Research projects on creating global Monetary/Energy/Material EE SUT

Experiences from EU FP7 CREEA and other projects

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Director Institute of Environmental Sciences (CML), Leiden University (70%) and TNO (30%) per 1 October 2013, small visiting position at NTNU

- Chemist, RUU, 1987
- Ministry of Environment < 1990, after this TNO, Program manager Sustainable Innovation & Economy (5 Mio Euro/yr)
- PhD in policy sciences, Tilburg University, 1997, prof. J. Cramer
- 20% professor of Sustainable Innovation, NTNU, Trondheim, Norway

London Group meeting, 12-14 November 2013, London

Introduction

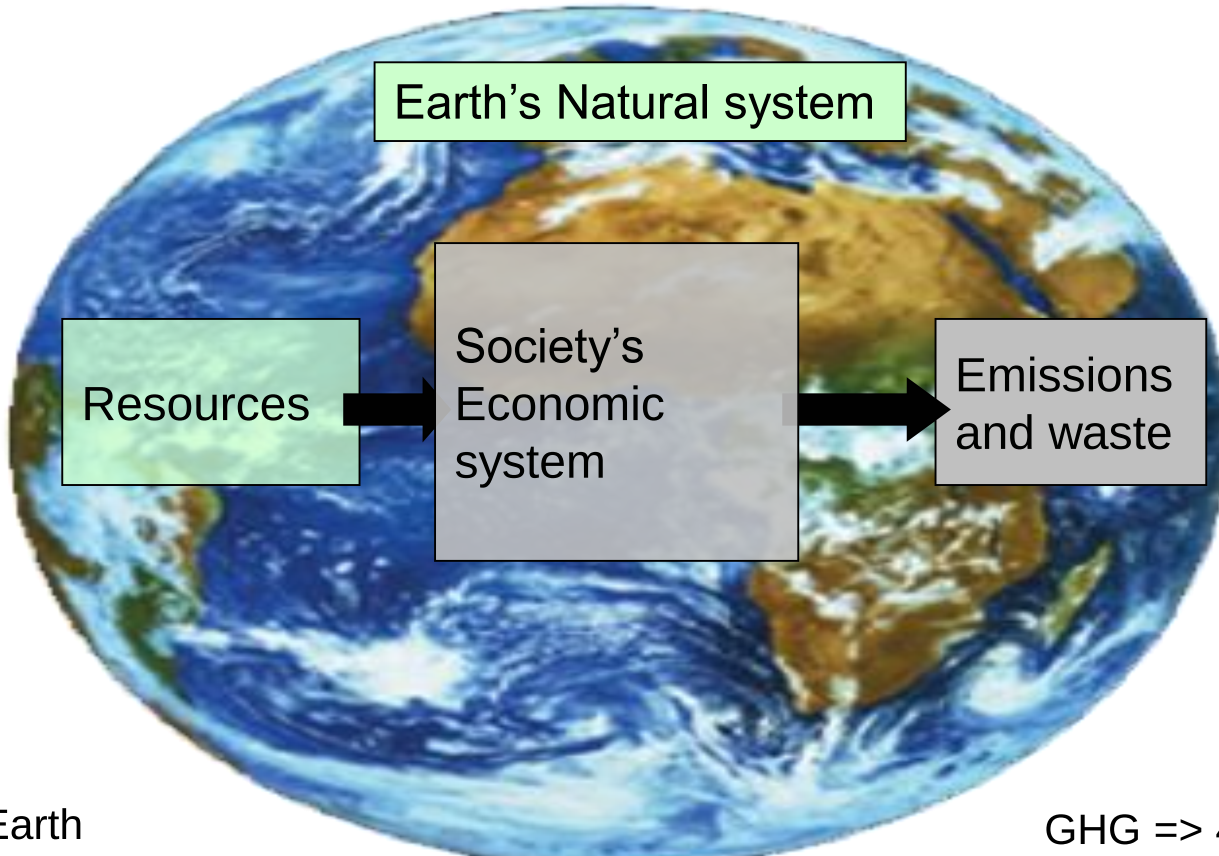
1. **Resource Efficiency**, **Green Economy** and **Sustainable Consumption** are key UN and EU policies

2. **Eurostat** and **EEA** are the EU's official data and indicator providers

3. CML, TNO, NTNU, and partners gave major scientific support
   - Eurostat Data Centre Projects
   - Some 15 Million Euro of EU FP7 projects on global databases (EXIOPOL, CREEA, DESIRE, CARBON CAP)
     - 43 countries linked via trade
     - 160 sectors and product groups per country
     - 40 emissions, 80 resources, land and water per sector
     - Improvement of various impact indicators

4. This presentation
     - How we conceptualise the use of UN SEEA
     - State of the art in our and other projects
     - Experience with data availability and examples of assessments


The sustainability problem

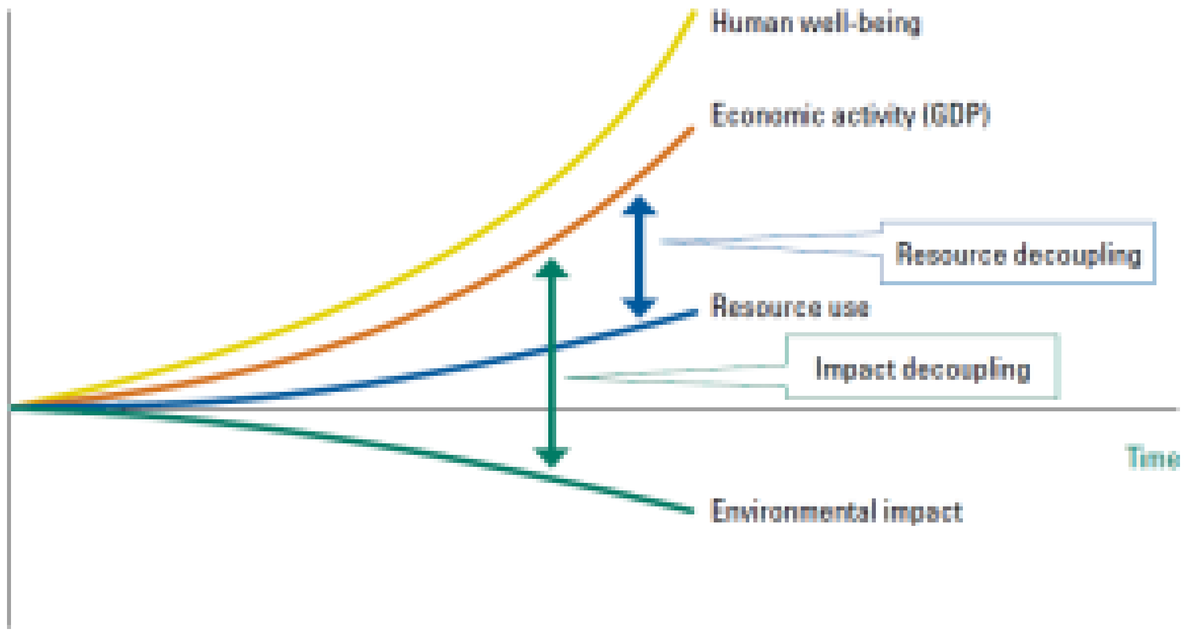


Footprint > 1 Earth
We deplete water, mineral & energy stocks
We use 35 % of biomass production
We have depleted fish stocks

GHG => 4-6 ^{o}C temp. Rise
Traffic emissions…
…etc.

What we want to measure and achieve

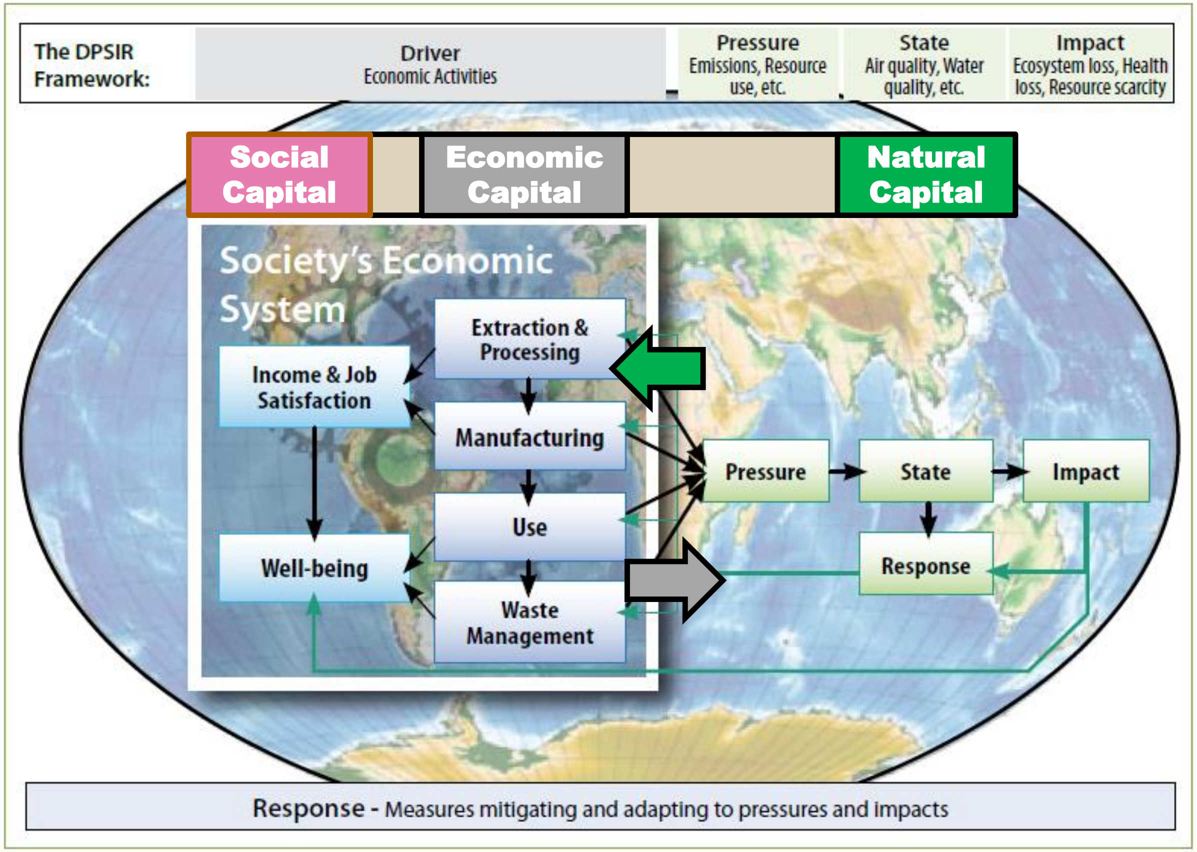
UN/EU/OECD/Chinese/Japanese agenda's on Sustainable Consumption and Production, Resource Efficiency, Green Economy…all aim at improved human well-being decoupled from resource use and emissions



How we conceptually summarize SEEA

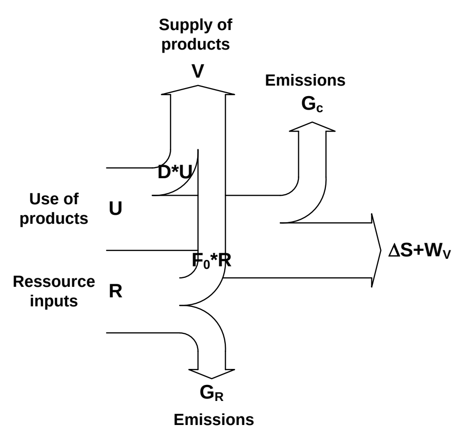
1. Elements

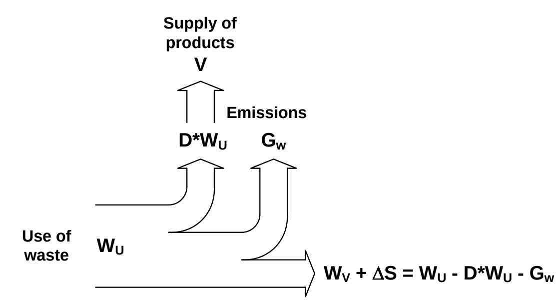
- Separate a Natural system and Socio-economic system
- Use Driver-Pressure-State-Impact-Response chain
- Include Natural-Economic-Social capital stocks
- Global MR Input-Output Framework with extensions for economic system



Some key working blocks covered in our projects

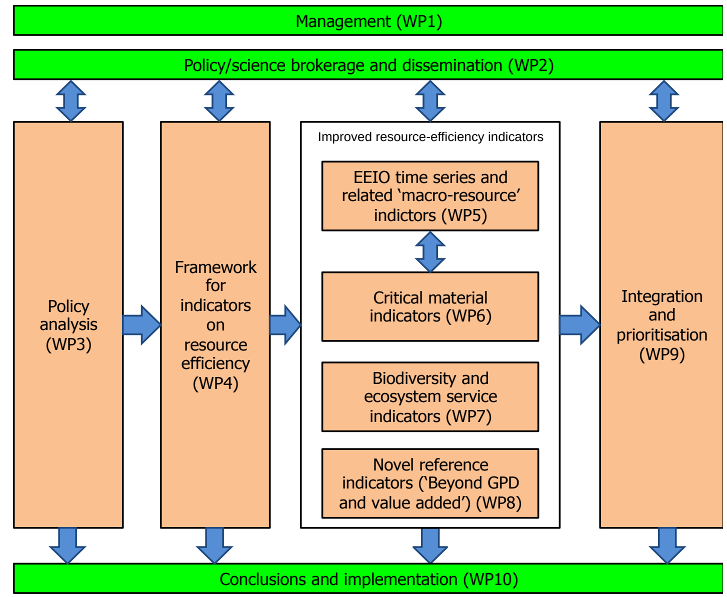
- EXIOPOL: Global MR EE IO/SUT 43 countries, 129 sectors, 40 emissions, 80 resources, land, water for 2000 – finished
- CREEA:
  - Deeper experimentation with water, material/waste, forestry and carbon accounts
  - Where possible feeding into the 2007 version of EXIOBASE
  - New features
    - (Almost) full product detail of IEA energy products
    - Improved detailing and trade linking, using real transport and insurance information for margins
    - Estimated global physical-energy SUT which balances waste and material flows

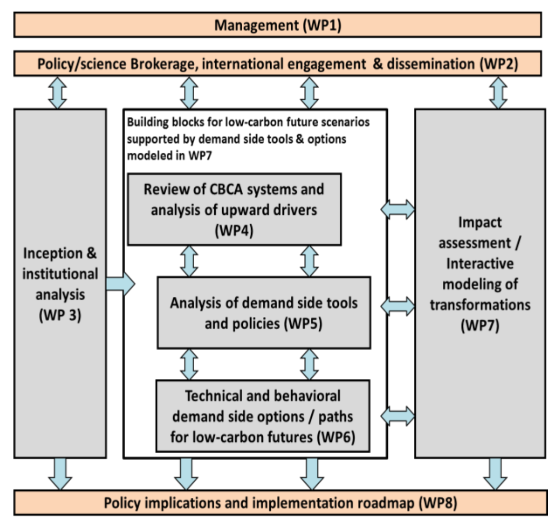





Some key working blocks covered in our projects

- DESIRE: Indicators for Res. Eff
  - EXIOBASE time series
  - Extra focus on
    - <u>critical materials</u>
    - <u>Biodiversity & ecosystem service indicators linked to economic activities</u>
    - <u>Beyound GDP as reference</u>
    - <u>Selecting meaningful indicators</u>
- CARBON-CAP: Consumption based carbon accounts
  - <u>Uncertainty assessments</u>
  - Policy measures & scenarios





Review of similar work

TABLE 1. Review of the main GMRIO databases.

Database name	Countries	Type	Detail ($i \times p$)*	Time	Extensions	Approach
EORA	World (around 150)	MR SUT/IOT	Variable (20–500)	1990–2009	Various	Create initial estimate; gather all data in original formats; formulate constraints; detect and judge inconsistencies; let routine calculate global MR SUT/IOT
EXIOPOL	World (43 + RoW)	MR SUT	129×129	2000**	30 emissions, 60 IEA energy carriers, water, land, 80 resources	Create SUTs; split use into domestic and imported use; detail and harmonize SUTs; use trade shares to estimate implicit exports; confront with exports in SUT; RAS out differences; add extensions
WIOD	World (40 + RoW)	MR SUT	35×59	1995–2009, annually	Detailed socio-economic and environmental satellite accounts	Harmonize SUTs; create bilateral trade database for goods and services; adopt import shares to split use into domestic and imported use; trade information for RoW is used to reconcile bilateral trade shares; add extensions
GTAP-MRIO	World (129)	MR IOT	57×57	1990, 1992, 1995, 1997, 2001, 2004, 2007	5 (GWP), Land use (18 AEZ), energy volumes, migration	Harmonize trade; use IOTs to link trade sets; IOT balanced with trade and macro-economic data
GRAM	World (40)	MR IOT	48×48	2000, 2004	Various	Use harmonized OECD IOTs; neglect differences like ixi and pxp; use OECD bilateral trade database to trade link
IDE-JETRO	Asia-Pacific (8: 1975) (10: 1985–2005)	MR IOT	56×56 (1975) 78×78 (1985–1995), 76×76 (2000, 2005)	1975–2005	Employment matrices (2000, 2005)	Harmonize IOTs based on cross-country survey information; link via trade, manual balancing to reduce discrepancies within a certain bounds

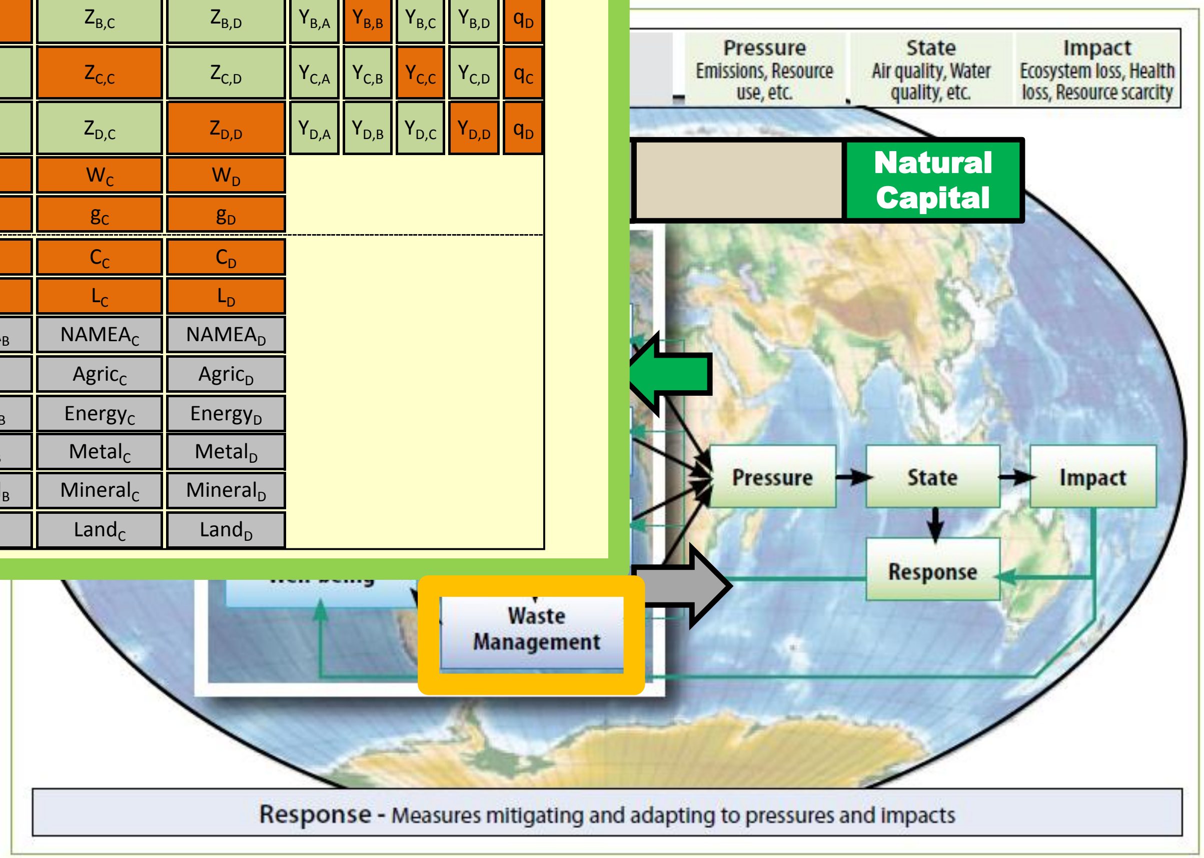
*i = number of industries, p = number of products, **The follow-up project CREEA constructs the EE GMRIO for 2007.

Tukker, Dietzenbacher (2013), Economic systems research 25, p 1-19

Typical data situation: economic system

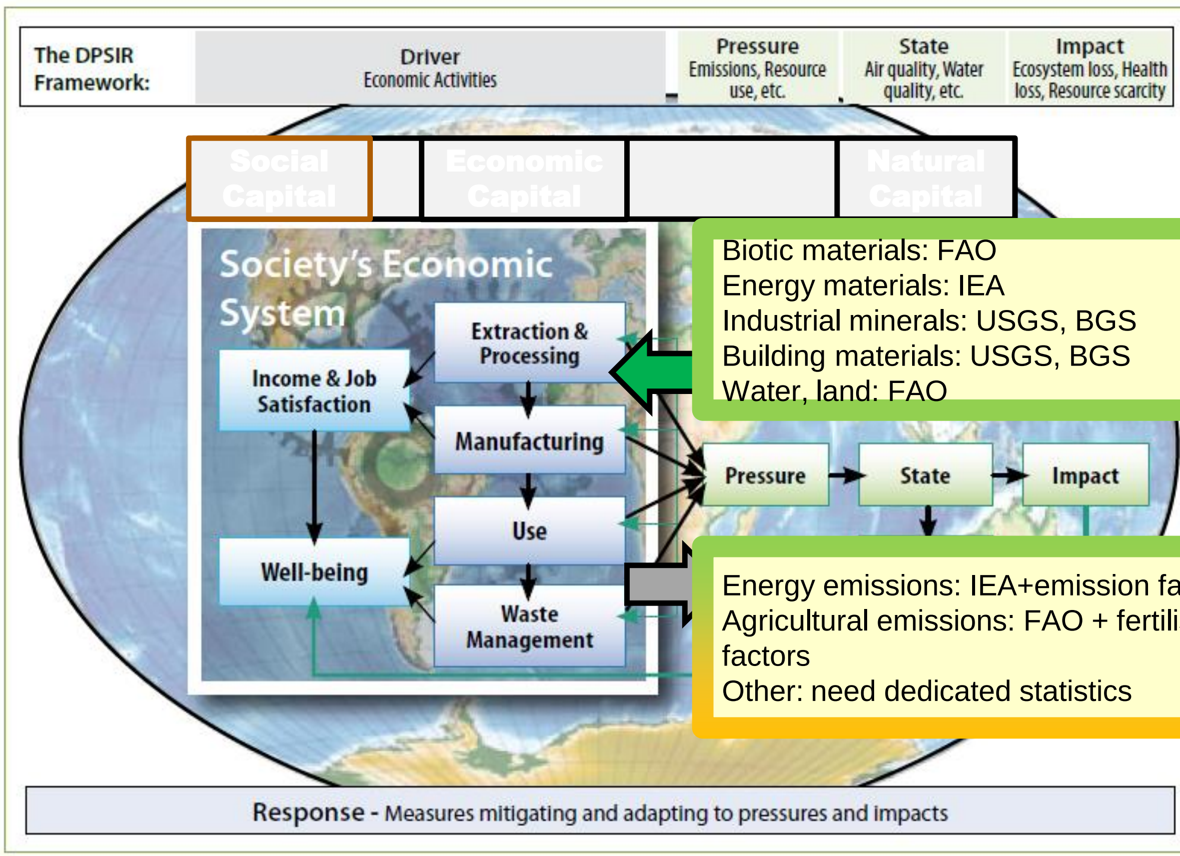
Economic data: UN SEEA supply & use / input output system: good (waste: medium)

	Industries				$Y_{*,A}$	$Y_{*,B}$	$Y_{*,C}$	$Y_{*,D}$	q
Products	$Z_{A,A}$	$Z_{A,B}$	$Z_{A,C}$	$Z_{A,D}$	$Y_{A,A}$	$Y_{A,B}$	$Y_{A,C}$	$Y_{A,D}$	q_A
Products	$Z_{B,A}$	$Z_{B,B}$	$Z_{B,C}$	$Z_{B,D}$	$Y_{B,A}$	$Y_{B,B}$	$Y_{B,C}$	$Y_{B,D}$	q_D
Products	$Z_{C,A}$	$Z_{C,B}$	$Z_{C,C}$	$Z_{C,D}$	$Y_{C,A}$	$Y_{C,B}$	$Y_{C,C}$	$Y_{C,D}$	q_C
Products	$Z_{D,A}$	$Z_{D,B}$	$Z_{D,C}$	$Z_{D,D}$	$Y_{D,A}$	$Y_{D,B}$	$Y_{D,C}$	$Y_{D,D}$	q_D
W	W_A	W_B	W_C	W_D					
g	g_A	g_B	g_C	g_D					
C & L	$Capital_A$	C_B	C_C	C_D					
C & L	$Labor_A$	L_B	L_C	L_D					
Environ Ext	$NAMEA_A$	$NAMEA_B$	$NAMEA_C$	$NAMEA_D$					
Environ Ext	$Agric_A$	$Agric_B$	$Agric_C$	$Agric_D$					
Environ Ext	$Energy_A$	$Energy_B$	$Energy_C$	$Energy_D$					
Environ Ext	$Metal_A$	$Metal_B$	$Metal_C$	$Metal_D$					
Environ Ext	$Mineral_A$	$Mineral_B$	$Mineral_C$	$Mineral_D$					
Environ Ext	$Land_A$	$Land_B$	$Land_C$	$Land_D$					



Typical data situation: pressures

Pressures: resource extraction good , emissions: good to medium

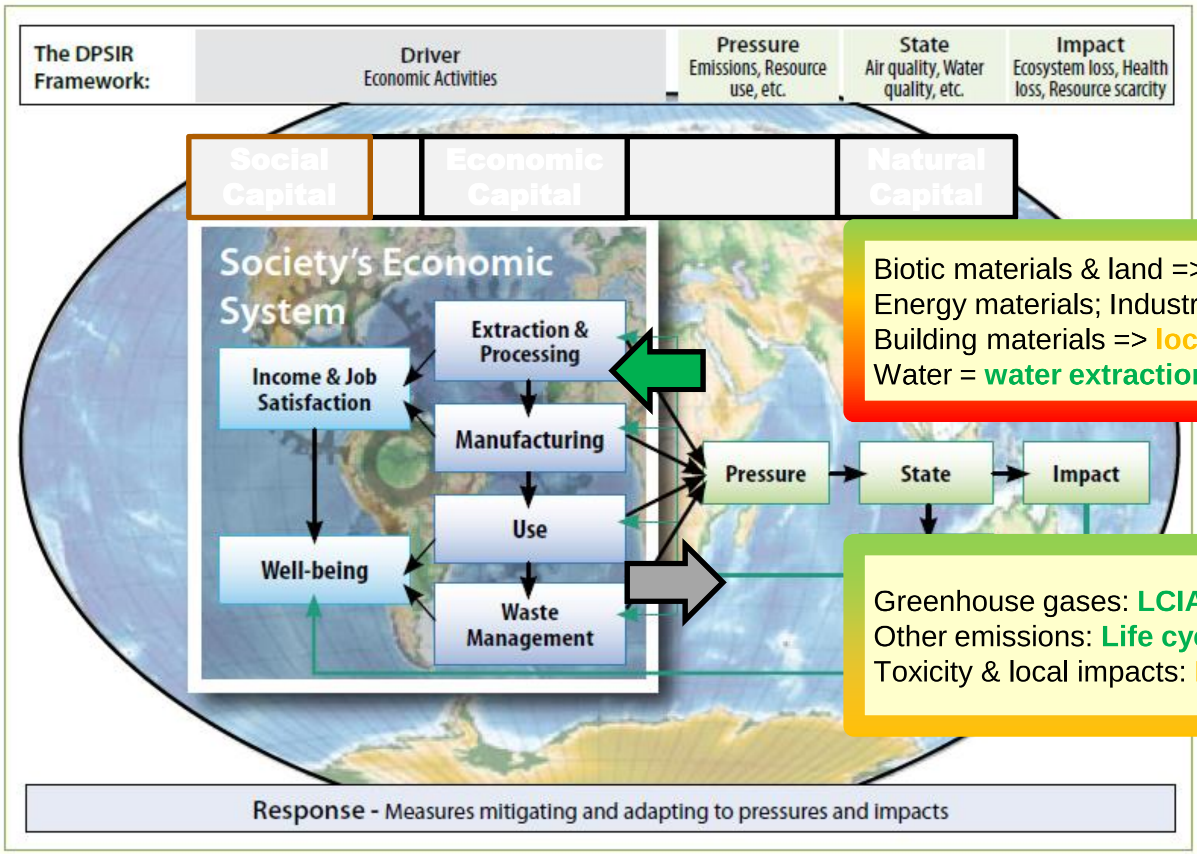


Biotic materials: FAO
Energy materials: IEA
Industrial minerals: USGS, BGS
Building materials: USGS, BGS
Water, land: FAO

Energy emissions: IEA+emission factors
Agricultural emissions: FAO + fertiliser use+emission factors
Other: need dedicated statistics

Typical data situation: impacts

Impact indicators: emissions good (global warming) to medium (toxic impacts); resources good (water) to bad (biodiversity)



Biotic materials & land => **biodiversity**
Energy materials; Industrial minerals;
Building materials => **local impacts**
Water = **water extraction index**

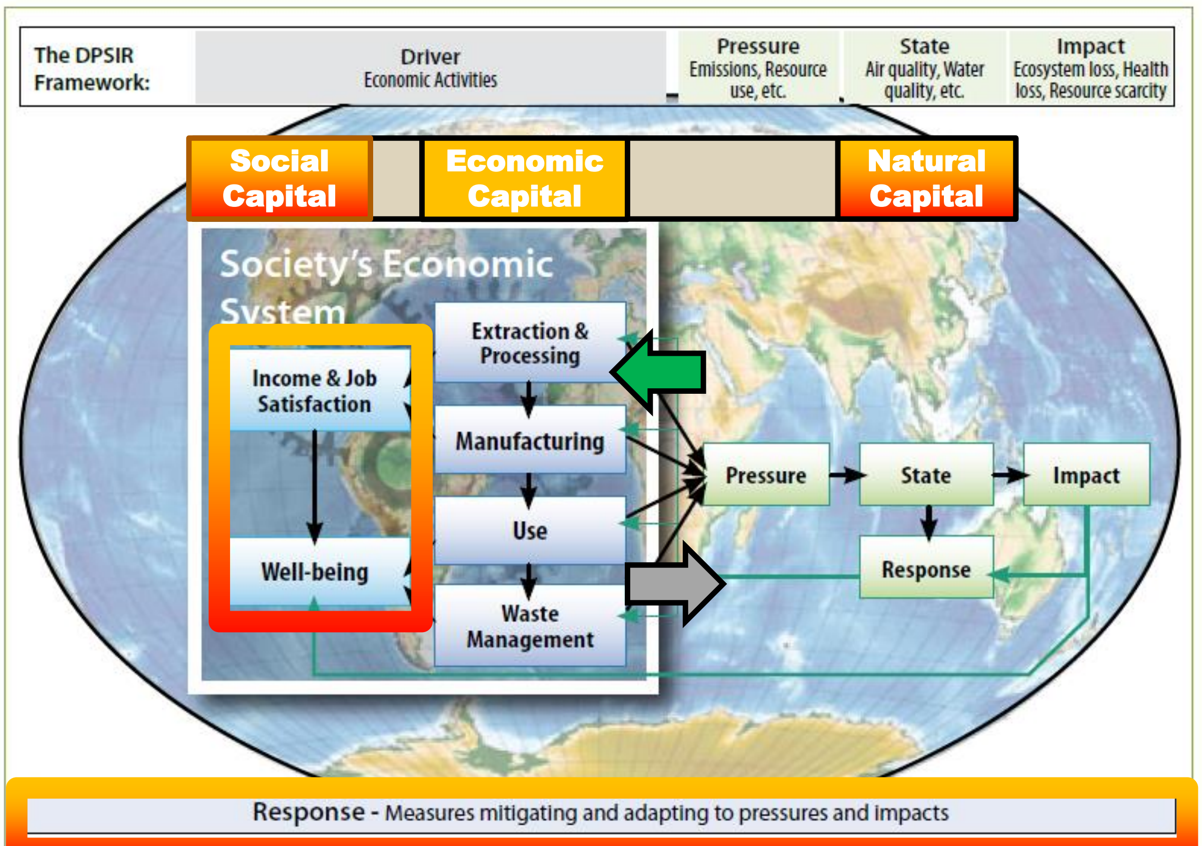
Greenhouse gases: **LCIA – GWP**
Other emissions: **Life cycle impact ass.**
Toxicity & local impacts: **Medium**

Typical data situation: responses & capital stocks

Responses: <u>**medium**</u> to <u>**bad**</u>

Economic capital: <u>**medium**</u>; Social and Natural capital: <u>**medium**</u> to <u>**bad**</u>;

limited insights in <u>**safe thresholds**</u>



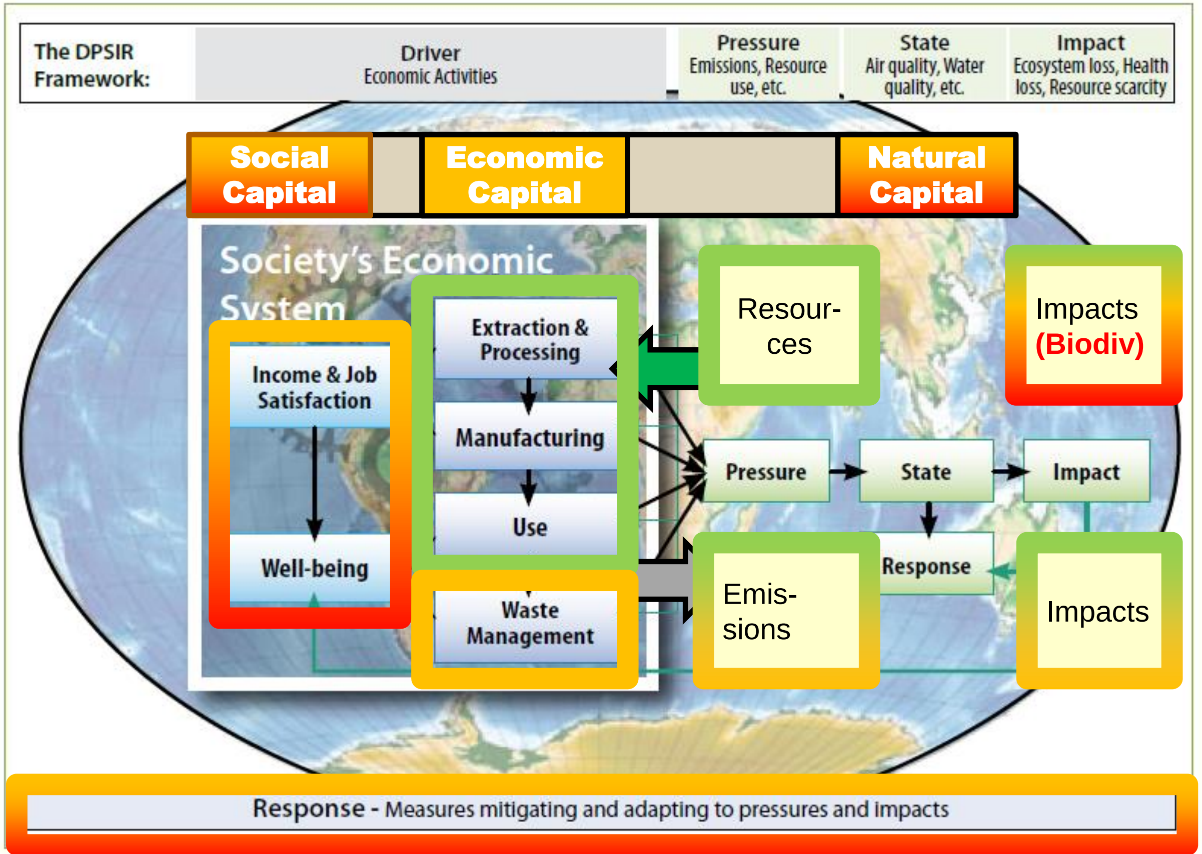

(Simplistic?) summary

“Good”: economic system; resource & emission pressures, some impacts

Medium: Some emission pressures, some impacts, economic capital, waste

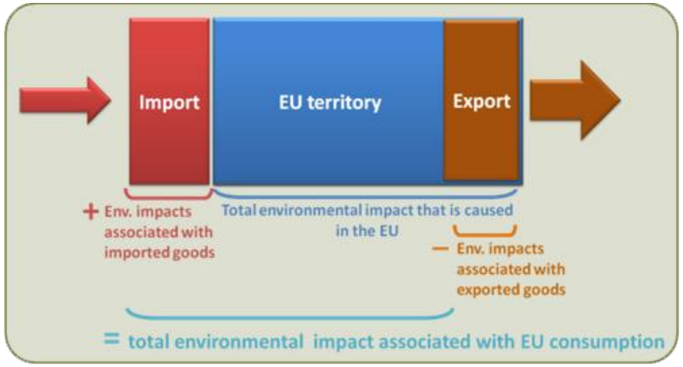
Bad: part of social capital, natural capital, responses, biodiversity impacts

Now to some examples with green boxes/available data!

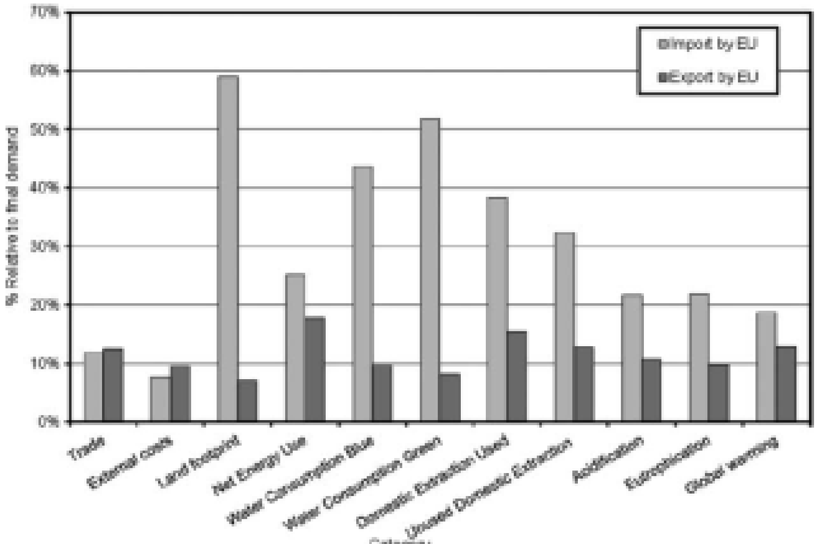


Example 1: Impacts of EU27 consumption

1. Consumption & production perspective



2. Example: % impacts of EU27 consumption abroad. Water, land, materials >30%



Note: Trade taken relative to Europe's final demand (which is given the small difference between exports and imports close to GDP). The global warming excludes emissions from land use change.

Source: EU FP6 EXIOPOL project, TNO, CML et al.

Example 2: 80% of impacts of consumption caused by

Food (meat and dairy)

Mobility

Housing (heating and cooling) and Electrical appliances

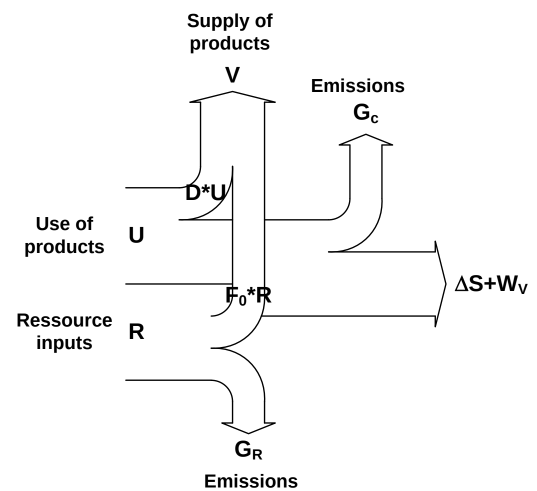
COICOP	Study	Dall et al.	Kok et al.	Labouze et al.	Nemry et al.	Nijdam and Wilting	CEDA EU25
	Indicator	Energy	Energy	GWP	GWP	GWP	GWP
	Main approach	Bottom-up	Hybrid	Bottom-up	Bottom-up	IO	IO
CP01-02	Food	26,2%	13,0%	7,0%NA	3,6%NA	22,1%	31,0%
CP03	Clothing	1,3%	2,2%	3,3%	1,3%	6,5%	2,4%
CP04-05	Housing	40,8%	54,3%	58,8%	53,5%	33,4%	23,6%
CP06	Health		1,8%		0,3%	0,3%	1,6%
CP07	Transport	19,5%	18,3%	29,6%	32,9%	17,3%	18,5%
CP08	Communication			0,0%	2,9%	0,0%	2,1%
CP09	Recreation	7,2%	8,1%	0,0%		15,1%	6,0%
CP10	Education		1,8%			0,7%	0,5%
CP11	Restaurants					2,8%	9,1%
CP12	Miscellaneous	5,1%	0,4%	1,3%	5,4%	1,8%	5,2%
	TOTAL	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%

Source: EIPRO study, TNO, CML, VITO and DTU for DG JRC IPTS


Example 3: Resource-efficiency by sector

- Advanced method
- Estimates not only economic, but also physical relations in an Input-Output table
- Per sector
  - Input intermediate products + resources
  - Output of manufactured products
  - Output of waste and emissions

	Industries				$Y_{*,A}$	$Y_{*,B}$	$Y_{*,C}$	$Y_{*,D}$	q
Products	$Z_{A,A}$	$Z_{A,B}$	$Z_{A,C}$	$Z_{A,D}$	$Y_{A,A}$	$Y_{A,B}$	$Y_{A,C}$	$Y_{A,D}$	q_A
	$Z_{B,A}$	$Z_{B,B}$	$Z_{B,C}$	$Z_{B,D}$	$Y_{B,A}$	$Y_{B,B}$	$Y_{B,C}$	$Y_{B,D}$	q_D
	$Z_{C,A}$	$Z_{C,B}$	$Z_{C,C}$	$Z_{C,D}$	$Y_{C,A}$	$Y_{C,B}$	$Y_{C,C}$	$Y_{C,D}$	q_C
	$Z_{D,A}$	$Z_{D,B}$	$Z_{D,C}$	$Z_{D,D}$	$Y_{D,A}$	$Y_{D,B}$	$Y_{D,C}$	$Y_{D,D}$	q_D
W	W_A	W_B	W_C	W_D					
g	g_A	g_B	g_C	g_D					
C & L	$Capital_A$	C_B	C_C	C_D					
	$Labor_A$	L_B	L_C	L_D					
Environ Ext	$NAMEA_A$	$NAMEA_B$	$NAMEA_C$	$NAMEA_D$					
	$Agric_A$	$Agric_B$	$Agric_C$	$Agric_D$					
	$Energy_A$	$Energy_B$	$Energy_C$	$Energy_D$					
	$Metal_A$	$Metal_B$	$Metal_C$	$Metal_D$					
	$Mineral_A$	$Mineral_B$	$Mineral_C$	$Mineral_D$					
	$Land_A$	$Land_B$	$Land_C$	$Land_D$					



Source: EU FP7 CREEA project, TNO, 2-0 LCA, CML, NTNU, SERI, others

TNO innovation for life

Example 4: Redundancy of indicators revisited

Despite the many indicator systems, the consumption perspective and impact indicators often are forgotten

	Pressures		Impacts	
	EU27 territory	Consum-ption	EU27 territory	Consum-ption
Material Use	Domestic material use **Domestic Material Consumption** 7	Global material demand **Raw Material Consumption** 2	***Territorial part of*** **Life-Cycle Resource Indicator** *(Env. weighted Material Consumption)* 0	**Life-Cycle Resource Indicator** *(Env. weighted Material Consumption)* 0
Energy Use & Climate Change	Domestic energy use **Gross Inland Energy Cons.** 4	Global energy demand **Energy Footprint** 0	Domestic GHG emissions **Territorial GHG Emissions** 12	Global GHG emissions **Carbon Footprint** 4
Water use	Domestic water use **Water abstraction** 4	Global water demand **Water Footprint** 2	Domestic water exploit. **Water Exploitation Index** 2	Global water exploit. **Global Water Consumption Index** 0
Land Use	Domestic land use **Domestic Land Demand** 2	Global land demand **Actual Land Demand (Footprint)** 3	Domestic LU intensity **Human Appropriation of Net Primary Production** 0	Global LU intensity *eHANPP, LEAC and other indicators on ecosystem quality* 0

Source: EU FP7 DESIRE project, TNO et al.


TNO innovation for life

Recommendations (done at UN Beijing Workshop)

1. Use **UN SEEA** as an agreed **coherent concept**
2. Work where possible with **existing data & indicator compilers**
3. Use **UN SEEA**, existing **economic accounts** and **pressure databases** in combination with **existing impact assessment methods**
4. Use an EE IO framework: ensures that with territorial accounts you can calculate **consumption-based accounts**
5. Research community but also London Group members have developed harmonization routines already good enough for a first informal data set
   - Detailing & harmonization
   - Linking via trade
   - Estimating emissions & resource uses with existing macro-databases

6. Data gaps: likely on **social capital**, **natural capital/state**, **responses**
7. Improve scientific basis for **impact indicators (e.g. biodiversity)**
8. Improve insights in **thresholds related to natural and social capital**

Conclusions and recommendations

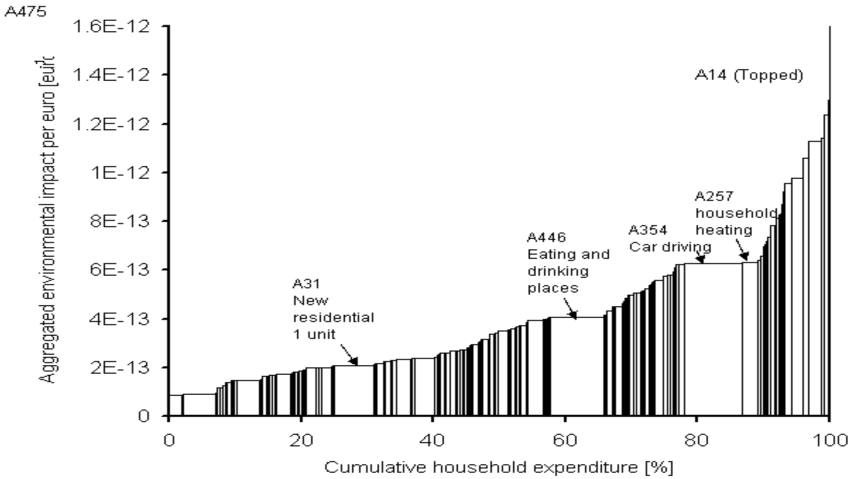
1. Global MR EE IO databases are **<u>still in development</u>**; going in one step to a statistical accepted database is now too much
2. In the next 1-2 years we get much insight in **<u>uncertainties between databases</u>**
3. There is however a need to go **<u>‘beyound just research status’</u>**
4. How can we realise this? Some ideas
   - Get NSI Directors of some 5-10 interested countries/regions working already on this behind this (via a side event on an UN SD meeting?)
   - Joint project of such countries + researchers
     - Best practices
     - Maybe combining some first official data sets
     - Cf OECD working group on MFA
   - Use of international funding like Europe Aid Switch Asia for practical projects with Asian Statistical offices

Thanks for your attention!

Slides with additional examples

What you can calculate with EE SUT and IOT

- EU EIPRO (480 sector EE IOT)
  - Priority setting of products
  - Proved that food, mobility and housing were prio’s
- EU Diet change
  - Change to healthy diets by changing demand vector
  - Showed rebounds by linking EE IOT to the CAPRI model



Tukker (ed., 2006), Journal Industrial Ecology 10: 3

	Aggregated environmental impacts (%)			
	Scenario 0: Status quo	Scenario 1: Recommendations	Scenario 2: Recommendations including red meat reduction	Scenario 3: Mediterranean
Sub-scenario ‘All’				
Food	27	27	25	25
Non-food	73	73	73	73
Total	100	100	98	98
Sub-scenario ‘All + first order’				
Food	27	27	25	25
Non-food	73	73	74	73
Total	100	100	99	98
Sub-scenario ‘All + first and second orders’	100	100	99	99

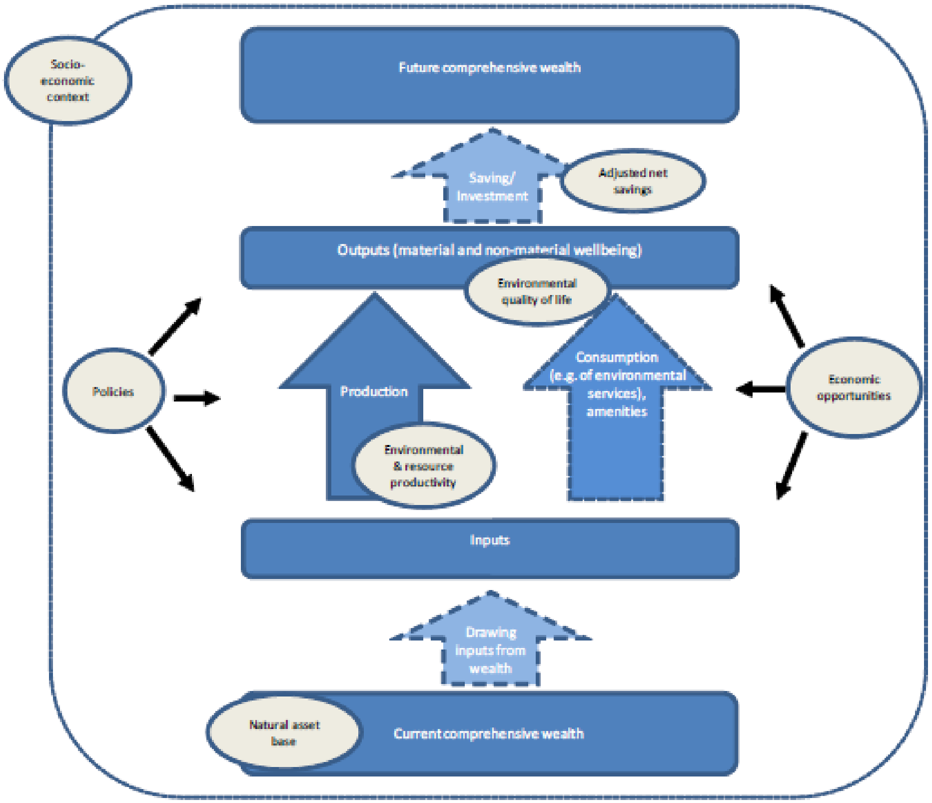
Tukker et al., 2011, Ecological Economics (in press)

Based on a string of EU funded projects next to EEA and Eurostat work

1. Goal: building the most ambitious macro-database and dynamic model for
   - Economic interactions in and between countries (MR IO Table)
   - At a > 130 sector and product level
   - Including detailed emission and resource extraction data
2. Role of each project (total 15 Mio Euro, with TNO, CML, NTNU, SERI, others)
   - EXIOPOL: first version of the database, TNO government money: first version of a dynamic CGE model (EXIOMOD)
   - CREEA: 2^{nd} base year; water extraction by river basin; using IEA and other information to create the worlds first physical and energy MR IO linked to economic data
   - DESIRE: builds MR EE IO time series; adds biodiversity indicators; rigorous assessment of resource indicators; identification of ‘minimum useful set’
   - CARBON-CAP: consumption based emission analysis for climate policy
   - EMINIMM: quantifies diffusion of eco-innovation, to be fed into our model
   - POLFREE: aligns EXIOMOD with an environmental model; sophisticated evaluation of resource efficiency scenarios for Europe
   - DG ENV: visible scenario-analysis with the EXIOMOD model

To avoid indicator proliferation, we need a concept

1. Is in part logic thinking
2. Is in part alignment
3. Example: Green growth knowledge platform
    - Inputs: the natural asset base
    - Production: intensity/productivity
    - Outputs: material and non-material wellbeing



Note: White ovals represent indicator categories.

To sum up

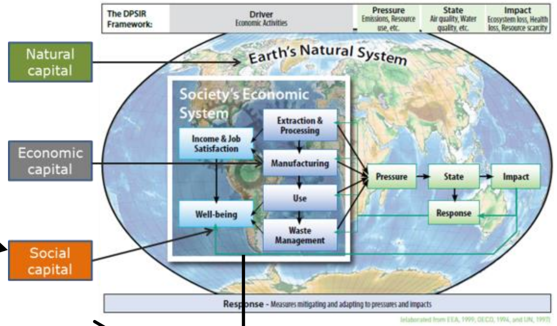
1. Measure natural capital stock / Environmental state & relevant thresholds

2. Measure well-being and social capital stock

3. Measure responses

4. Get detailed stock-flow data of the economic system and its material flows and emissions; f.i. in an EE IO format following UN SEEA – which includes
    - Drivers
    - Capital stock

5. Gives one related dataset allowing for calculating pressures and impacts, from a consumption and territorial perspective



		Industries				$Y_{*,A}$	$Y_{*,B}$	$Y_{*,C}$	$Y_{*,D}$	q
Products		$Z_{A,A}$	$Z_{A,B}$	$Z_{A,C}$	$Z_{A,D}$	$Y_{A,A}$	$Y_{A,B}$	$Y_{A,C}$	$Y_{A,D}$	q_A
		$Z_{B,A}$	$Z_{B,B}$	$Z_{B,C}$	$Z_{B,D}$	$Y_{B,A}$	$Y_{B,B}$	$Y_{B,C}$	$Y_{B,D}$	q_D
		$Z_{C,A}$	$Z_{C,B}$	$Z_{C,C}$	$Z_{C,D}$	$Y_{C,A}$	$Y_{C,B}$	$Y_{C,C}$	$Y_{C,D}$	q_C
		$Z_{D,A}$	$Z_{D,B}$	$Z_{D,C}$	$Z_{D,D}$	$Y_{D,A}$	$Y_{D,B}$	$Y_{D,C}$	$Y_{D,D}$	q_D
W		W_A	W_B	W_C	W_D					
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C & L		$Capital_A$	C_B	C_C	C_D					
		$Labor_A$	L_B	L_C	L_D					
Environ Ext		$NAMEA_A$	$NAMEA_B$	$NAMEA_C$	$NAMEA_D$					
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		$Energy_A$	$Energy_B$	$Energy_C$	$Energy_D$					
		$Metal_A$	$Metal_B$	$Metal_C$	$Metal_D$					
		$Mineral_A$	$Mineral_B$	$Mineral_C$	$Mineral_D$					
		$Land_A$	$Land_B$	$Land_C$	$Land_D$					

Some examples

1. Natural capital & thresholds

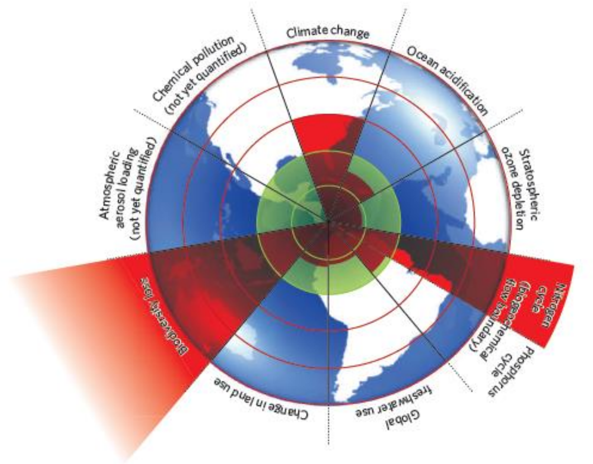
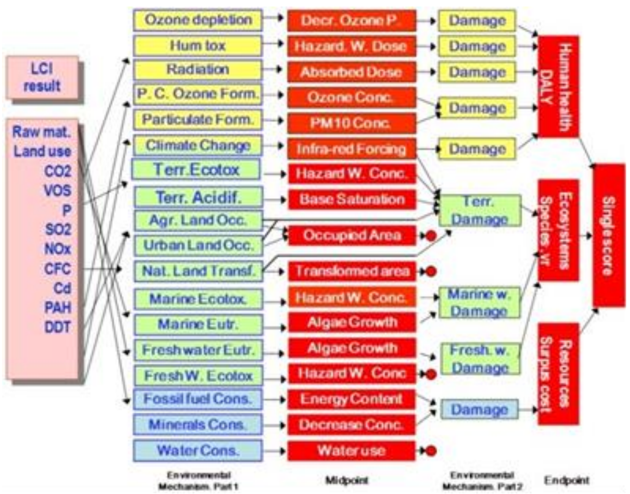


Figure 1 | Beyond the boundary. The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded.

2. Well being and social capital (-)

3. Responses (-)

4. Stock-flow data in economy and related pressures and impacts

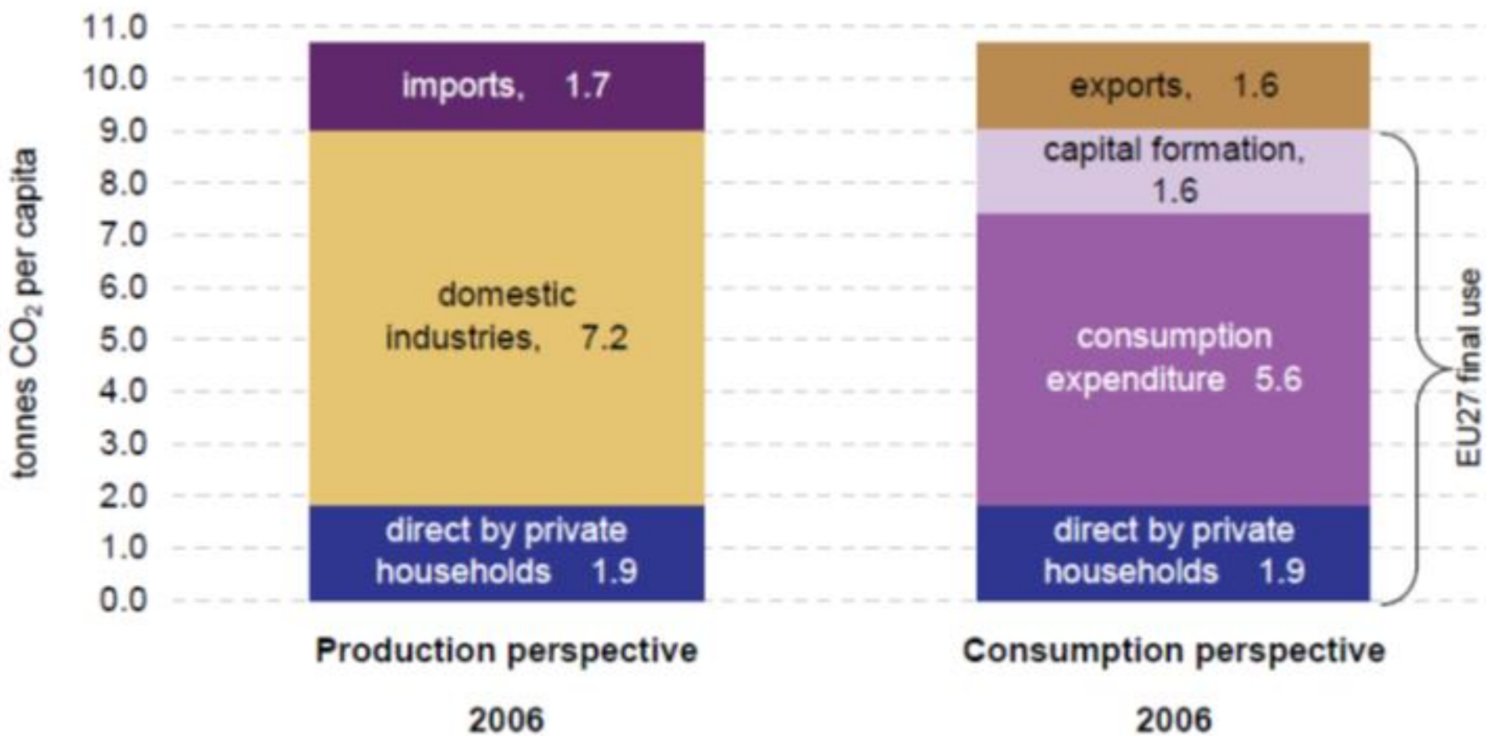


TNO innovation for life

How to select the 'best' indicator set

- Use the RACER concept
  - relevant,
  - acceptable,
  - credible,
  - easy and
  - robust'
- Use the Policy Cycle Concept – do the indicators help in all steps?
- Use correlation analysis to understand which headline indicators have most saying power

Example 2: Carbon emissions of EU (Eurostat)



Source: Eurostat EE SUT/IOT project, DG JRC IPTS, TNO, CML, NTNU, RUG

What are the key policy objectives?

1. SCP

*"the use of services and related products which respond to basic needs and bring a **better quality of life** while **minimizing the use of natural resources** and toxic materials as well as the emissions of waste and pollutants over the life-cycle so as not to jeopardize the needs of future generations*

2. Green Economy

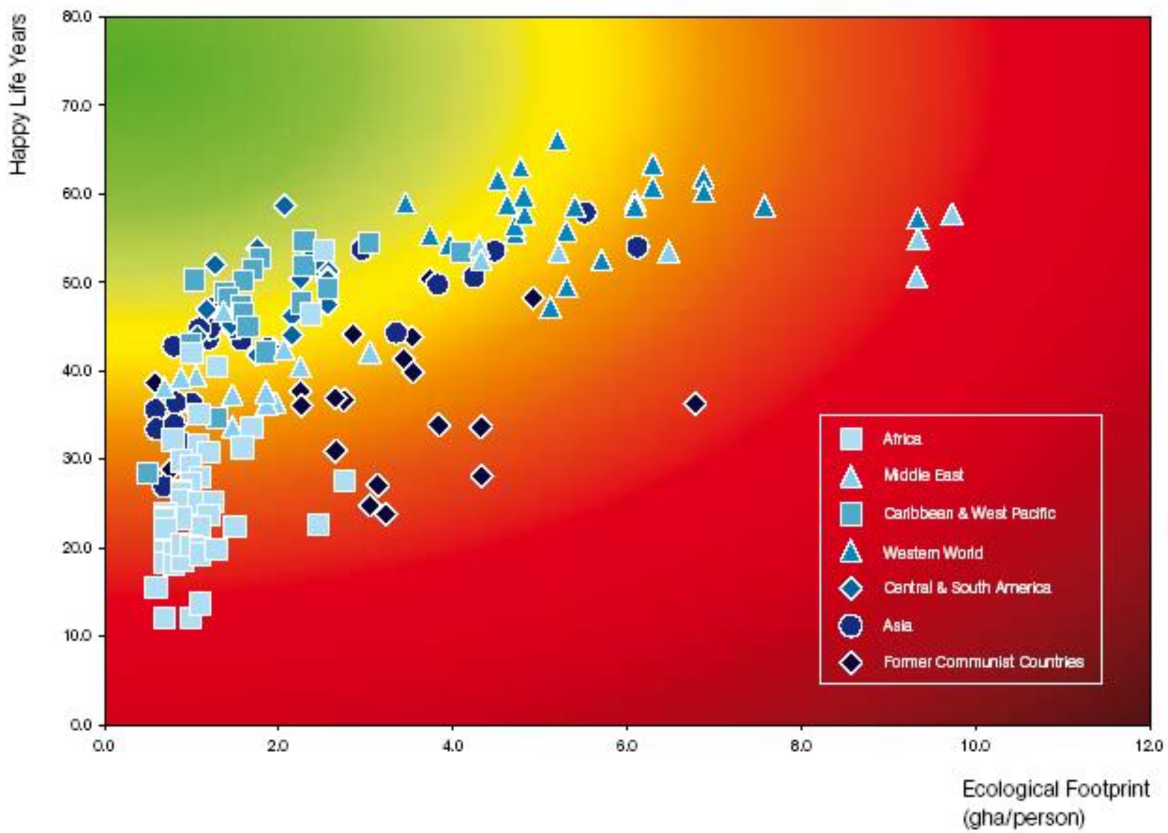
*"one that results in **improved human well-being** and social equity, while significantly **reducing environmental risks and ecological scarcities**"*

3. Resource Efficiency

*using the Earth's limited resources in a sustainable manner while minimising impacts on the environment. It allows us to create more with less and to **deliver greater value** with **less input***

Example 4: Quality of life versus impacts

Happy life years versus ecological footprint by country



Source: new economics foundation