

ENV 501 / GR A3 30

Material Flow Analysis and resource management

Prof. Dr. Claudia R. Binder claudia.binder@epfl.ch

Dr. Maria A. Hecher maria.hecher@epfl.ch

Dr. Francisco Xavier Felix Martin Del Campo francisco.felixmartindelcampo@epfl.ch

Exercices Teacher Assistant Jaïr Campfens jair.campfens@epfl.ch

Student Assistant Alicia Pérez Domouso alicia.perezdomouso@epfl.ch

- Florian Kohler, Swiss EW-MFA and the FSO
- Extension to circular flows
- Urban Metabolism vs. Urban MFA
- System boundaries of cities
- Accounting approaches and methods
- Where to find data

Course outline

8:15 - 9:00 and 9:15 - 10:00

13:15 - 14:00

14:15 - 15:00

Block I:
EW-MFA
global /
national

W1 - Sep 12

Introduction to the course and general concepts

All

Exercise

Project

W2 - Sep 19

EW – MFA and EW – MFA in different countries

FMC

Exercise

Project

W3 - Sep 26

EW – MFA in the Swiss context, Urban Metabolism

External Guest –
Florian Kohler

Exercise

Project

W4 - Oct 03

EW – MFA in the Swiss context: Cantons and Circular Economy

Exercise

Project

W5 - Oct 10

The Service-Stock-Flows Nexus

CRB

Exercise

Project

W6 - Oct 17

Dynamic MFA

External Guest –
Stefan Pauliuk

Exercise

Project

Oct 24

Autumn break

Block II:
MFA
regional /
urban

W7 - Oct 31

Spatial MFA

FMC

Exercise

Project

W8 - Nov 07

Input-Output Analysis and Material Flow Cost Accounting

External Guest –
Vincent Moreau

Exercise

Project

W9 - Nov 14

MFA and Uncertainty

External guest –
Stefan Pauliuk

Exercise

Project

W10 - Nov 21

Case studies: Waste management in Indonesia / Critical Raw Materials in the Swiss context

GF & FMC

Exercise

Project

Block III:
Social
sciences
and
public
policy

W11 - Nov 28

Social Metabolism

CRB

Exercise

Project

W12 - Dec 05

Agent-based model

CRB, FMC, MAH,
SLC

Past exam

Project

W13 - Dec 12

Group Project Presentation

CRB, FMC, MAH

Project

Project

W14 - Dec 19

Group Project Presentation

CRB, FMC, MAH

Project

Project

Content of lecture

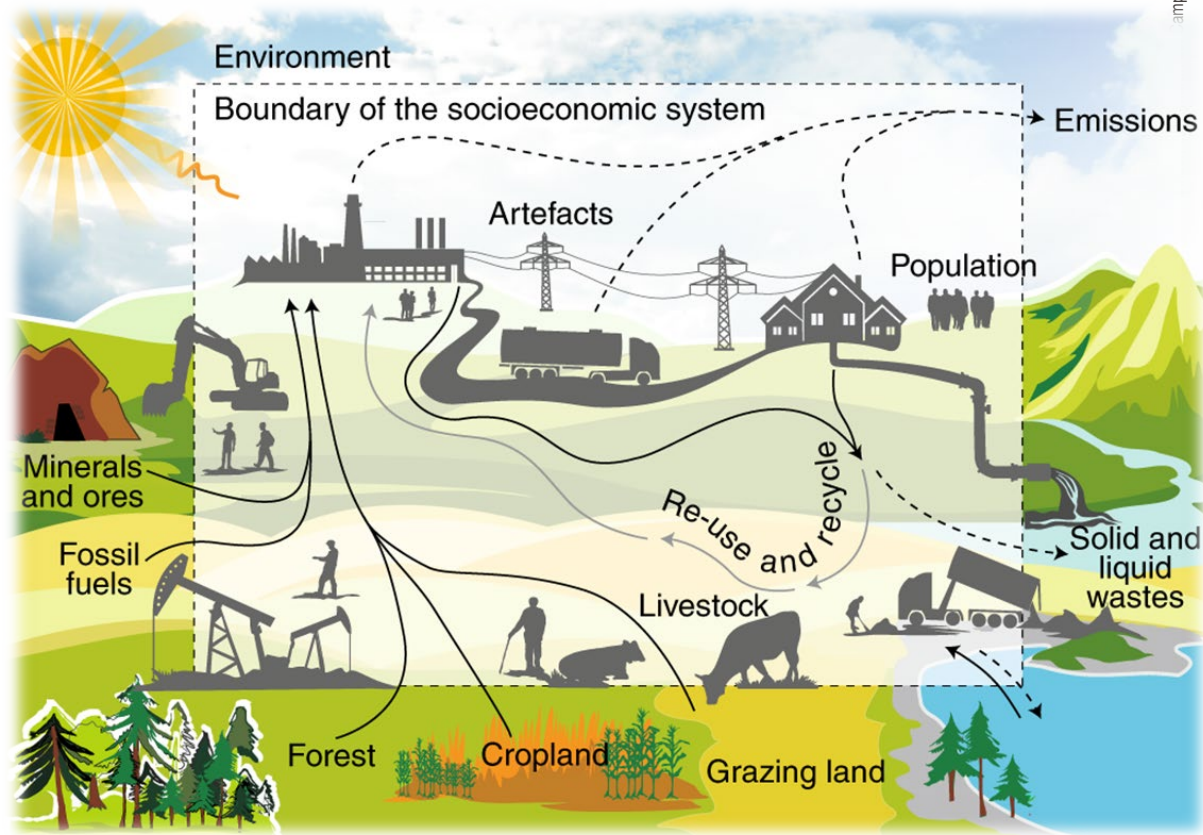
- EW-MFA recap and adaptability to other boundaries
- Example of Swiss Cantons
- Validation of methodology and insights
- Insights from Urban MFA's and policies

EW-MFA and adaptability to other boundaries

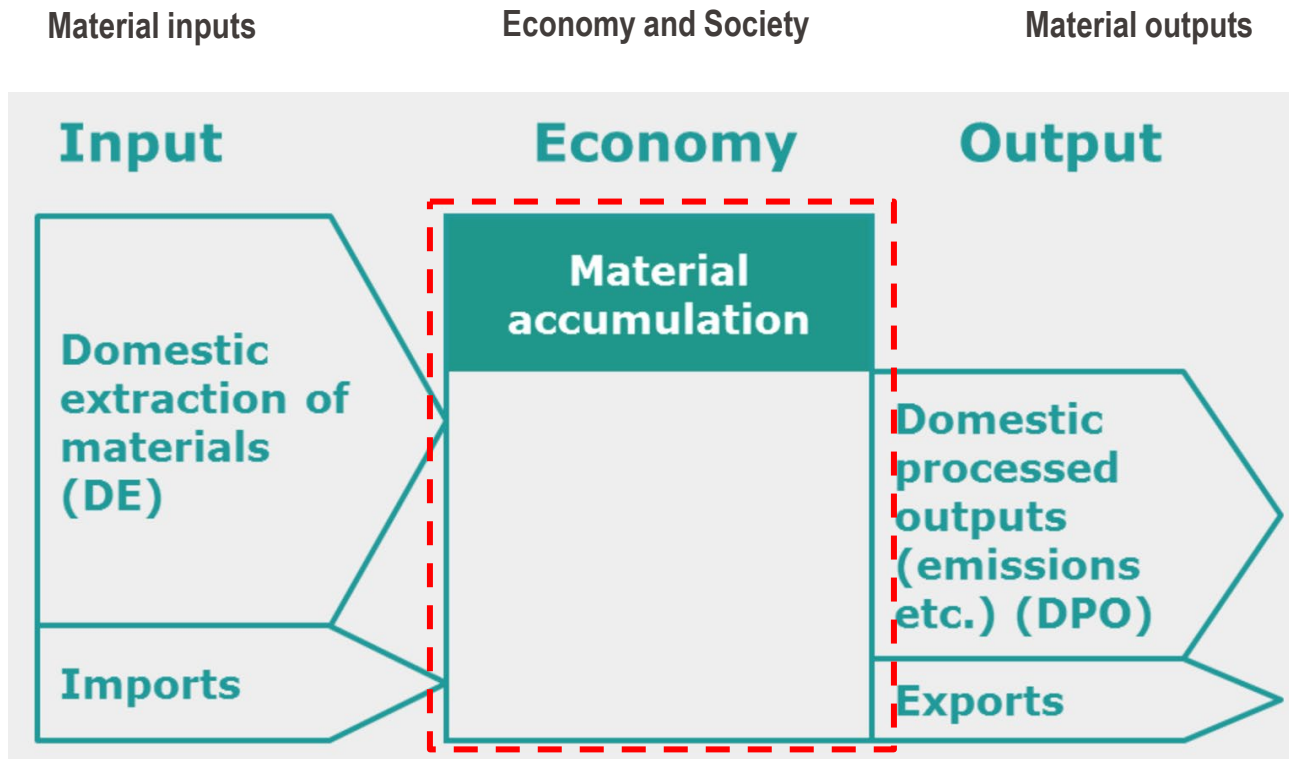


Economy-wide Material Flow Analysis (EW-MFA) (recap)

- Accounts for **all material flows** in **physical** terms
- **Interactions** of the domestic **economy** with the natural **environment** and the rest of the **world** economy
- Follows the principle of **mass conservation**

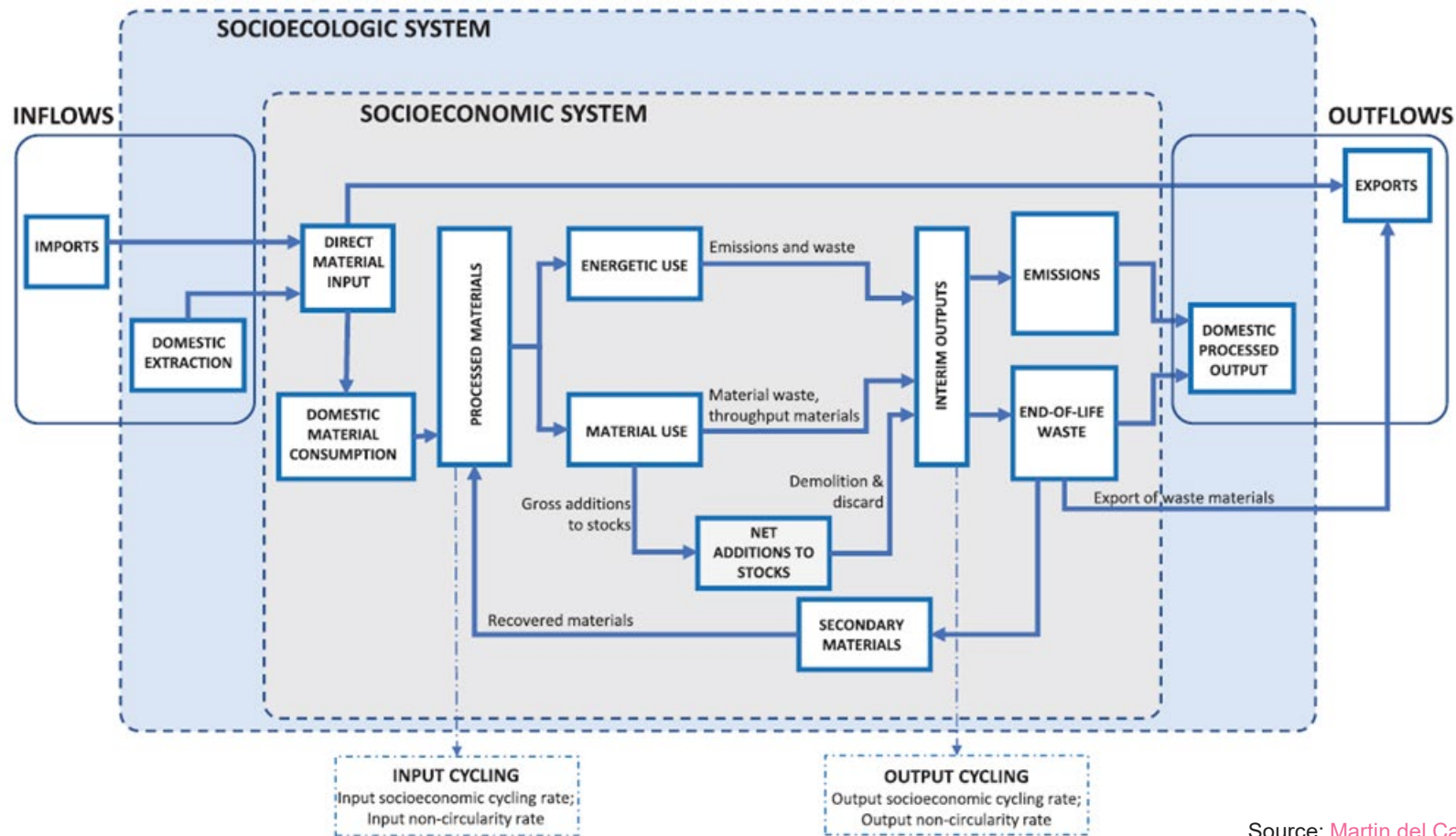


EW-MFA (recap)

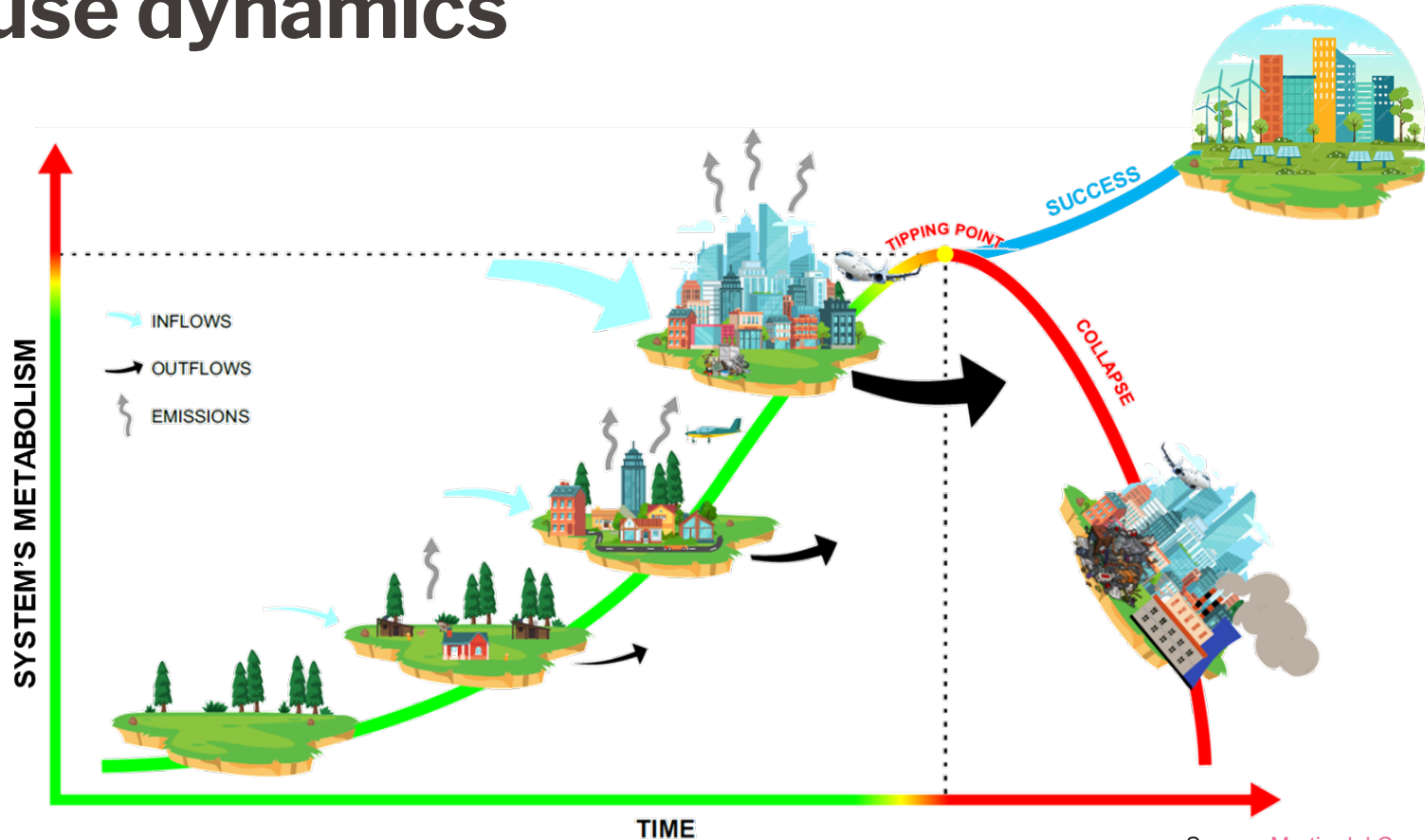


Material flows within the economy are not clearly represented in EW-MFA
Water and electricity flows are not represented as well

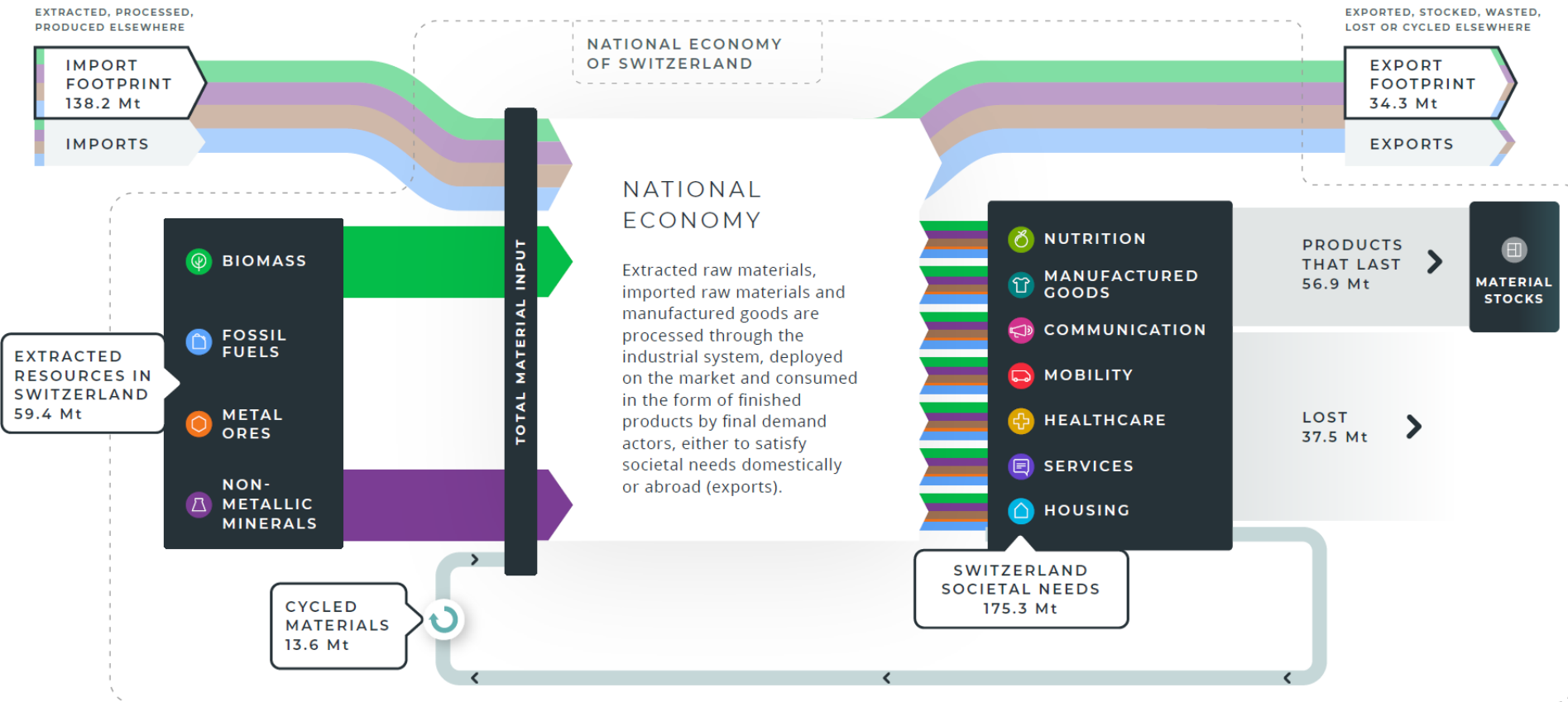
EW-MFA (recap)

Source: [Martin del Campo et al., 2023](#)

Relevance of resource-use dynamics



EW-MFA for Switzerland in 2022



Swiss administrative boundaries

Country



Cantons (26)



Regionalization of EW-MFA

- **Importance**
 - Tailors analysis to local conditions and resource flows
 - Enhances policy relevance by focusing on regional dynamics
- **Methodological Approach:**
 - Collect regional data on domestic extraction, imports, exports, and emissions.
 - Use sub-national boundaries for detailed insights into material flows.
- **Benefits**
 - Identifies regional strengths and weaknesses in resource use
 - Facilitates targeted interventions and policies for sustainable development
 - Allows comparison and benchmarking

Regionalization of EW-MFA: Challenges

- **Data Availability**
 - Limited access to region-specific data (imports/exports)
 - Need for harmonization across sub-national databases
- **Methodological Consistency**
 - Ensuring uniformity in data collection and analysis methods
 - Adapting national methodologies to local contexts without losing accuracy
 - Balancing granularity with data reliability and availability.
- **Policy Integration**
 - Aligning regional findings with national policies and objectives
 - Bridging the gap between local and national governance structures
- **Stakeholder Engagement**
 - Involving local authorities and communities in data collection and interpretation
 - Ensuring that policies are responsive to regional needs and contexts

Example of Swiss Cantons





ELSEVIER

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Cleaner and Responsible Consumption

journal homepage: www.journals.elsevier.com/cleaner-and-responsible-consumption

Streamlining the regionalization of economy-wide material flow accounts (EW-MFA): The case of swiss cantons

Nicole S. Wiedmann, Aristide Athanassiadis^{*}, Claudia R. Binder

Laboratory for Human Environment Relations in Urban Systems (HERUS), Institute of Environmental Engineering (IIE), School of Architecture, Civil and Environmental Engineering (ENAC), Ecole Polytechnique Fédérale de Lausanne (EPFL), CH-1015, Lausanne, Switzerland

Steps

- Data Collection process
- Down-scaling the data on a cantonal scale
- Results by canton
- Final remarks

Source: [Wiedmann et al., 2023](#)

Data collection process

- **Gathering data following the EW-MFA questionnaires**

- Domestic Extraction (DE)
- Import
- Export
- Domestic Processed Output (DPO)

- **Data storage**

- Metabolism of City (MoC) Data Hub
- Spreadsheet (Excel)
- List of contacted people

- **EW-MFA Handbook 2018**

Layers

- Layer 1: Context
- Layer 2: Biophysical characteristics
- Layer 3: Infrastructure
- Layer 4: Stocks and flows**
- Extra: General photos

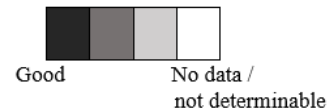
[View all instructions](#)

i This layer is all about extraction flows, consumption addition to (artificial) stocks (e.g. Building stocks).

Data and information to obtain

- 4.01. Extraction: Fishing
- 4.02. Extraction: Agriculture
- 4.03. Extraction: Forestry
- 4.04. Extraction: Mining
- 4.05. Production Flows: Manufacturing
- 4.06. Flows: Consumption
- 4.07. Household budget surveys
- 4.08. Stocks: Buildings
- 4.09. Stocks: Infrastructure
- 4.10. Stocks: Vehicles
- 4.11. Stocks: Livestock
- 4.12. Flows: Energy
- 4.13. Flows: Water
- 4.14. Flows: Imports and exports
- 4.15. Emission to air
- 4.16. Emissions to water
- 4.17. Dissipative use of products
- 4.18. Waste flows

Source: [EW-MFA Handbook, 2018](#)



- Available data considering MoC Data Hub layers

- To fill in an EW-MFA questionnaire
 - Different sources
 - Transform metrics
 - Downscaling

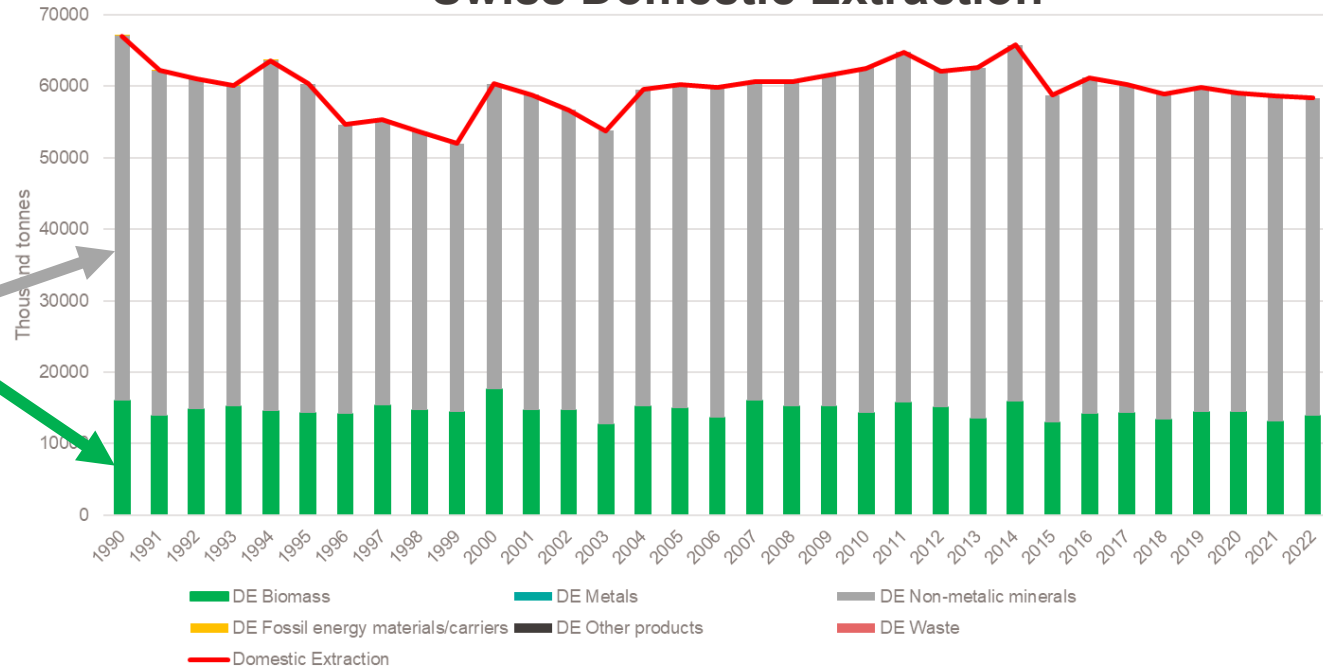
	Data Quality	Lausanne City			Vaud Canton			Geneva City			Geneva Canton		
		A	F	OA	A	F	OA	A	F	OA	A	F	OA
1. Context	Boundaries, Economic activities, Population & Policies												
2. Biophysical	Soil, Vegetation, Biodiversity, Water, Climate & Minerals												
3. Infrastructure	Land use, Networks, Services, Manufacturing sites, Transports...												
4. Stocks & Flows	Natural extraction												
	Consumption, budget surveys												
	Stocks: Buildings, Infrastructure												
	Stocks: Vehicles												
	Stocks: Livestock												
	Flows: Energy												
	Flows: Water												
	Flows: Imports & Exports												
	Emissions (air, water, products)												
	Waste flows												

Matrix representing the collected data by availability and quality.
A: Availability; F: Format; OA: Open Access

Domestic Extraction (DE)

- Fossil energy materials / carriers
- Biomass
- Metals
- Minerals

Swiss Domestic Extraction



Crops, fodder crops and residues

- Utilised Agricultural Area (UAA) classification 3, [FSO](#)
- Swiss biomass production
 - DE Switzerland, [FSO](#)
 - Fruits (UAA), wine and beetroots production, [FOAG](#)
 - Crops and milk production, yield factors - regional and cantonal level, [USP](#)
 - Vegetables production (request data, available for main producer cantons), [SZG CCM CSO](#)

Crops

$$\begin{aligned}
 \text{Mass production per canton} &= \text{Primary data} \\
 &= \frac{\text{Cantonal UAA}}{\text{Swiss UAA}} \times \text{Swiss Production} \\
 &= \text{Cantonal UAA} \times \text{Yield factor}
 \end{aligned}$$

Wine [hl → tons]

$$\text{Tons of wine} = (\text{Primary data [hl]}/0.8)/10$$

DE – Biomass (Wood & Wild life)

Wood

- Wood harvest in Switzerland by Canton [m³], [FSO](#)

Wild life

- Fish statistics per canton, [BAFU](#) – Bundesamt für Umwelt
- Hunting statistics per canton, [BAFU](#) – Bundesamt für Umwelt
- Hunting statistics per canton, [FSO](#)

Wood [m³ → tons]

1. For sawlogs and veneer logs, a 10% extra volume need to be added in order to account for bark.
2. A Swiss factor is applied to convert the volume in mass: 0.52 t/m³ for hardwood, and 0.68 t/m³ for softwood.

Wild life

Hunting, is it allowed in Switzerland?

Conversion factor number of head to weight in EW-MFA Handbook

DE – Minerals data sources & calculations

Data sources

- Cantonal Statistical Office (VD – STATVD, GE – OCSTAT)
- Cantonal department of the territory (DGE-GEODE Vaud, DSPE-GESDEC Genève)

Transform metrics

- Usually from $\text{m}^3 \rightarrow \text{tons}$
 - Specific factors from Cantonal department
 - EW-MFA Handbook



Image: La carrière d'Holcim à Eclépens (VD)



Imports & Exports

- Fossil energy materials / carriers
- Biomass
- Metals
- Minerals
- Other products
- Wastes imp/exp for final treatment

NST code	MF code
1 Products of agriculture, hunting, and forestry; fish and other fishing products	MF1
2 Coal and lignite; crude petroleum and natural gas	MF4
3 Metal ores and other mining and quarrying products; peat; uranium and thorium	MF2
4 Food products, beverages and tobacco	MF1
5 Textiles and textile products; leather and leather products	MF1
6 Plaiting materials; pulp, paper and paper products; printed matter and recorded media	MF1
7 Coke and refined petroleum products	MF4
8 Chemicals, chemical products, and man-made fibers; rubber and plastic products ; nuclear fuel	MF4
9 Other non metallic mineral products	MF3
10 Basic metals; fabricated metal products, except machinery and equipment	MF2
11 Machinery and equipment n.e.c.; office machinery and computers; electrical machinery and apparatus n.e.c.; radio, television and communication equipment and apparatus; medical, precision and optical instruments; watches and clocks	MF2
12 Transport equipment	MF2
13 Furniture; other manufactured goods n.e.c.	MF5
14 Secondary raw materials; municipal wastes and other wastes	MF6
15 Mail, parcels	MF5
16 Equipment and material utilized in the transport of goods	MF5
17 Goods moved in the course of household and office removals; baggage and articles accompanying travellers; motor vehicles being moved for repair; other non market goods n.e.c.	MF5
18 Grouped goods: a mixture of types of goods which are transported together	MF5
19 Unidentifiable goods: goods which for any reason cannot be identified and therefore cannot be assigned to groups 01-16.	MF5
20 Other goods n.e.c.	MF5
21 Unknown	MF5

Imports & Exports - Road

Road transport

- Swiss Heavy Vehicles (yearly survey)
 - Eurostat, road transport by NST 2007 code for NUTS 3 regions (equals to swiss cantons): Loading → Exported ; Unloading → Imported
 - Swiss Heavy Vehicle survey by main Swiss regions – FSO
- Foreign Heavy Vehicles (every 5 years) - FSO
 - Complete missing years by liner regression
 - Data aggregated by main Swiss regions – downscaling →

$$\frac{\text{Eurostat data NUTS 3}}{\text{FSO data SHV Survey by main Swiss regions}} \quad \text{or}$$

$$\frac{\text{Eurostat data NUTS 3}}{\text{Aggregation Eurostat data of Cantons composing your main region}}$$

- Swiss Light Vehicles (every 10 years) - FSO
 - Complete missing years by linear regression or Swiss trends of goods transported
 - Allocation to NST 2007 code by considering the share of other surveys

Imports & Exports - Rail

Basisausgabe zur Logistikmarktstudie Schweiz, Band 2017 – Kapitel 3

- Cantonal statistics by mean of transport (often aggregated and considering only foreign exchanges)
- Eurostat dataset import from abroad to Swiss main regions
- HSG study intra-regional trades of goods by rail. Share compared to Swiss Heavy Vehicles survey.

in 1000 t von	nach	Genfersee-region	Espace Mittelland	Nordwest-schweiz	Zürich	Ostschweiz	Zentral-schweiz	Tessin	Total
Genferseeregion		35 761	6 492	1 239	673	636	522	188	45 510
Strasse		94%	76%	44%	30%	27%	55%	16%	88%
Schiene		6%	24%	56%	70%	73%	45%	84%	12%
Espace Mittelland		5 195	63 984	5 077	1 717	2 610	3 337	463	82 382
Strasse		80%	97%	83%	59%	71%	84%	39%	93%
Schiene		20%	3%	17%	41%	29%	16%	61%	7%
Nordwestschweiz		1 848	7 316	33 704	3 646	2 511	4 603	802	54 430
Strasse		56%	88%	98%	78%	65%	87%	38%	90%
Schiene		44%	12%	2%	22%	35%	13%	62%	10%
Zürich		377	11 555	2 581	26 454	3 659	2 544	630	37 398
Strasse		49%	76%	94%	97%	74%	78%	19%	91%
Schiene		51%	24%	6%	3%	26%	22%	81%	9%
Ostschweiz		454	1 561	1 604	3 811	40 202	1 400	348	49 379
Strasse		49%	74%	83%	93%	98%	86%	94%	96%
Schiene		51%	26%	17%	7%	2%	14%	6%	4%
Zentralschweiz		342	2 096	2 048	2 023	1 007	26 677	333	34 527
Strasse		70%	97%	95%	90%	86%	99%	59%	97%
Schiene		30%	3%	5%	10%	14%	1%	41%	3%
Tessin		46	392	589	189	252	344	9 625	11 438
Strasse		35%	42%	19%	43%	88%	77%	>99%	91%
Schiene		65%	58%	81%	57%	12%	23%	<1%	9%
Total		44 021	82 995	46 842	38 513	50 877	39 427	12 388	315 064
Strasse		90%	94%	93%	91%	92%	94%	87%	92%
Schiene		10%	6%	7%	9%	8%	6%	13%	8%

■ Anteil Strasse >50% ■ Anteil Schiene >50%

Tabelle 6: Modalsplit (Strasse vs. Schiene) in und zwischen den Grossregionen in 1000 t im Jahr 2014
(Quellen: SBB Infrastruktur (2015): Schienengüterverkehr der Schweiz 2014, BFS (2016): Gütertransporterhebung 2014)

HSG Logistikmarktstudie supplied by CFF Infrastructures in 2021

Domestic Processed Output (DPO)

- Emissions to air
- Waste
- Emissions to water
- Dissipative use of products
- Dissipative losses



Activity data

- Cantonal statistics office (energy consumption, industries present on the territory, number of cars and fuel consumption)
- Cantonal department of energy

GHG and other pollutant gas emissions factors

- [National Inventory Report](#) (FOEN)
- [Informative Inventory Report](#) (FOEN)

Livestock emissions factor

- [IPCC Report 2006](#) (Dong et al.)

Emissions to air of HFCs, PFCs, SF6, Heavy Metals, and POPs, were downscaled from the Swiss EW-MFA based on Per Capita numbers

- Cantonal statistical office
- Cantonal department of geology and soils usually in charge of waste management
 - What is interesting for you? Type of waste and disposal method



- Based on the waste water treatment plant reports
 - Know which plants you have in your region
 - Analysis of water released into the environment
- MF4.01 Dissipative use of organic fertiliser, 5% of it considered in MF 3.04 Other substances and organic materials

		Concentrations			Rendements en %	
		Entrée	Sortie			
Paramètres	Unité			Traitée	Traitée + Déversé	Traitée
Matières en suspension	mg/l		10			
DBO ₅	mg O ₂ /l	182	8	12	95.8	93.3
DCO		395	35	46	91.5	88.4
Carbone organique total	mg C/l	101				
Carbone organique dissous			10		90.0	
Phosphore ortho	mg P/l		0.11			
Phosphore total		5.09	0.35	0.51	93.1	90.0
Ammonium	mg N/l	24.30	14.79			
Nitrate + nitrite			9.33			

Bilan de l'épuration Vaudois en 2019
Annexe E2 - Capacités et résultats 2019 de la "STEP vaudoise"

DPO – Dissipative use of products and dissipative losses

- Organic fertiliser: *Number of livestock (FSO) × manure production factor* (EW – MFA Handbook 2018)
- Mineral fertiliser, Pesticide, Seeds: $Swiss\ DPO \times \frac{Cantonal\ UAA}{Swiss\ UAA}$
- Sewage sludge: illegal environmental dumping since 2008
- Compost, Solvents: $Swiss\ DPO \times \frac{Cantonal\ population}{Swiss\ population}$
- Salt, Dissipative losses: $Swiss\ DPO \times \frac{Cantonal\ Impermeable\ surface}{Swiss\ Impermeable\ surface}$

EW-MFA (Canton) results

Canton Vaud EW-MFA indicators in thousands of tons											
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
DE	5255	5217	5239	5508	5260	5075	5285	4972	4986	5061	4892
IMP	25069	27067	22607	23158	26309	23629	26678	29676	27794	30429	32684
EXP	25917	26674	21107	23280	26530	23135	27436	28239	25459	28162	29665
DPO	4413	4406	4518	4223	4306	4448	4130	4139	4200	4105	3985
DMI	30323	32283	27846	28666	31569	28704	31963	34648	32780	35490	37575
DMC	4406	5609	6739	5386	5039	5568	4527	6409	7322	7328	7910
PTB	655	2192	2911	1138	1360	1271	1037	2616	3524	3658	4383
Canton Geneva EW-MFA indicators in thousands of tons											
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
DE	1123	1124	1120	1129	1123	1112	1126	1111	1162	1252	1239
IMP	12046	11486	10801	11377	12738	11403	10803	11264	9945	10746	9314
EXP	11027	10127	10180	10699	12464	11125	10988	11355	10420	10048	9127
DPO	2075	2023	2084	1842	1886	1886	1636	1704	1684	1696	1612
DMI	13169	12609	11921	12505	13861	12515	11928	12374	11107	11999	10553
DMC	2142	2482	1741	1807	1397	1390	940	1019	687	1950	1426
PTB	1019	1358	621	678	274	-186	-91	-475	698	187	
Swiss EW-MFA indicators in thousands of tons (FSO data)											
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
DE	60708	61623	62899	64979	62203	63405	65571	60150	60922	60528	59733
IMP	52168	49423	51957	52876	52234	54072	53383	53506	53914	53953	52339
EXP	17256	15275	16297	17163	16462	16477	17044	16770	16804	17974	17780
DPO	59565	58294	60507	56536	58527	59947	55385	55997	57121	56555	55218
DMI	112875	111047	114855	117855	114436	117477	118954	113656	114837	114482	112072
DMC	95619	95771	98558	100692	97974	101000	101910	96886	98033	96508	94292
PTB	34912	34148	35659	35713	35772	37595	36339	36736	37111	35980	34559

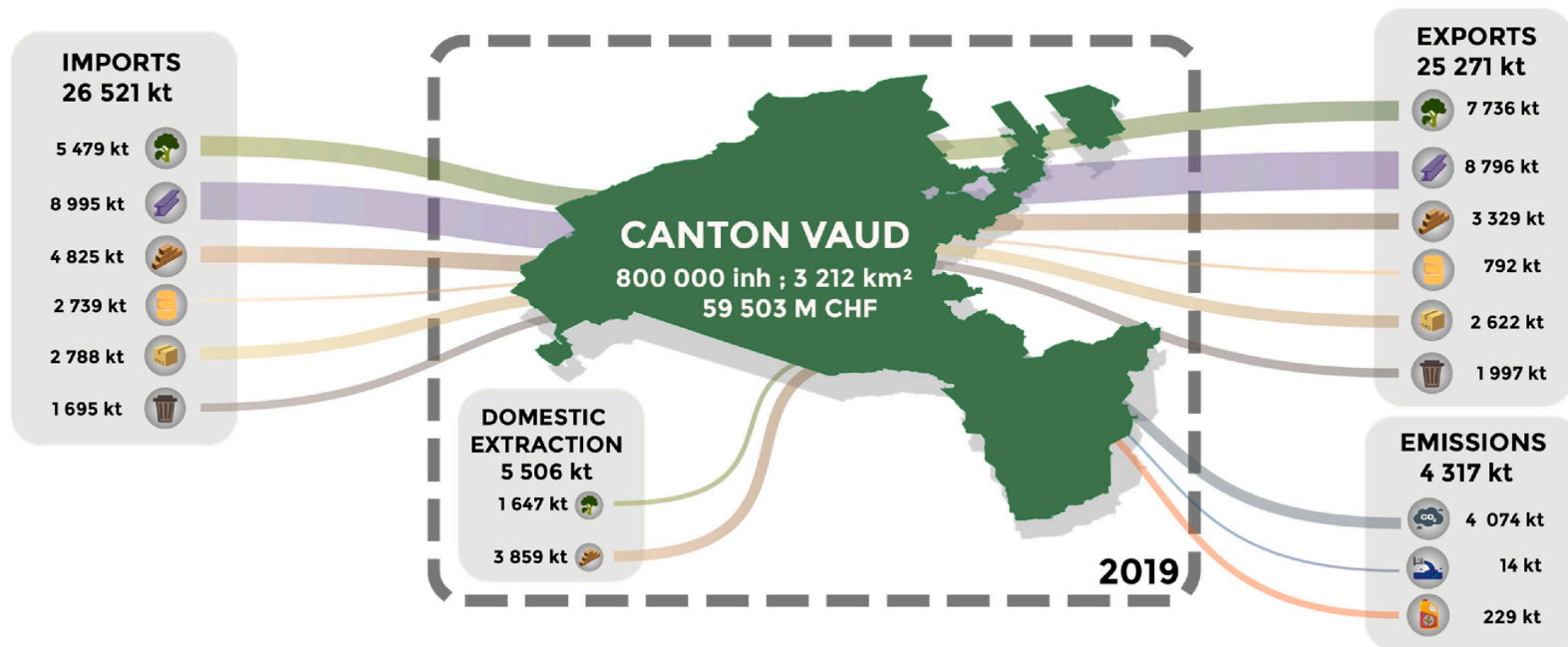
Other indicators:

Laboratory on
Human-
Environment
Relations in
Urban Systems

Indicator	Method
DMI	DE + IMP
DMC	DMI – EXP
PTB	IMP – EXP

Canton Vaud EW-MFA indicators in tons per capita											
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
DE	7.8	7.6	7.5	7.7	7.2	6.9	7.1	6.5	6.4	6.4	6.2
IMP	37.3	39.3	32.2	32.5	36.2	32.2	35.6	39.0	35.9	38.8	41.2
EXP	38.6	38.8	30.1	32.6	36.5	31.5	36.6	37.1	32.9	35.9	37.4
DPO	6.6	6.4	6.4	5.9	5.9	6.1	5.5	5.4	5.4	5.2	5.0
DMI	45.1	46.9	39.7	40.2	43.5	39.1	42.7	45.5	42.4	45.2	47.4
DMC	6.6	8.2	9.6	7.6	6.9	7.6	6.0	8.4	9.5	9.4	10.0
PTB	13.5	14.6	8.9	11.0	9.3	12.0	14.4	13.2	12.1	17.8	14.8
Canton Geneva EW-MFA indicators in tons per capita											
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
DE	2.6	2.5	2.5	2.5	2.4	2.4	2.4	2.3	2.4	2.6	2.5
IMP	27.5	25.7	23.8	24.9	27.7	24.6	23.0	23.6	20.5	22.0	18.8
EXP	25.2	27.7	22.5	23.4	27.1	24.0	23.4	23.8	21.5	20.5	18.4
DPO	4.7	4.5	4.6	4.0	4.1	4.1	3.5	3.6	3.5	3.5	3.3
DMI	30.1	28.3	26.3	27.3	30.1	27.0	25.4	25.9	22.9	24.5	21.3
DMC	4.9	5.6	3.8	3.9	3.0	3.0	2.0	2.1	1.4	4.0	2.9
PTB	2.3	3.0	1.4	1.5	0.6	0.6	-0.4	-0.2	-1.0	1.4	0.4
Swiss EW-MFA indicators in tons per capita (FSO data)											
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
DE	8.0	7.9	8.0	8.2	7.7	7.8	8.0	7.2	7.2	7.1	7.0
IMP	6.8	6.3	6.6	6.6	6.5	6.6	6.5	6.4	6.4	6.4	6.1
EXP	2.2	2.0	2.1	2.2	2.1	2.0	2.1	2.0	2.0	2.1	2.1
DPO	7.7	7.5	7.7	7.1	7.3	7.4	6.7	6.7	6.8	6.7	6.5
DMI	14.7	14.3	14.6	14.8	14.2	14.4	14.4	13.6	13.6	13.5	13.1
DMC	12.4	12.3	12.5	12.7	12.2	12.4	12.4	11.6	11.6	11.4	11.0
PTB	4.5	4.4	4.5	4.5	4.5	4.6	4.4	4.4	4.4	4.2	4.0

EW-MFA Canton Vaud in 2019



Legend



Biomass



Metal ores



Non-metallic minerals



Fossil energy carriers



Other products



Waste for final treatment



Emissions to air



Emissions to water



Dissipative use of products

Limits of this study

- Data accuracy and metric conversion
 - Limited data on import and export flows
 - Consequently DMI, DMC and PTB
- Need of improvement of environmental monitoring

- Overview of resources needs / environmental pressure
- Dig further in different flows to...
 - Circularize flows
 - Implement local flows
 - Developing new policies
 - Implement mitigation strategies
- Improvement of environmental monitoring techniques and data availability



Circular Economy

- Laboratory on Human-Environment Relations in Urban Systems

- Planet earth is a finite resource

“This [future world] will be a small, closed, limited, planetary society, almost certainly dependent on solar energy for its input or power, and it will have to recycle virtually all its materials into a circular economy, in which the dumps become the mines”

Background



Living things need food and water



Societies need cars, buildings, electronics, etc.



- Modern societies:
Linear “take-make-dispose”
economy

Definition of Circular Economy

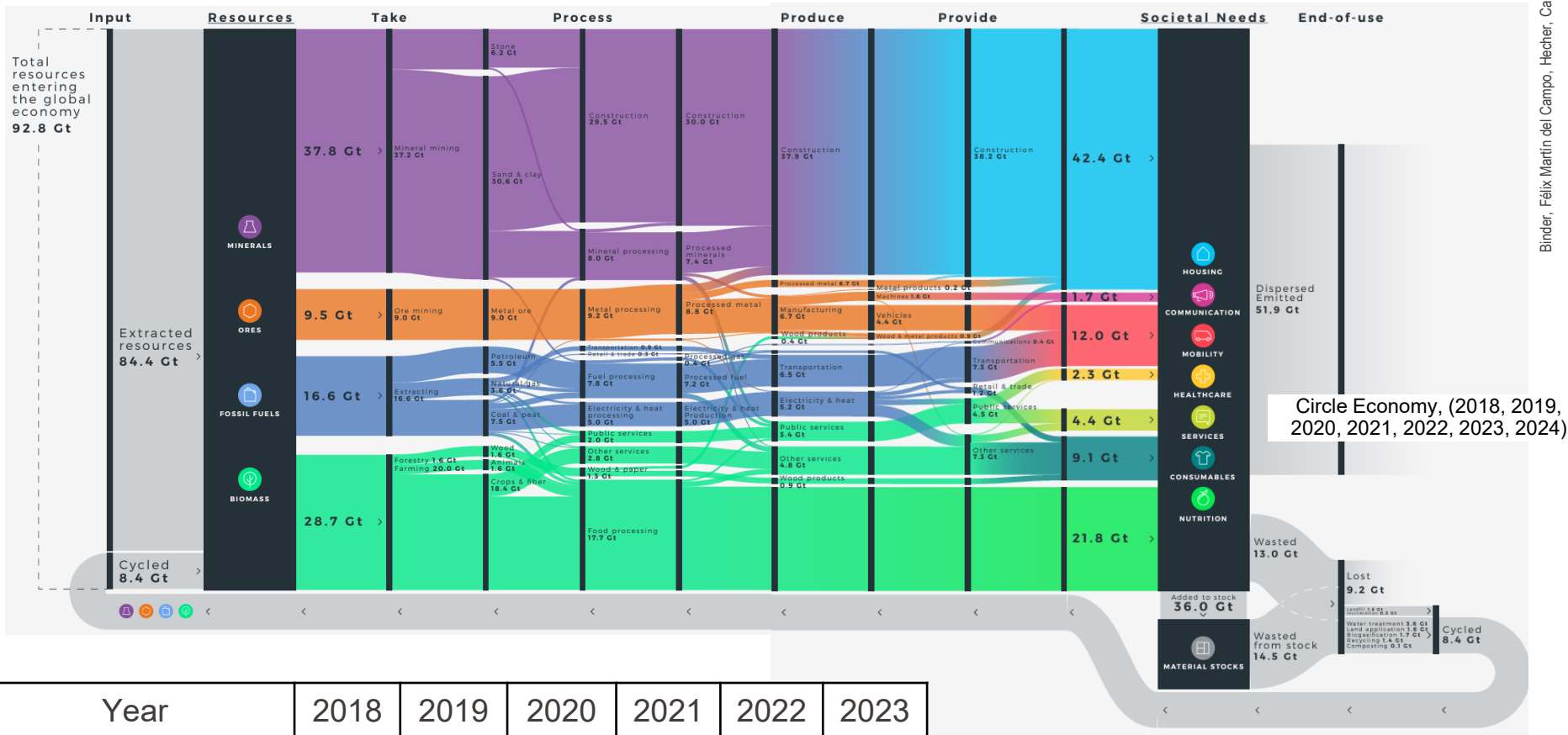


“Economic system of production, trade and consumption that, from the design of a product through to its end of life, is designed to optimize the use of resources and reduce the impact of economic activity on the environment”

How far are we from achieving this?

Global Circularity gap

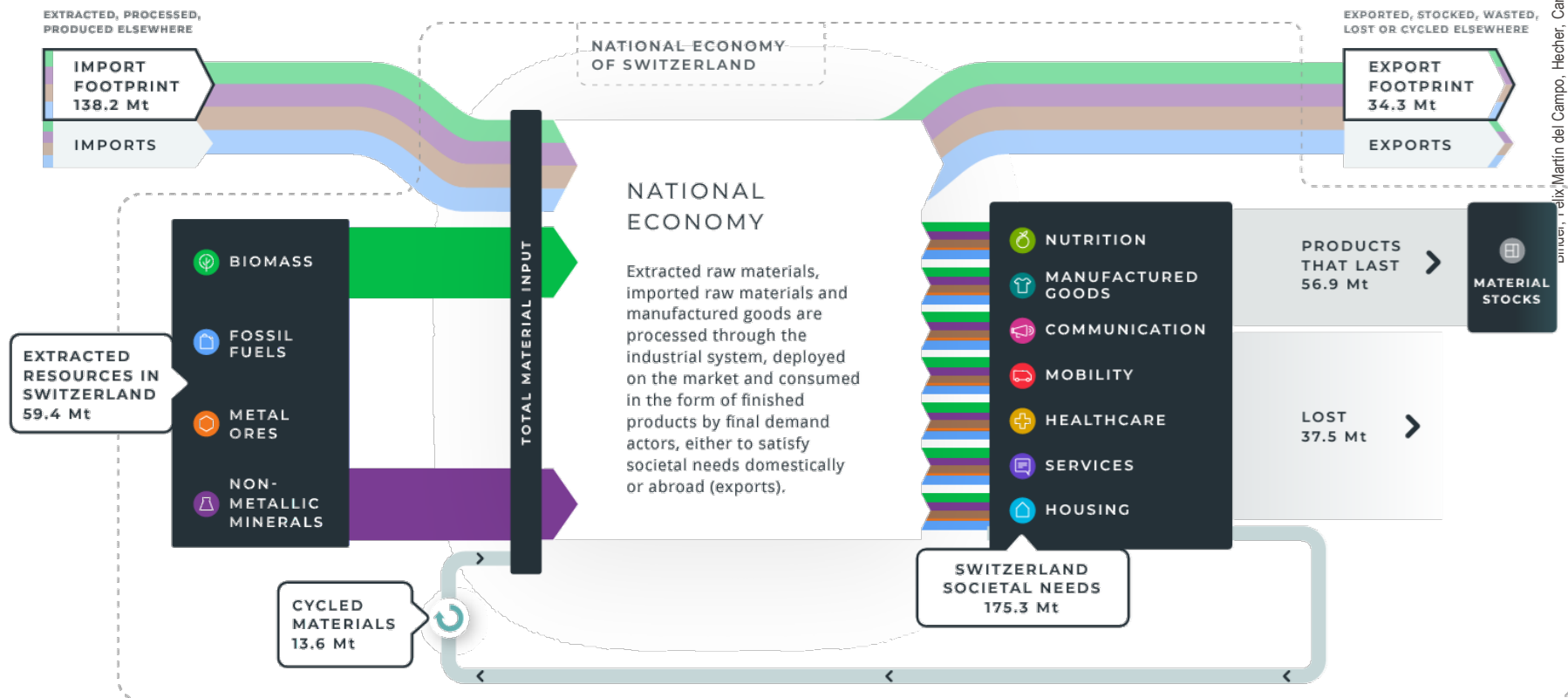
$$\text{Circularity gap} = \frac{\text{Cycled materials}}{\text{DMI}}$$



Switzerland's Circularity gap

$$\text{Circularity gap} = \frac{\text{Cycled materials}}{\text{DMI}}$$

40



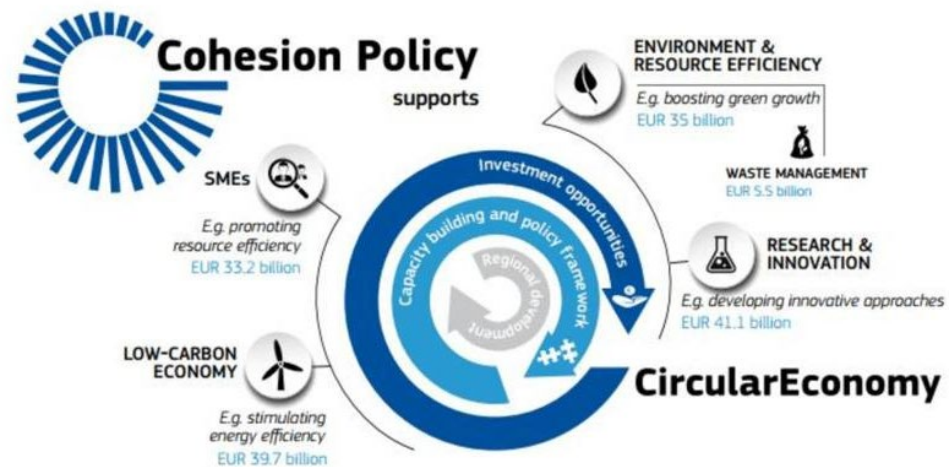
Source: EPFL, Martin del Campo, Hecher, Camplins

Year	2023
Circularity Gap (%)	6.9

“Economic system of production, trade and consumption that, from the design of a product through to its end of life, is designed to optimize the use of resources and reduce the impact of economic activity on the environment”

- **How can we design a future Circular Economy?**
 - Economic system
 - Production
 - Trade
 - Consumption
 - Product Design
 - End-of-life
 - Optimizing resources
 - Impacts

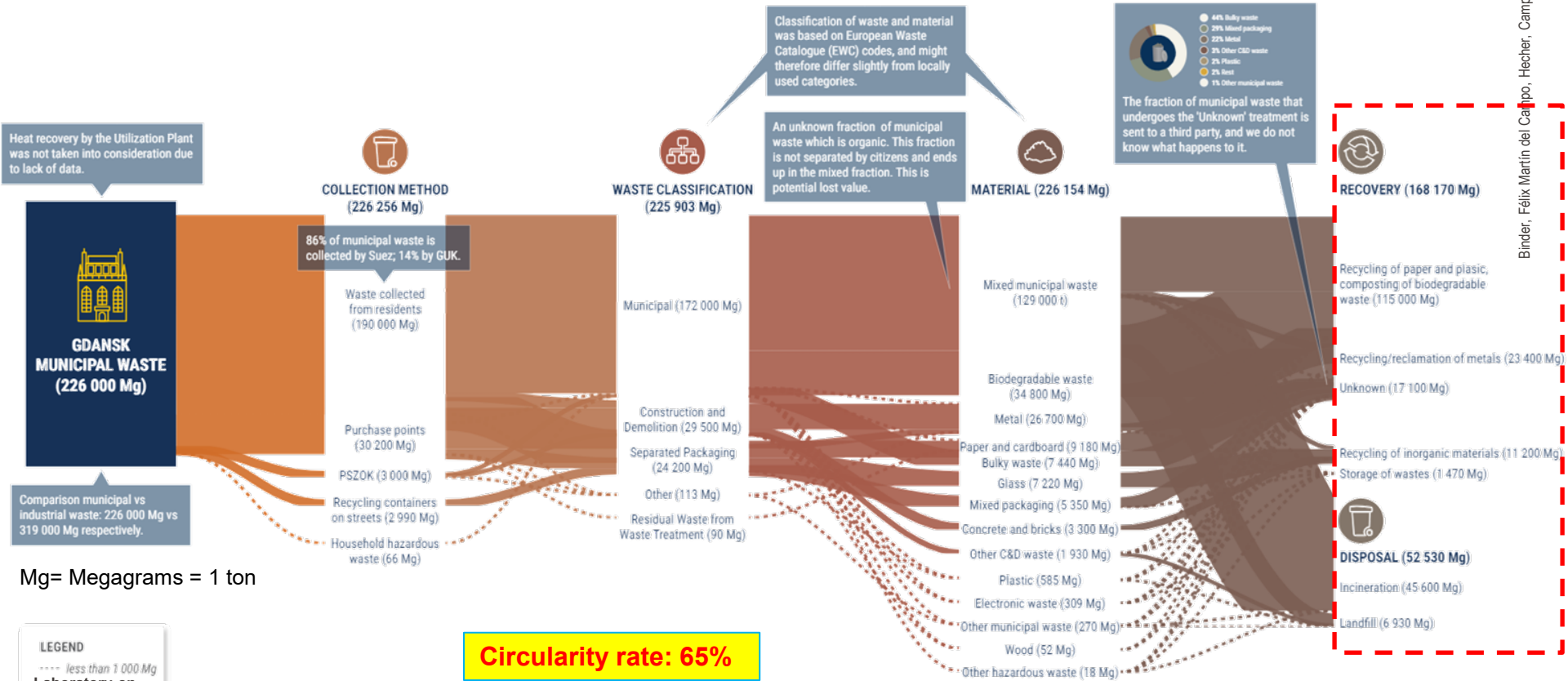
Insights from Urban MFA's and policies



- Laboratory on Human-Environment Relations in Urban Systems

Insights from Urban Metabolism

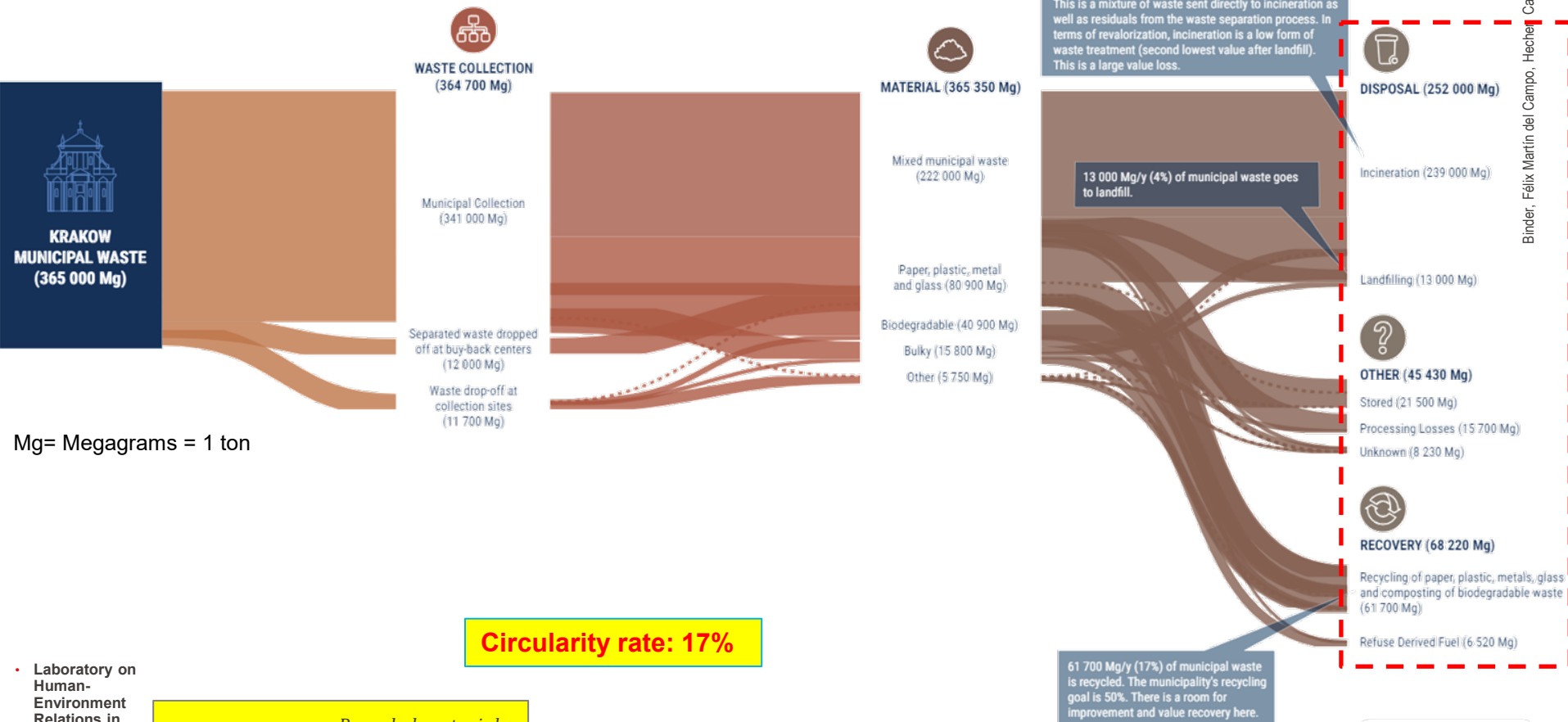
- Cities are **not** at all **self-sufficient**
 - This reliance on external flows highlights the vulnerability of cities to disruptions in supply chains and resource availability, especially as population growth and urbanization continue
- **Scale** matters
 - To optimize resource management and urban planning, it's crucial to understand the specific context of the scale at which material flows are being assessed
- Difficult to make **circular**
 - To create more circular systems, cities would need to redesign production, consumption, and waste processes. This includes strategies that prioritize infrastructure for material recovery, encouraging modular and reusable design, and shifting economic incentives toward resource conservation



Mg= Megagrams = 1 ton

$$\text{Circularity rate} = \frac{\text{Recycled materials}}{\text{Total waste}}$$

Source: [Metabolic Institute, 2021](#)



Mg= Megagrams = 1 ton

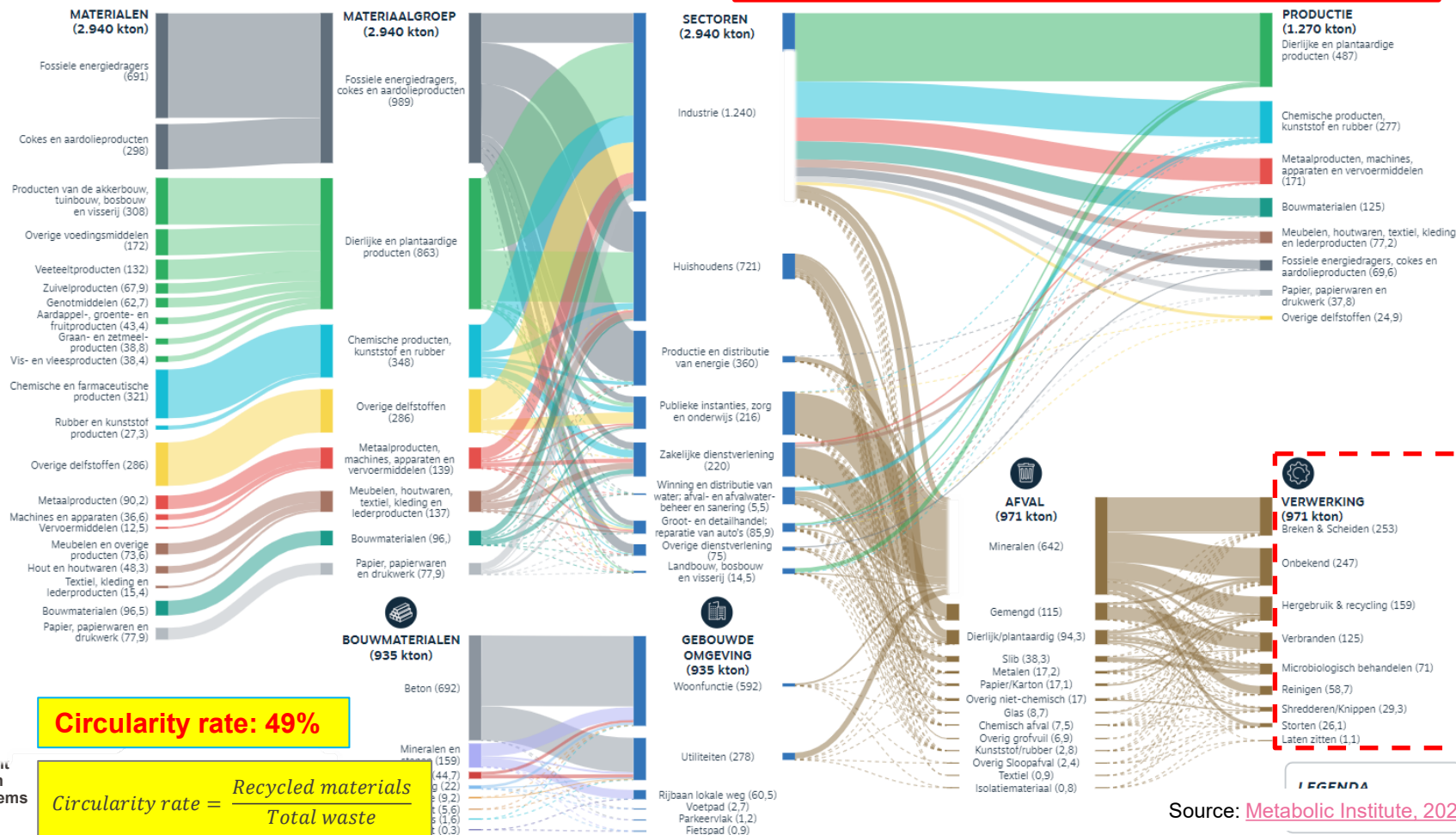
- Laboratory on Human-Environment Relations in Urban Systems

$$\text{Circularity rate} = \frac{\text{Recycled materials}}{\text{Total waste}}$$

Source: [Metabolic Institute, 2021](#)

Urban Metabolism

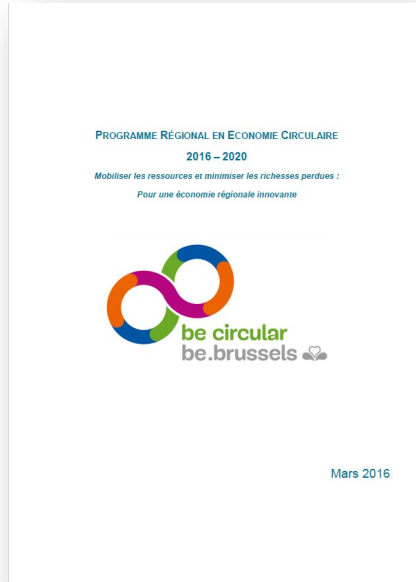
City of Utrecht, Netherlands, 2021



Insights from Policies

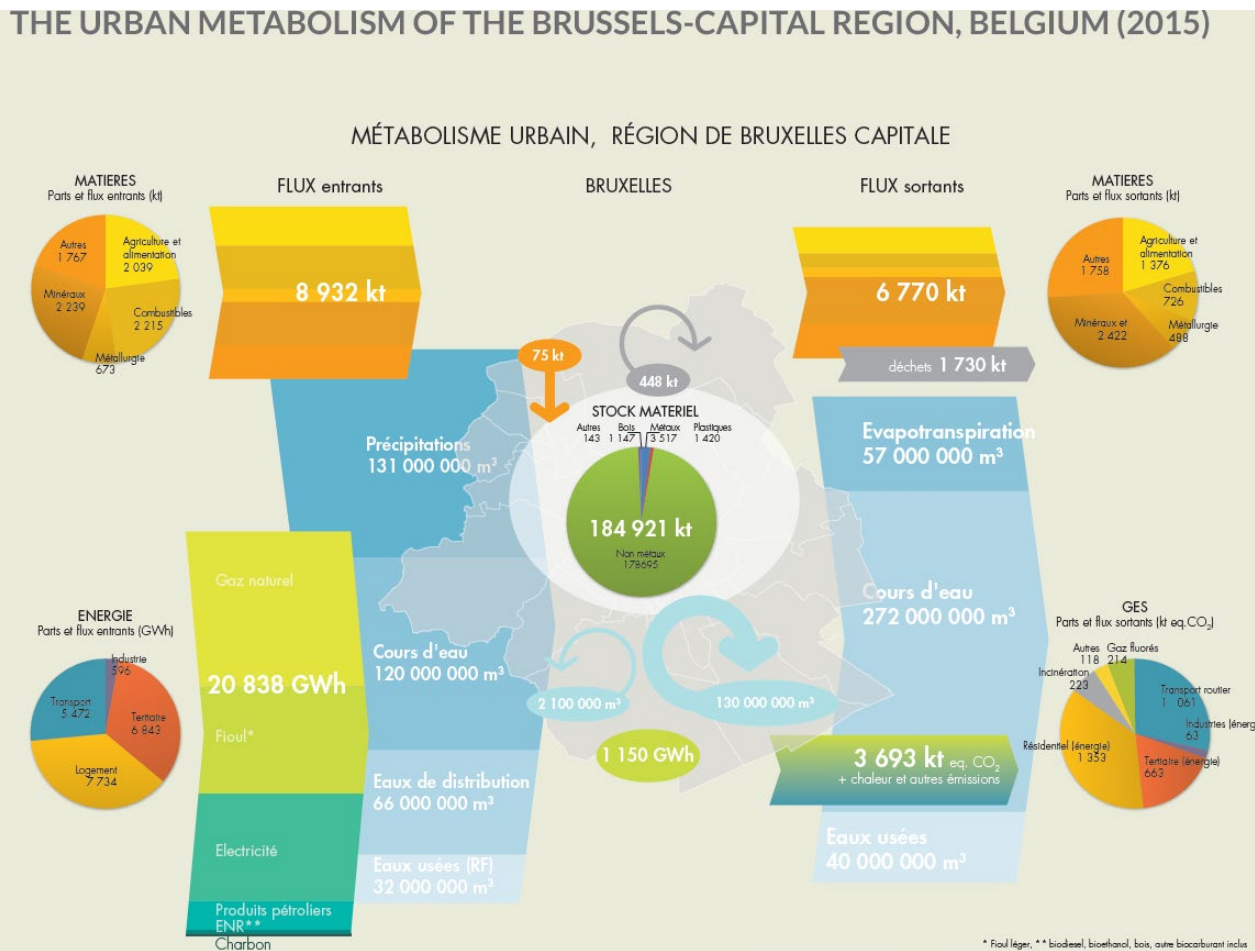
- Cities are **not** at all **self-sufficient** – Need to prioritize local resources.
 - Policies that support localized systems for **food, energy, and material recovery** can significantly enhance urban resilience.
- **Scale** matters - Adapt Circular Economy strategies
 - A city-level strategy might prioritize **household recycling** and **community-based resource recovery**, while regional policies might target **industrial by-products** and broader recycling infrastructure
- Difficult to make **circular** - Support Circular Design and Waste Infrastructure.
 - Circular economy policies can drive **eco-design** and **modular construction** approaches, which reduce waste at the source and allow materials to be recovered more easily.

Circular Economy policies at city scale



Sources: [Gosuin, Fremault & Laanan, 2016](#); [Mairie de Paris, 2017](#); [LWARB, 2017](#)

Circular Economy policies - Brussels

Source: [Gobbo, 2021](#)

Circular Economy policies - Brussels

- Urban metabolism study in 2014-2015
- 3 ministries, 4 administrations
- 4 strategic themes
 - Transversal (43 measures): define a favorable normative and legal framework
 - Sectoral (48 measures): Construction (13), resources and wastes (24), logistics (7), retail (4)
 - Territorial (8 measures)
 - Governance (12 measures)

PROGRAMME RÉGIONAL EN ÉCONOMIE CIRCULAIRE

2016 – 2020

Mobiliser les ressources et minimiser les richesses perdues :

Pour une économie régionale innovante



Mars 2016

Circular Economy policies - Paris

	Paris (2,166,000 inhab.)		PPC (6,321,000 inhab.)		IdF (11,259,000 inhab.)	
	kt	t/cap	kt	t/cap	kt	t/cap
INPUT						
Local extraction						
Fossil fuels	0	0.0	0	0.0	540	0.0
Minerals	0	0.0	0	0.0	16,990	1.5
Biomass	0	0.0	30	0.0	6,010	0.5
Total local extraction	0	0.0	30	0.0	23,540	2.1
Imports						
Fossil fuels	3,910	1.8	13,050	2.1	26,100	2.3
Others	15,240	7.0	56,450	8.9	88,350	7.8
Total Imports	19,160	8.8	69,500	11.0	114,450	10.2
DMI	19,160	8.8	69,530	11.0	137,990	12.3
OUTPUT						
To nature						
Emissions to air	6,710	3.1	24,470	3.9	53,840	4.8
Waste landfilled	0	0.0	2,500	0.4	20,010	1.8
Emissions to water	0	0.0	10	0.0	40	0.0
Dissipative flows	150	0.1	440	0.1	2,400	0.2
DPO	6,860	3.2	27,410	4.3	76,290	6.8
Exportations						
Exported flows to nature	4,100	1.9	9,610	1.5	69	0.0
Exports excluding wastes	8,380	3.9	40,410	6.4	58,500	5.2
Total exports	12,480	5.8	50,020	7.9	58,570	5.2
DMO	19,340	8.9	77,430	12.2	134,860	12.0
LEPO	10,960	5.1	37,020	5.9	76,360	6.8
RECYCLING						
Local	0	0.0	4,210	0.7	7,320	0.7
External	1,850	0.9	440	0.1	0	0.0
Total recycling	1,850	0.9	4,660	0.7	7,320	0.7
Wastes exported	5,950	2.7	10,050	1.6	70	0.0
DMC	4,830	2.2	19,070	3.0	79,420	7.1
DMC _{corr}	10,780	5.0	29,120	4.6	79,490	7.1
BI oxygen (combustion)	6,560	3.0	24,010	3.8	52,650	4.7
BO water (combustion)	3,280	1.5	12,010	1.9	26,330	2.3
NAS	3,100	1.4	4,110	0.7	29,460	2.6

Note: P = Paris; PPC = dense urban area (Paris and its dense suburb, taken together); IdF = Ile-de-France region. One kiloton (kt) = 10³ tonnes (t) = 10³ megagrams (Mg, SI) ≈ 1.102 × 10³ short tons. t/cap = tonnes per capita. DMI = direct material input; DPO = domestic processed output; DMO = direct material output; LEPO = local and exported processed output; DMC = domestic material consumption; DMC_{corr} = corrected domestic material consumption; BI = balancing inputs; BO = balancing outputs; NAS = net addition to stock.

Circular Economy policies - Paris

- **Urban metabolism study in 2009**
- **Etats Généraux de l'Economie Circulaire in 2015** (120 organisation proposed 65 initiatives)
- **First roadmap in 2017** (15 actions for 3 scales)
 - Planning and construction (3)
 - Reduction, reuse and repair (4)
 - Support for actors (5)
 - Public procurement (2)
 - Responsible consumption (1)
- **Second roadmap from 2018 to 2019**

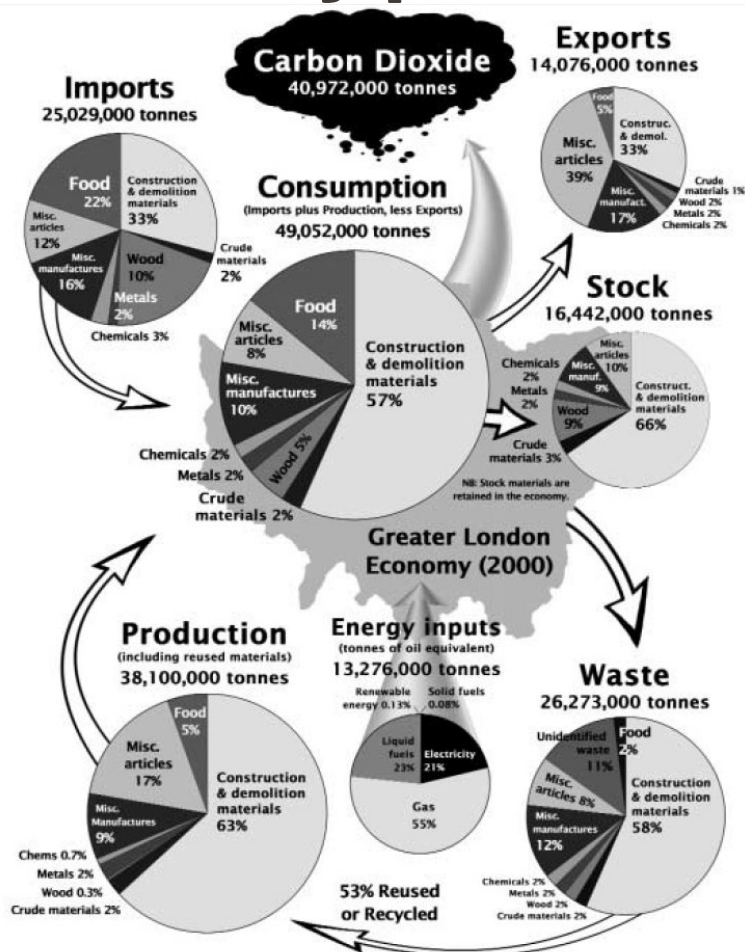


PLAN
**ÉCONOMIE
CIRCULAIRE**
de PARIS

ADOPTÉ AU CONSEIL DE PARIS
DES 3, 4 ET 5 JUILLET 2017

2017-2020

Circular Economy policies - London



Source: Best Foot Forward Ltd., 2002

Circular Economy policies - London

- **Urban metabolism study in 2002**
- **ReLondon (formerly LWARB) governmental entity, CE Route map**
 - Built environment (13 actions): CE design (5), managing building materials (4), operation of buildings (4)
 - Food (9 actions): preventing avoidable food waste (3), valuing food waste and food surplus (3), maximising use of urban space for food growing (3)
 - Textiles (10 actions): design (1), embedding CE into the textile supply chain (6), re-use and recycling
 - Electricals (11): design (2), extending the life of products (6), and effective collection and recycling (3) aspects.
 - Plastics (7 actions)



An aerial photograph of a desert landscape. A light-colored, winding road or path cuts through the sandy terrain. In the foreground, there are dark, rocky outcrops and some sparse, low-lying green shrubs. The background shows a vast, open desert valley with some distant hills under a bright sky.

Thank you for your attention!