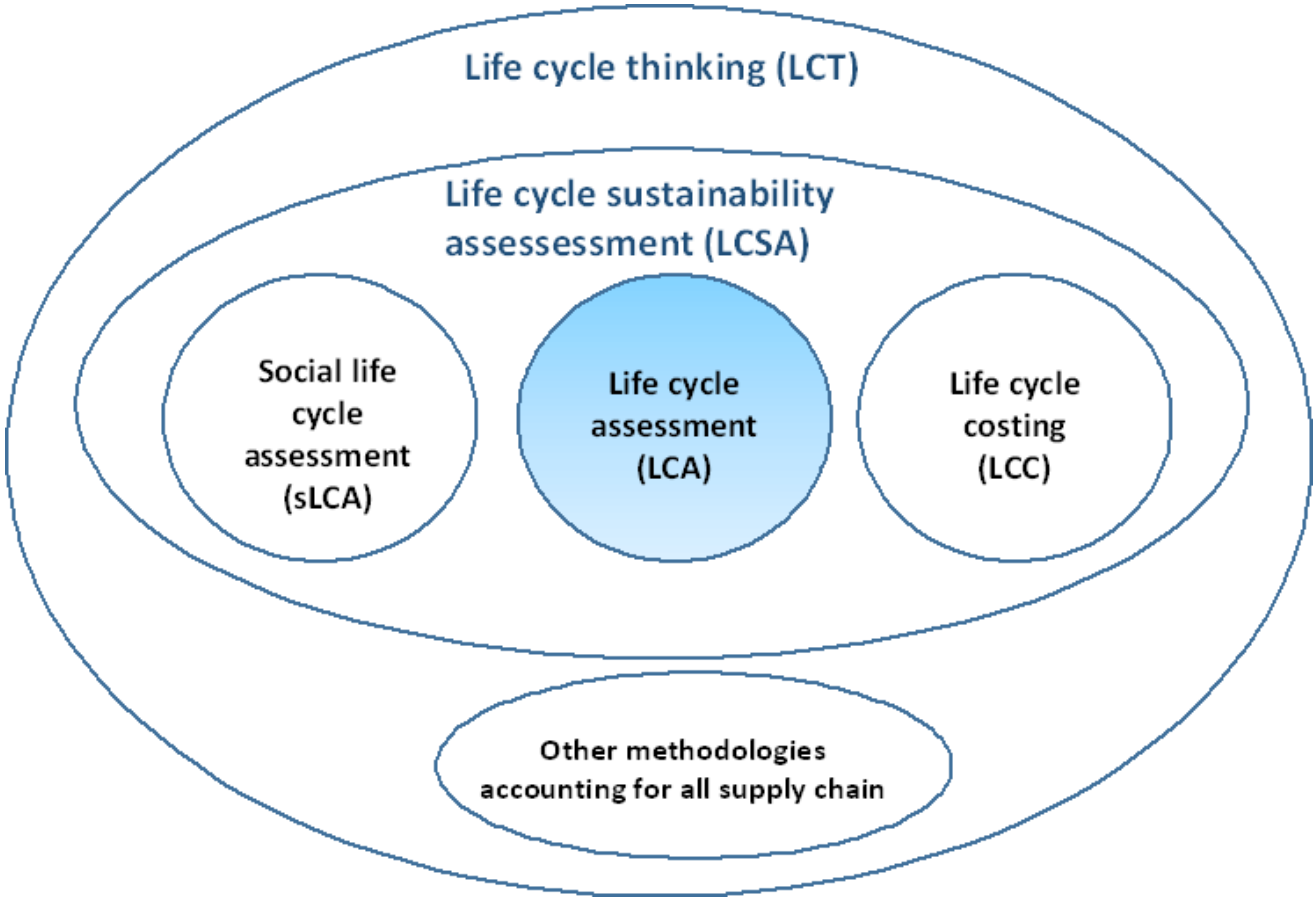
**Jo Dewulf**
**and L. Boone, S. Huysveld & S.E. Taelman**

# Contents

1. Introduction:
   The Sustainability Assessment Toolbox today
2. Sustainability assessment of biobased production:
   Role of site specificity of agriculture
3. Resource efficiency of bio-based
   versus fossil-based products?
4. The resource footprint of biomass:
   how to deal with marine resources?

# 1. Introduction:
## The Sustainability Assessment Toolbox today:



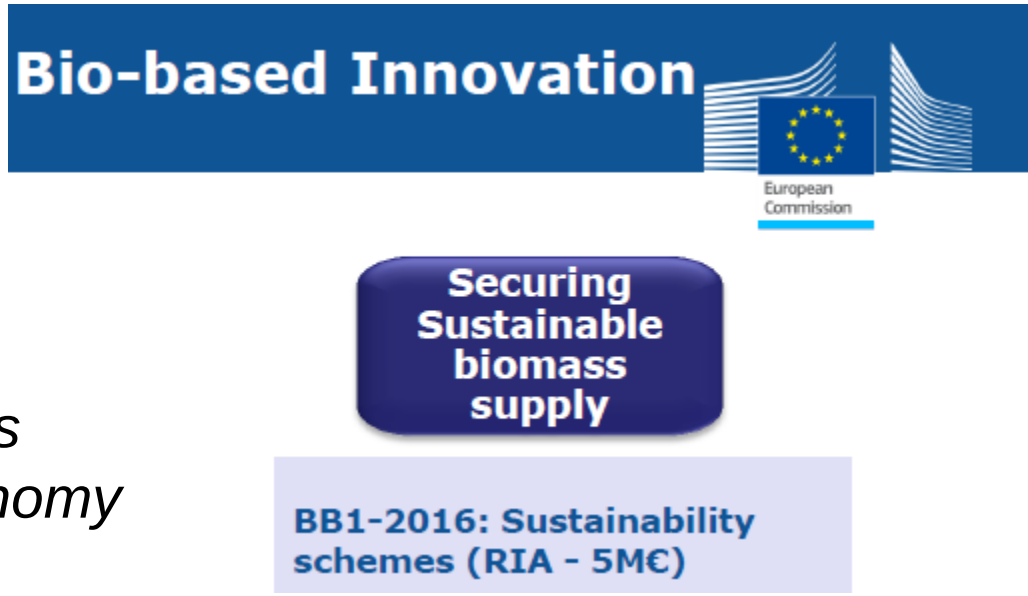

- Key advantage: avoiding burden shifting
- Some convergence in practice: ISO, ILCD, PEF
- Key input: data

Dewulf et al., 2016

Bottle necks in Environmental LCA for (biobased) products:

- Resources: footprinting and efficiency
- Land use: role in resource footprint and source of biodiversity

From LCA to LCSA:
e.g.:
Horizon 2020 BB-01 call
(now 2nd stage phase):

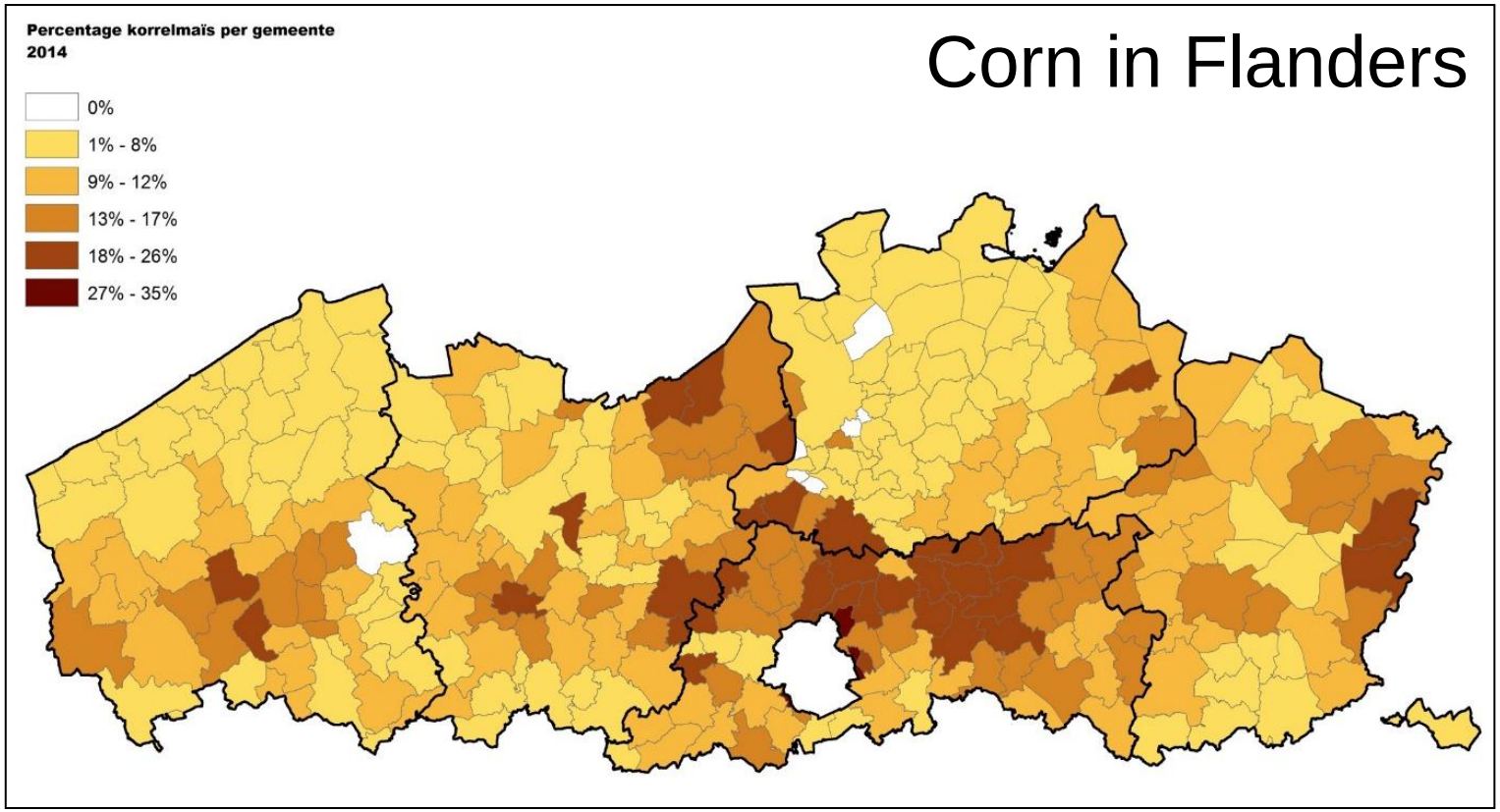



*Building in next to LCA:*

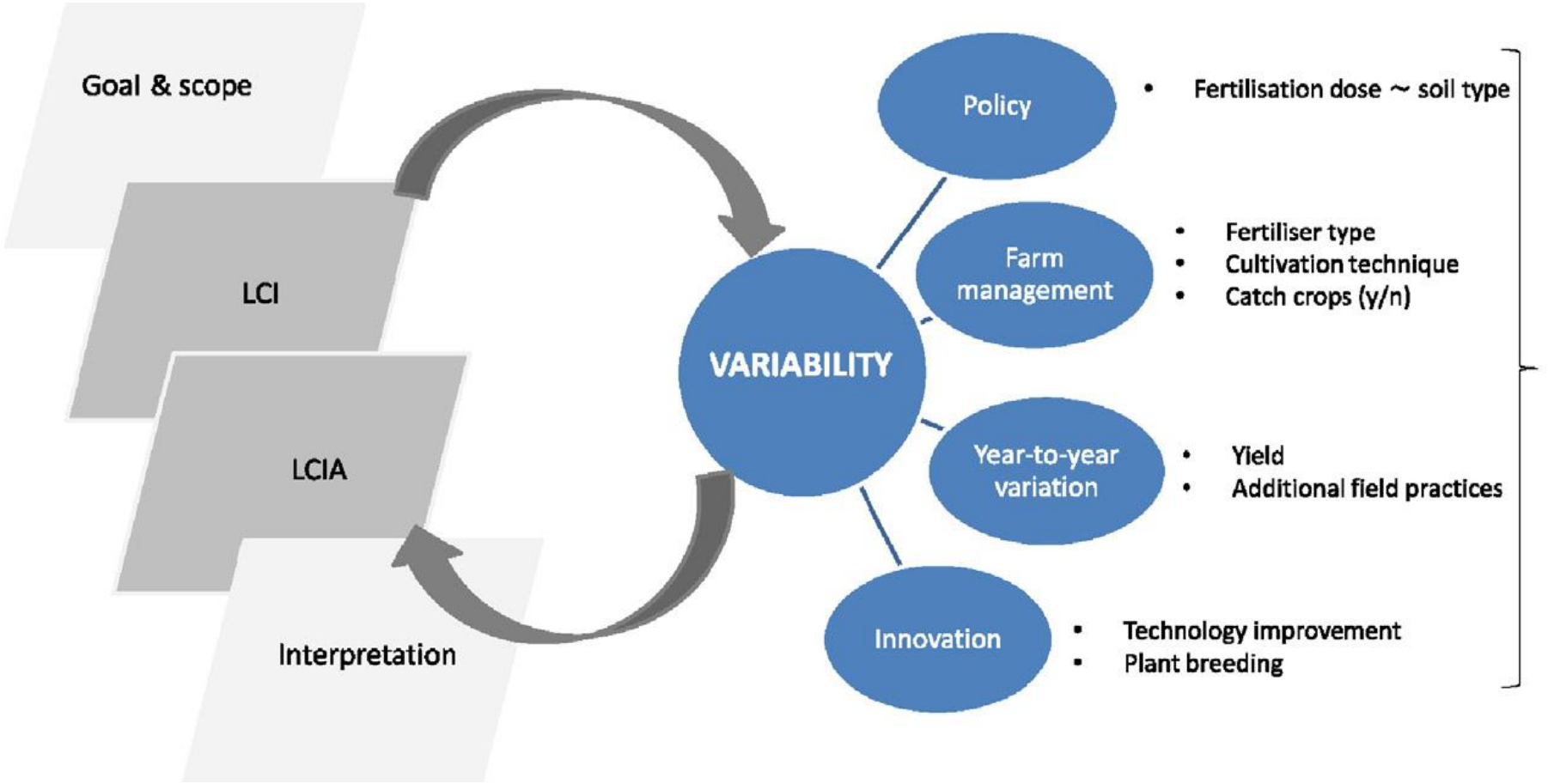
- *economic and social factors*
- *aspects of the circular economy*
- *resource efficiency*
- *the principle of cascade use*
- *the development of ILUC factors*

# 2. Sustainability assessment of biobased production: role of site specificity of agriculture

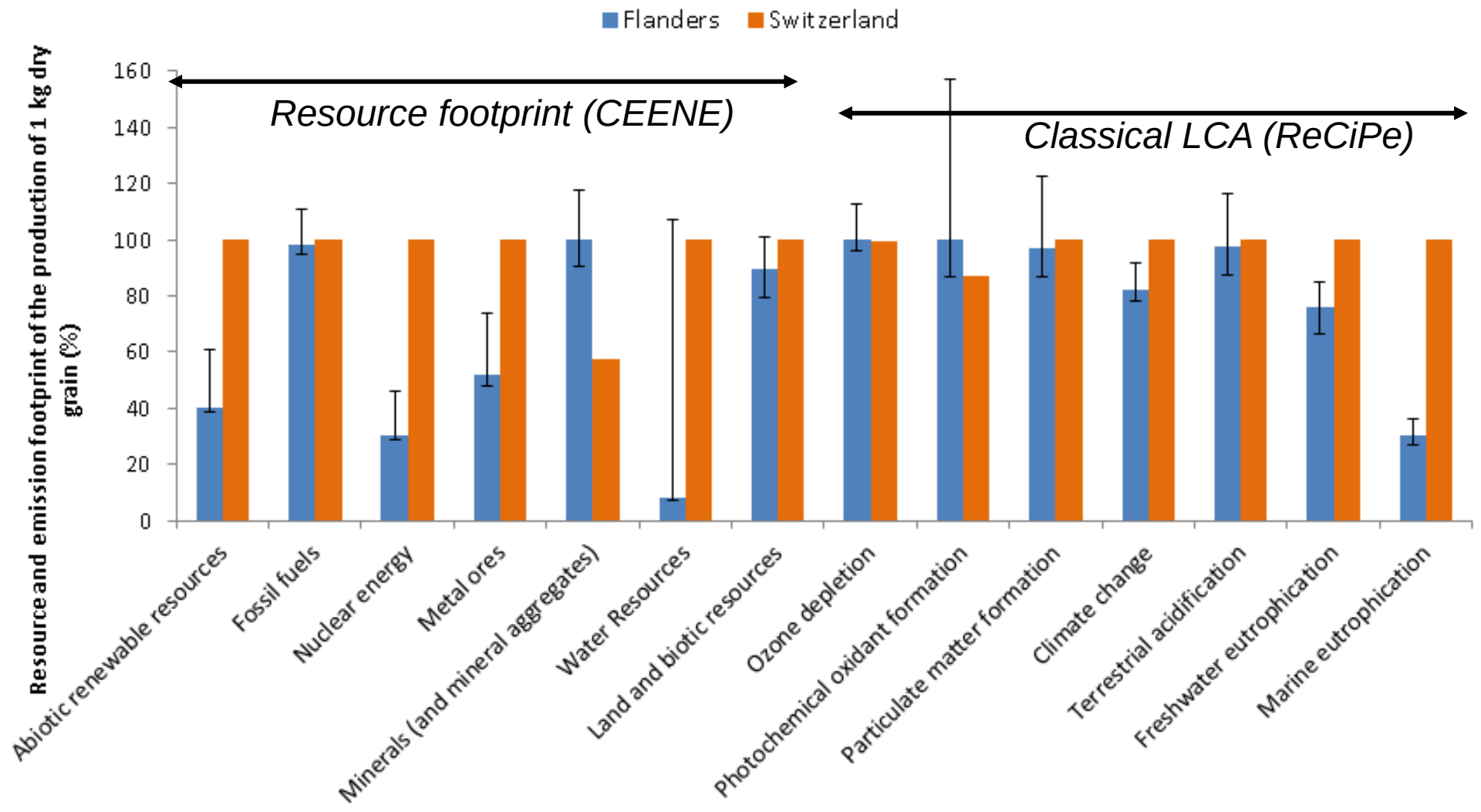
- Core element: data inventory
- Can we use data from a generically applied database?



# Variability in Flanders:



# Relative LCA results Flanders versus CH:




→ Need for site-specific and practice-specific data

Boone et al., 2016

# 3. Resource efficiency of bio-based versus fossil-based products?

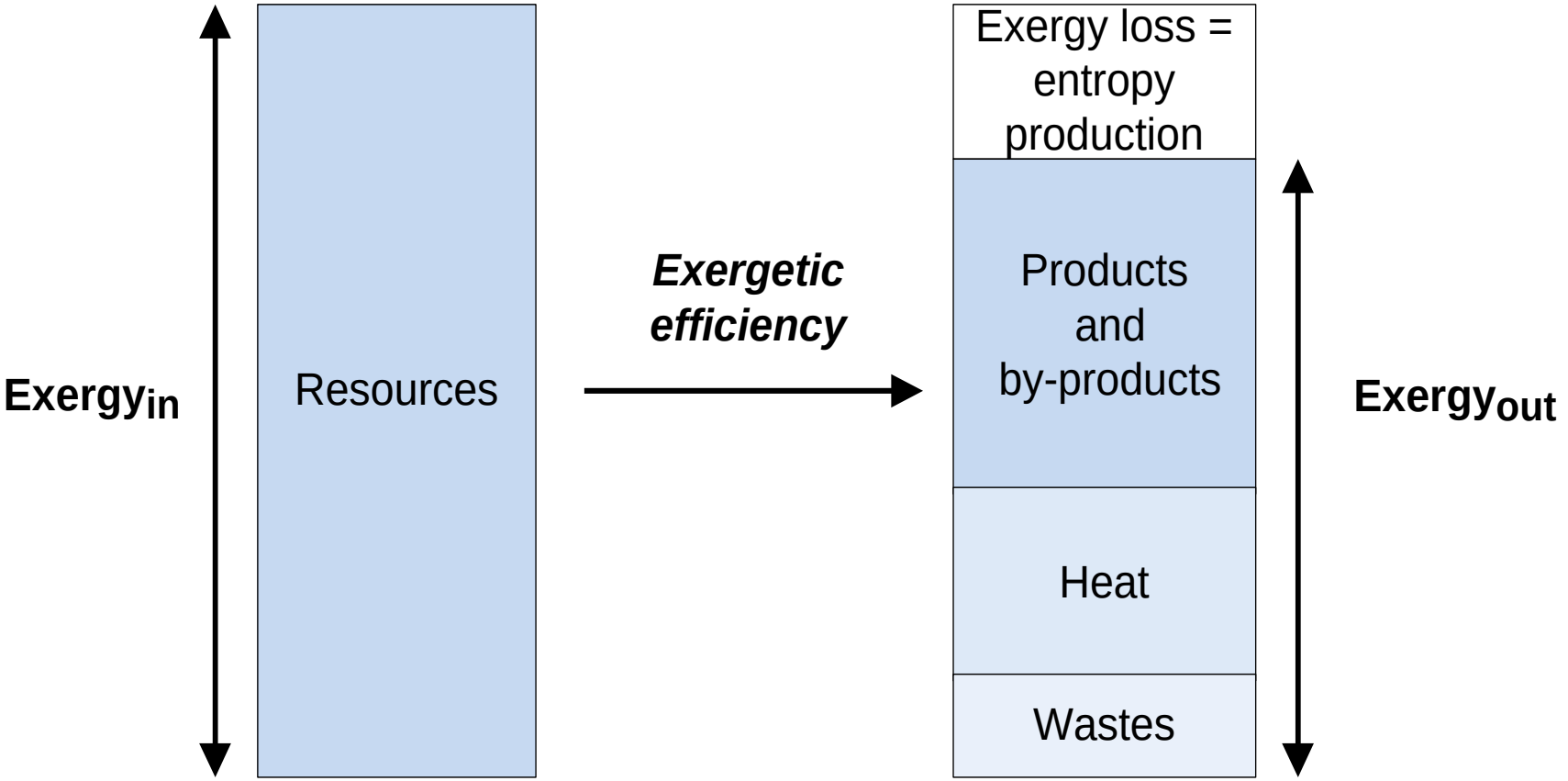
- Resource efficiency: output (products) versus input (resources)
- Cumulative overall resource efficiency assessment (COREA):

  Resources: - at cradle: full production chain / life cycle

  - all types of natural resources

- To be solved:
  - Land resources
  - Renewables versus fossils: cradle?

# Resource efficiency metric: exergy

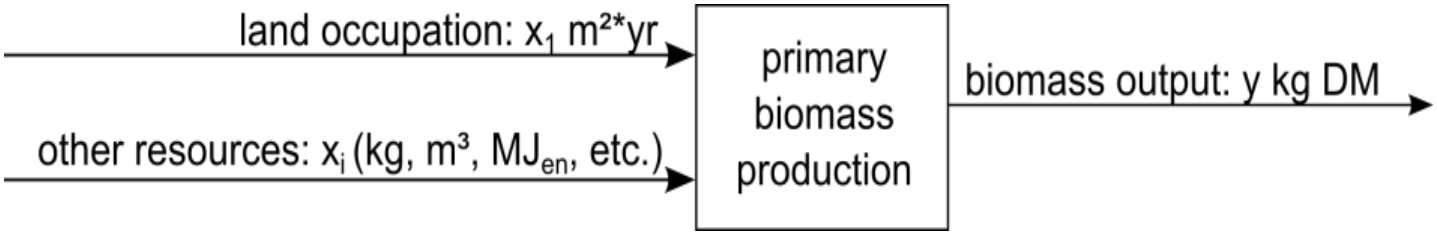



= Resource Accounting Method (RAM)

= Resource efficiency: from 0-100% scale

Dewulf et al., 2008

# Exergy-based RAM: how to deal with land?




| | CExD | CEENE v2013 |
|---|---|---|
| Land resources | X | V |
| Water resources | V | V |
| Mineral resources | V | V |
| Metal resources | V | V |
| Fossil resources | V | V |
| Nuclear resources | V | V |
| Renewable energy resources resources | V | V |

CEENE 2013:
Land resources: accounting via deprived solar energy

# Alternatives for resource accounting for land:

What is the “maximum” solar energy deprived and
to be taken into account for resource efficiency calculation ?

1. TMCA :

*Theoretical Maximum Conserved solar energy into Aboveground biomass:*

= 4.8% of the solar energy

2. OMCA :

*Observed Maximum Conserved solar energy into Aboveground biomass*

= 2.3% of the solar energy

## Resource efficiency (%) of electricity production:

| Approach | bio-based electricity | fossil-based electricity | |
|---|---|---|---|
| **CEENE TMCA** | 7.6 | 34.9 | 4.6 times less resource efficient |
| **CEENE OMCA** | 15.6 | 35.0 | 2.2 times less resource efficient |
| | 94-97% land | 99% fossil | |

Huysveld et al., 2015

# Solar energy consumption of fossils?

- Dukes (2003): recovery factors (RFs) for fossils:

  RF = proportion of the original photosynthetic product

  e.g. 0.000084 kg C gas/kg C biomass

  0.074 kg C hard coal/kg C biomass

- Efficiency of original photosynthesis: 1.7%

| Accounting for solar energy in fossils | No | | Yes | |
|---|---|---|---|---|
| **Approach** | **bio-based electricity** | **fossil-based electricity** | **bio-based electricity** | **fossil-based electricity** |
| **CEENE TMCA** | 7.6 | 34.9 | 0.014 | 0.00073 |
| | 4.6 times less resource efficient | | 18.6 times more resource efficient | |
| **CEENE OMCA** | 15.6 | 35.0 | 0.029 | 0.0016 |
| | 2.2 times less resource efficient | | 18.6 times more resource efficient | |

Huysveld et al., 2015

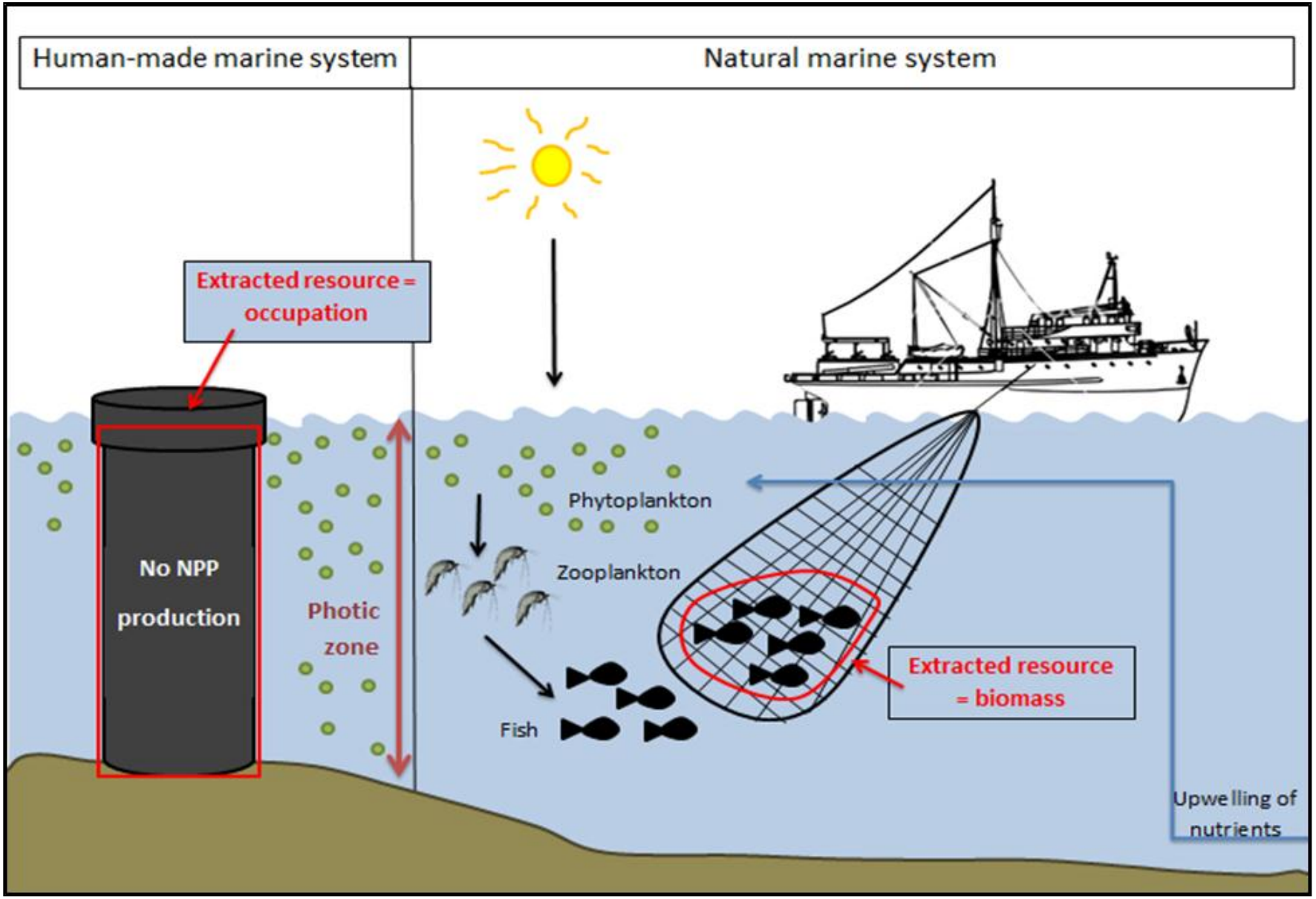
# 4. The resource footprint of biomass: how to deal with marine resources?

**Human made**

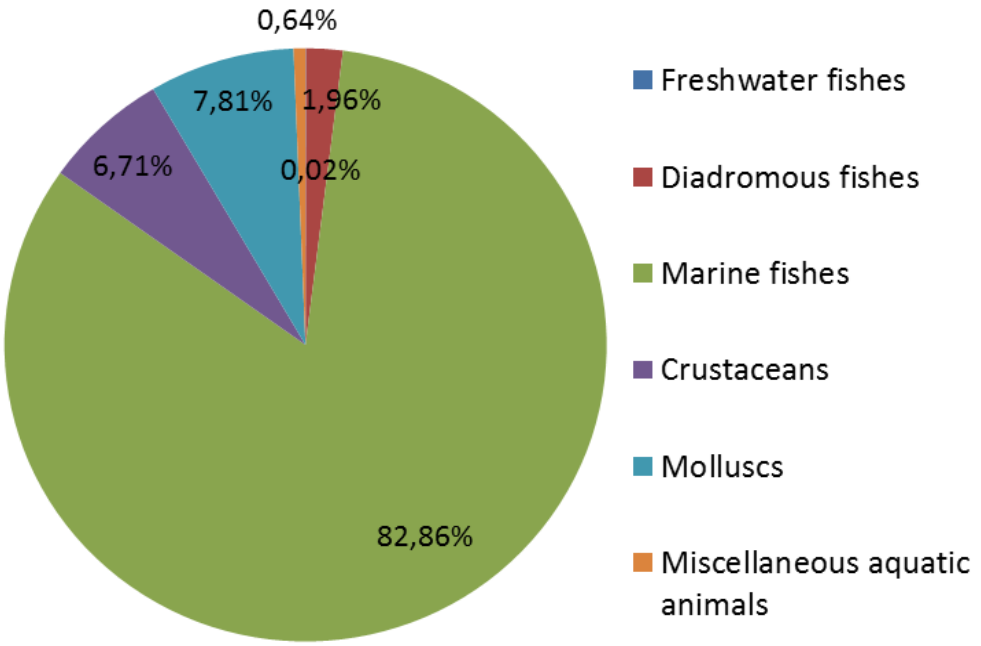
*Saccharina latissima*

**Natural biomass**


Seaweed growth
→ extra shadow
→ Natural NPP production hindered


Human-made marine system
Natural marine system
Extracted resource = occupation
No NPP production
Photic zone
Phytoplankton
Zooplankton
Fish
Extracted resource = biomass
Upwelling of nutrients

# *Natural:*



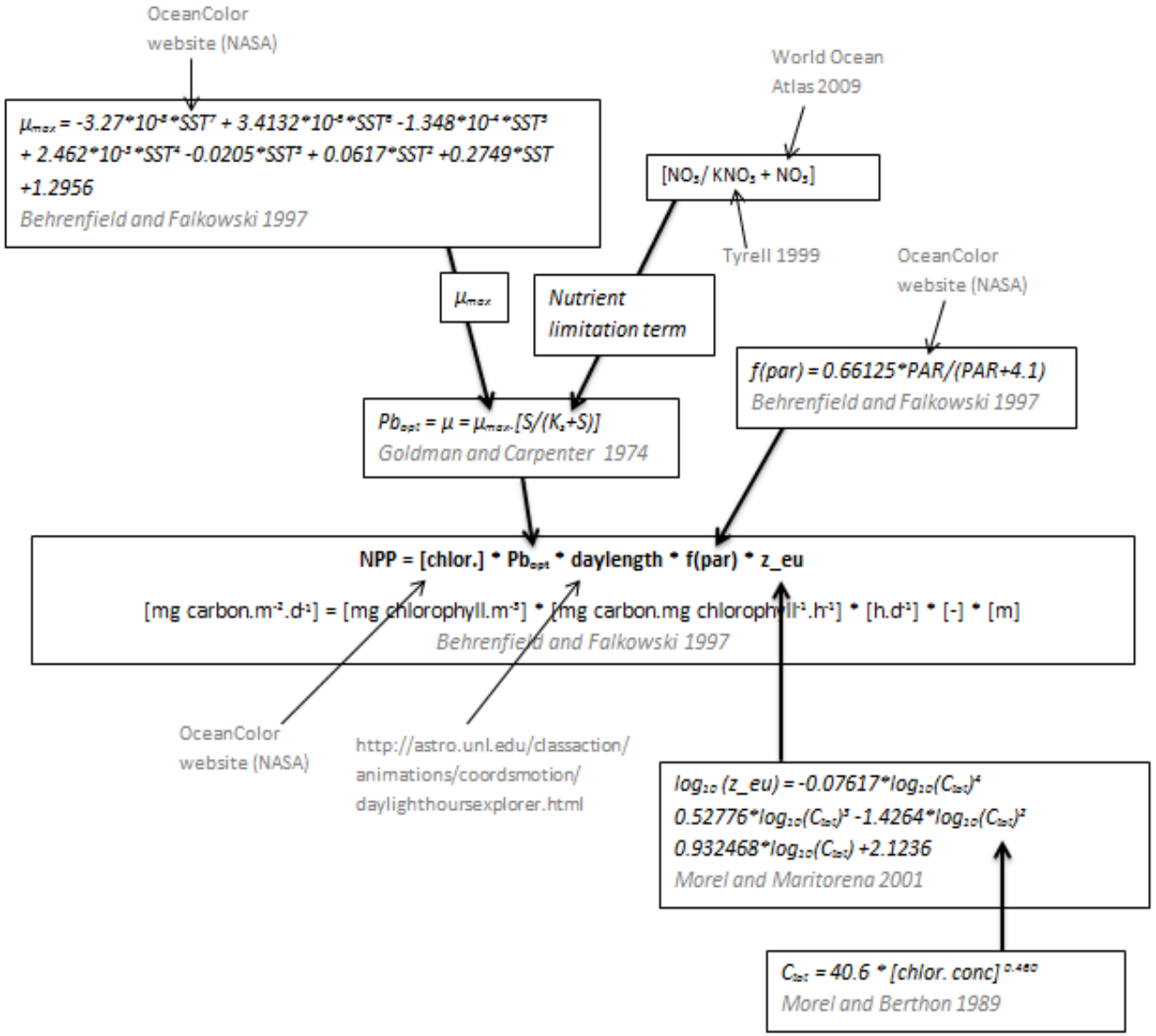

FAO 2010:
Global fisheries:
- Fish: 83%
- Molluscs: 8%
- Crustaceans: 7%

| Fish | | Molluscs | | Crustaceans | | Seaweed | |
|---|---|---|---|---|---|---|---|
| $MJ_{ex}$/kg FW | $MJ_{ex}$ /kg DW | $MJ_{ex}$ /kg FW | $MJ_{ex}$ /kg DW | $MJ_{ex}$ /kg FW | $MJ_{ex}$ /kg DW | $MJ_{ex}$ /kg FW | $MJ_{ex}$ /kg DW |
| 6.6 | 25.3 | 3.9 | 23.1 | 5.0 | 23.7 | 2.4 | 15.3 |

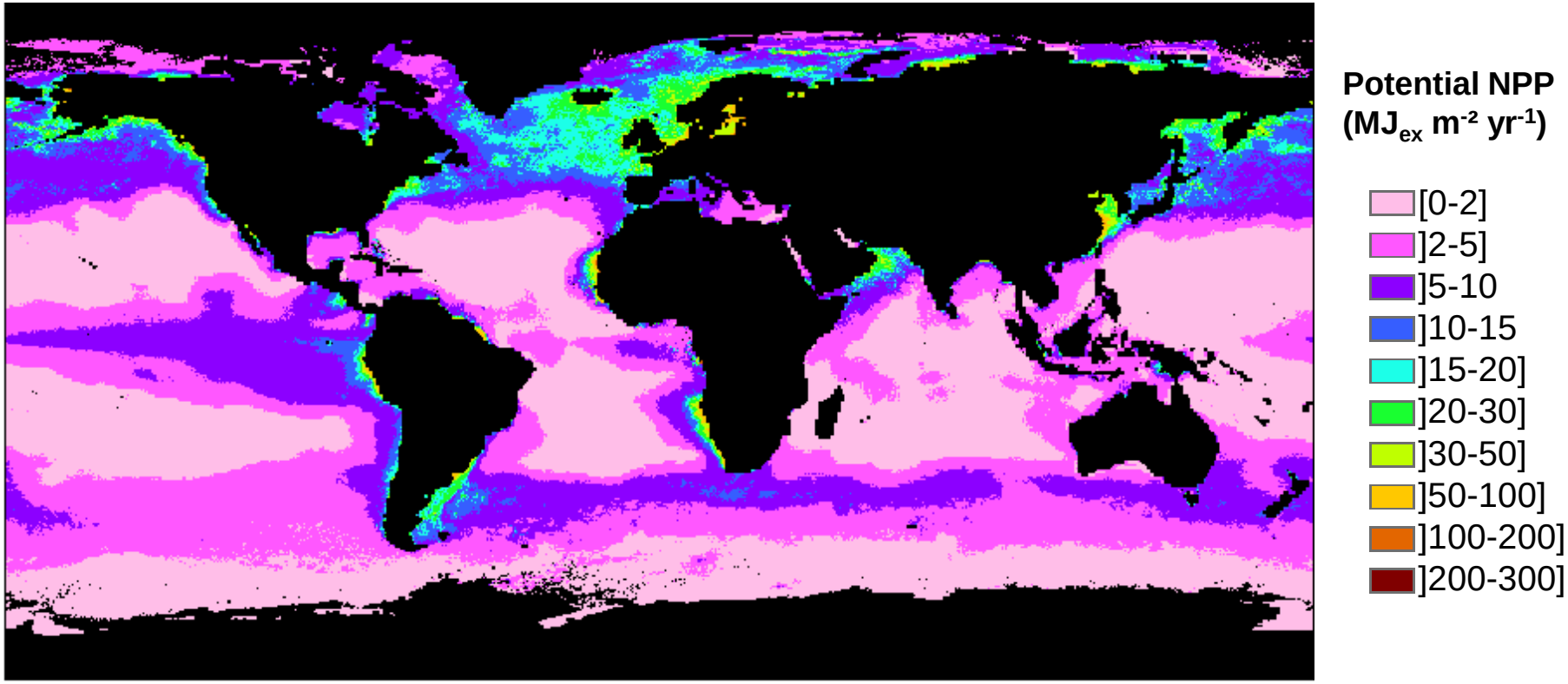
Taelman et al., 2014

## ***Human-made:***

Development of NPP marine world maps ($MJ_{ex}$ $m^{-2}$ $year^{-1}$)



# *Human-made*



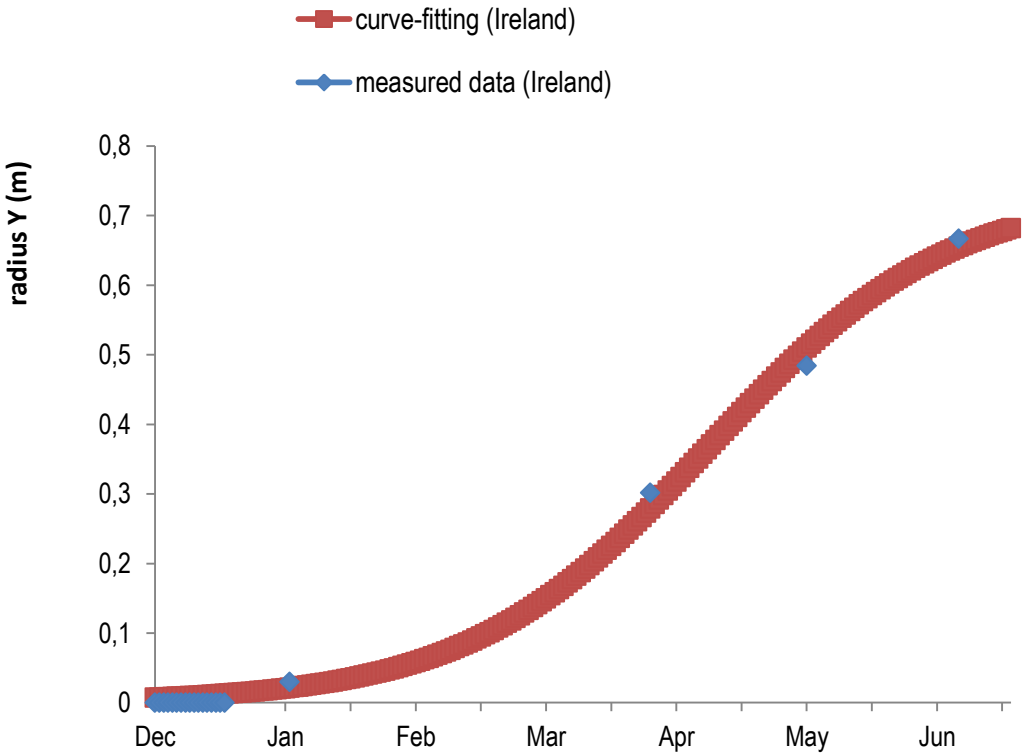

Area-weighted CF's for coastal regions (level of realms, provinces or ecoregions according to Spalding et al. 2007) and open ocean

Taelman et al., 2014

# Case Seaweed cultivation system in NW Europe:

Partial shading → natural NPP production is not fully avoided and an *occupation factor α* (between 0-1) is introduced

West Coast of Ireland






$$\alpha = \left(\sum_{X=1}^{365} \frac{effective\ sea\ surface\ occupation\ (X)}{total\ sea\ surface\ occupation}\ x100\right)/365$$

**= 2%**

THANK YOU