UNIVERSITY OF GHANA
DEPARTMENT OF GEOGRAPHY AND RESOURCE DEVELOPMENT

University of Stuttgart
Germany

Bundesministerium für Bildung und Forschung

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SuCCESS 24
Sustainable Cities
Circular Economy
Sub-Saharan Africa

Summer School Unlocking the Power of SDGs and Life Cycle Thinking!

Sustainability – LCA – LCSA

Accra
10.07.2024, 09:00 – 17:00

SDG colour wheel: https://www.un.org/sustainabledevelopment/news/communications-material/

Agenda

08:30– 09:00	Arriving at the lecture hall
09:00 – 09:45	Introduction (SDG related)
09:45 – 10:00	SDG activity
10:00 – 10:15	Coffee break
10:15 – 11:00	Lecture on Sustainability and LCA (Manuel)
11:00 – 12:00	Lecture on Sustainability Assessment Framework
12:00 – 13:00	Lunch break
13:00– 14:45	Work session 1
14:45 – 15:00	Coffee break
15:00 – 16:30	Work session 2
16:30 – 17:00	Recap and Outlook

Your lecturers

Manuel Lorenz

Head of Climate Action
EcoSquare Consulting GmbH

Julia Weißert

University of Stuttgart,
Institute for Acoustics and Building Physics (IABP),
Department Life Cycle Engineering (GaBi)

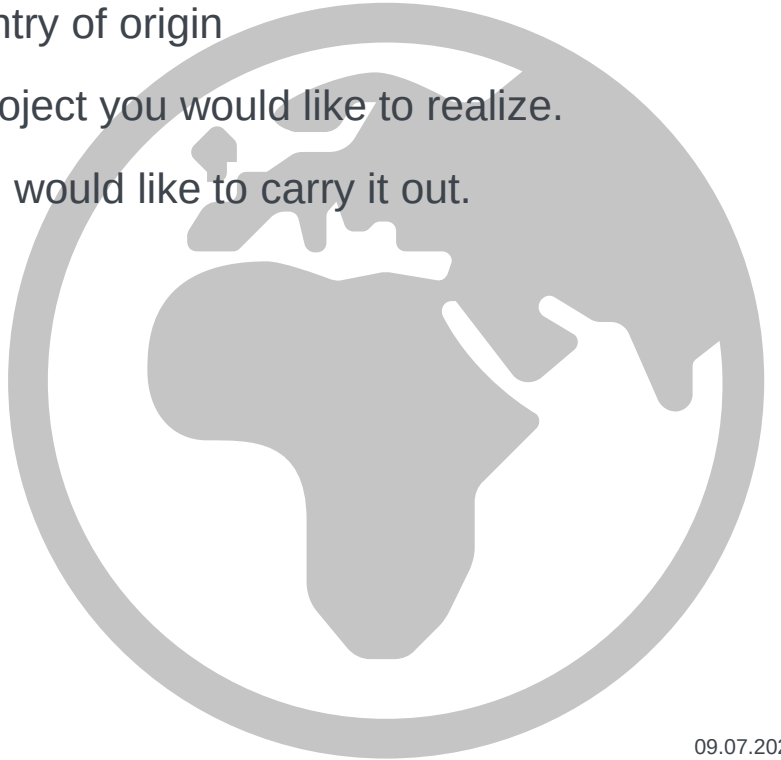
Sustainable Development Goals

© United Nations [6]

SDG Activity

- Imagine the floor is a map!

1. Place yourself in the position of you country of origin
2. Think about what kind of SDG-related project you would like to realize.
3. Locate yourself in the country where you would like to carry it out.
4. Tell us: Where? Why? Which SDG?



Manuel Lorenz

Sustainability and LCA

TABLE OF CONTENTS

01
Sustainability
Fundamentals

02
Sustainability
Assessment

03
Life Cycle Assessment
Methodology

04
Climate Change
Principle & Waste

Intro

Participants understand …

- ✓ … concept and definition of sustainability and sustainability assessment
- ✓ … structure of life cycle assessment and circular economy principles
- ✓ … basics of anthropogenic climate change and Greenhouse Gas (GHG) emissions
- ✓ … GHG emission sources within the waste sector and derive potential interventions to reduce GHG emissions

Intro

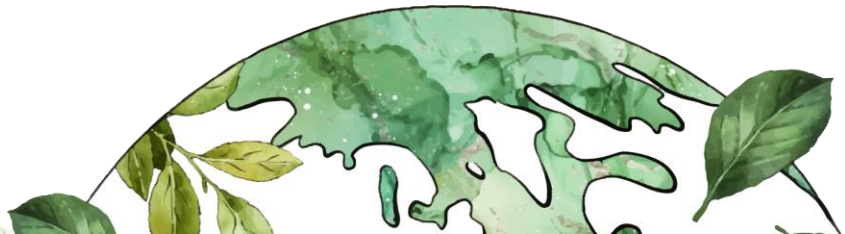
Please share in max 10 words your name and:

- What do you want to take home from
  - this Summer School
  - From the lecture on “Sustainability – LCA – LCSA”

01

Sustainability

Fundamentals



Sustainability

Definitions and Concepts:

Ca. 500 B.C.
Confucius Doctrine of harmony and center

- Limiting **resource depletion** leads to adequate supplies. (Examples: fishing, timber and agriculture)
- Unnecessary consumption is a moral mistake
- Human desire requires a limit for balance

→First demand for sustainable development at all
→Here in the sense of **limiting human greed** and observing the finiteness of natural resources

Sustainability

Definitions and Concepts:

Long B.C.
Indigenous knowledge…
… recognizes and understands that all parts of an **ecosystem** are connected.
… humans, animals, plants, and even rocks, are **dependent upon each other for survival and the well being** of the ecological niche they live in.
… prevents over-consumption of natural resources and leave something for the **next generation**.
… Everything that we do as humans effects the environment in some shape or form.
… understands their lives impact and **therefore treat nature with a level of respect** and admiration that is often dismissed in modern cultures.
… does **not savage the earth** for their own means.

Sustainability

Definitions and Concepts:

1713
Hans Carl from Carlowitz
Sylvicultura oeconomica - Instructions for wild tree cultivation:

- Adopted and translated from very old german language
- "... how such protection and cultivation of wood and timber [is] to be done so that there is a continuous, permanent and sustainable use [...] without which the land in its essence cannot remain."


Mit Gott!
SYLVICVLTVRA OECONOMICA,
Oder
Haußwirthliche Nachricht und Naturmäßige
Anweisung
Zur
Wilden Baum-Zucht,
Nebst
Gründlicher Darstellung/
Wie zu förderst durch Göttliches Benedeyen dem allenthalben und insgemein einreissenden
Grossen Holtz-Mangel/
Vermittelst Säe- Pflantz- und Versetzung vielerhand Bäume zu prospiciren/
Alles zu nothdürfftiger Versorgung des Hauß- Bau- Brau- Berg- und Schmeltz-Wesens/
Worbey zugleich eine gründliche Nachricht von dem in Churfl. Sächs. Landen
Gefundenen Turff
Dessen Natürliche Beschaffenheit/ grossen Nutzen/ Gebrauch und nützlichen Verkohlung.
Von
Hannß Carl von Carlowitz/
Königl. Pohl. und Churfl. Sächs. Cammer-Rath/ und Ober-Berg-Hauptmann.
Mit Königl. Pohl. und Churfürstl. Sächs. allergnädigsten PRIVILEGIO.
LEIPZIG/
verlegts Johann Friedrich Braun 1713.

Complete text available at:
https://www.slub-dresden.de/

Sustainability

Definitions and Concepts:

1972
Club of Rome – "*The limits of growth "*

- Extensive modeling:
  - Modeling quantities: industrialization, population, ressources, habitat, nutrition
  - Boundary conditions: raw material stocks, efficiency, births, environmental protection
- The result: a sharp warning of overuse and exhaustion of natural resources
- Reaching the absolute growth limits of the earth by the middle / end of the 21st century
  → Collapse in quality of life
- BUT: alternative development paths possible
- Actions of individuals with global effects, but geographical and temporal scales are beyond the imagination of individuals

Sustainability

Definitions and Concepts:
1987

Brundtland Report “Our Common Future”
*„Sustainable development seeks to reconcile **economic** development with the protection of **social** and **environmental** balance.”*

Sustainable development:
“Development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

- economic growth, social cohesion and environmental protection go hand in hand and are mutually supporting.

- Sustainable development is supposed to be social Equality between (*intergenerational*) Generations and within (*intragenerational*) everyone generation reach

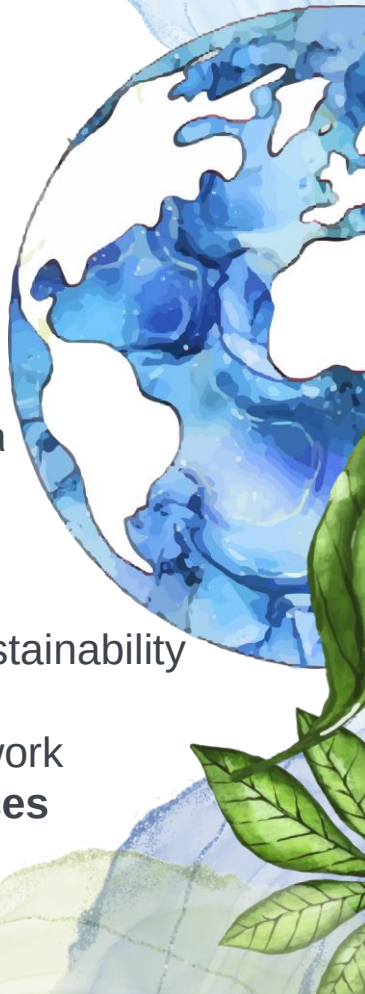
Sustainability

Definitions and Concepts:

1992

UN Conference on Environment and Development UNCED, Rio die Janeiro

- Recognition of the historical responsibility of industrialized nations (OECD)
- Declaration on Environment and Development, Agenda 21
  “Humanity stands at a defining moment in history. We are confronted with a perpetuation of disparities between and within nations, a worsening of poverty, hunger, ill health and illiteracy, and the continuing deterioration of the ecosystems on which we depend for our well-being. “
- Comprehensive development program that becomes the basis of many sustainability strategies
- Foundation of the Framework Convention on Climate Change (UN Framework **Convention on Climate Change, UNFCCC**) and **COP climate conferences** (Conference of the Parties)
- Start of **international climate protection diplomacy**



Sustainability

Definitions and Concepts:

1997

UN Climate Conference 1997, COP 3

→ **Kyoto Protocol**

- Agreement to reduce greenhouse gas emissions with binding limits
- After saving your own emissions, three instruments are available:
  - Emissions trading: global trading in greenhouse gas emissions
  - Implementation of measures in developing countries
    "**Clean Development Mechanism**"
  - Project-related cooperation with other industrialized countries

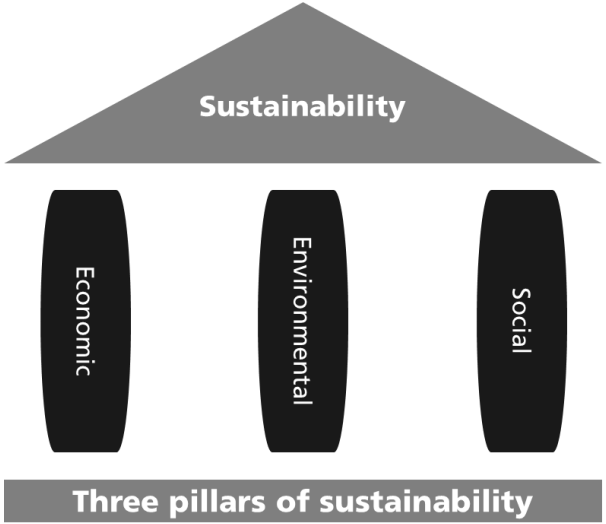
2002

World Summit on Sustainable Development, Johannesburg

- Tracking of previous activities
- Adaption of the **3 pillars Model** for sustainable development

Sustainability

Concept of the *3 pillars of sustainability*



UN Conference on Environment and Development, Rio de Janeiro (1992)
World Summit Johannesburg (2002)

Sustainability - global

"**17 SDGs** are an urgent call for action by all countries. They recognize that ending **poverty** and other deprivations must go hand-in-hand with strategies that improve **health** and **education**, reduce **inequality**, and spur **economic growth** – all while tackling **climate change** and working to preserve our **oceans** and **forests**."

Source: https://sdgs.un.org/goals

Sustainability - global

- **2030 Agenda for Sustainable Development**
- Adopted by all **United Nations Members** in **2015**
- **17 goals** to reach peace and prosperity for people and planet, now and into the future
- Balance the 3 dimensions of sustainable development: economic, social and environmental
- Every goal has 8 to 12 targets
- Total of 169 targets
- Every target has 1 to 4 indicators
- Used to measure, monitor and visualize progress towards each target
- total of 231 indicators

SDG poster: https://www.un.org/sustainabledevelopment/news/communications-material/

Sustainability – African union (1/3)

Agenda 2063 Goals	UN Sustainable Development Goals
1. A high standard of living, quality of life and well-being for all citizens.	1. End poverty in all its forms everywhere in the world 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture. 8. Promote sustained, inclusive and sustainable Economic growth, full and productive employment and decent work for all. 11.Make cities and human settlements inclusive, safe, resilient and sustainable.
2. Well educated citizens and skills revolution underpinned by science, technology and innovation.	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
3. Healthy and well-nourished citizens.	3. Ensure healthy lives and promote well-being for all at all ages.
4. Transformed economies.	8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all. 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
5. Modern agriculture for increased productivity and production.	2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
6. Blue/ocean economy for accelerated economic growth.	14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

Source: African Union Linking Agenda 2063 and the SDGs https://au.int/agenda2063/sdgs

Sustainability – African union (2/3)

Agenda 2063 Goals	UN Sustainable Development Goals
7. Environmentally sustainable and climate resilient economies and communities.	6. Ensure availability and sustainable management of water and sanitation for all. 7. Ensure access to affordable, reliable, sustainable and modern energy for all. 13. Take urgent action to combat climate change and its impacts. 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
8. A United Africa (Federal or Confederate).	
9. Continental financial and monetary institutions established and functional.	
10. World class infrastructure criss - crosses Africa.	9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
11. Democratic values, practices, universal principles of human rights, justice and the rule of law entrenched.	16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
12. Capable institutions and transformative leadership in place.	16.Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.

Source: African Union Linking Agenda 2063 and the SDGs https://au.int/agenda2063/sdgs

Sustainability – African union (3/3)

Agenda 2063 Goals	UN Sustainable Development Goals
13. Peace, security and stability is preserved.	16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.
14. A stable and peaceful Africa.	
15. A fully functional and operational APSA	
16. African cultural renaissance is pre-eminent.	
17. Full gender equality in all spheres of life.	5.Achieve gender equality and empower all women and girls.
18. Engaged and empowered youth and children.	4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. 5. Achieve gender equality and empower all women and girls.
19. Africa as a major partner in global affairs and peaceful co-existence.	17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.
20. Africa takes full responsibility for financing her development Goals.	10. Reduce inequality within and among countries. 17.Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Source: African Union Linking Agenda 2063 and the SDGs https://au.int/agenda2063/sdgs

Sustainability – European union (1/3)

Source: EU holistic approach to sustainable development

Sustainability – European union (2/3)

Source: EU holistic approach to sustainable development

Sustainability – European union (3/3)

"The European Green Deal sets out how to make Europe the first climate-neutral continent by 2050, boosting the economy, improving people's health and quality of life, caring for nature, and leaving no one behind."

European Commission, The European Green Deal, 2005

Plan includes:

- a circular economy action plan
- a Farm to Fork strategy which will reward farmers for managing and storing carbon in the soil, improved nutrient management, reducing emissions, ...
- a revision of the Energy Taxation Directive, looking closely at fossil fuel subsidies and tax exemptions (aviation, shipping)
- a sustainable and smart mobility strategy and
- an EU forest strategy. The latter will have as its key objectives effective afforestation, and forest preservation and restoration in Europe.
- a review and possible revision of the all relevant climate-related policy instruments, including the Emissions Trading System,

Sustainability – city level

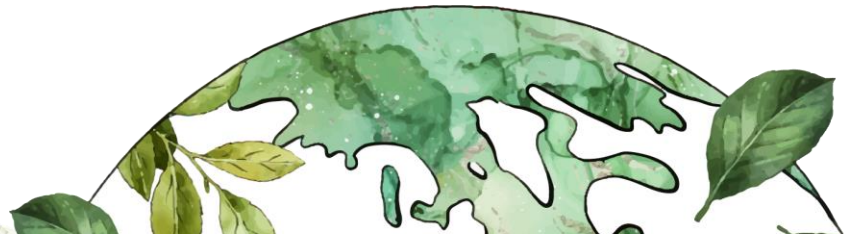
- C40 initiative – global network of nearly 100 mayors of the world's leading cities that are united in action to confront the climate crisis.
- Mission: Cooperate to implement local action on
  - Raise climate ambition through 1.5°C climate action plan
  - Build equitable and thriving communities via global and regional programmes.
  - Build a global movement through robust international advocacy and diplomacy.
  - Scale up climate action and sharing best practices across high-impact sectors.
  - Facilite access to finance for investment in green jobs and projects that improve resilience in cities.

https://www.c40.org/cities/

02

Sustainability

Assessment



How can we measure Sustainability?

“**Sustainability is difficult to quantify, maybe even impossible to measure.”**

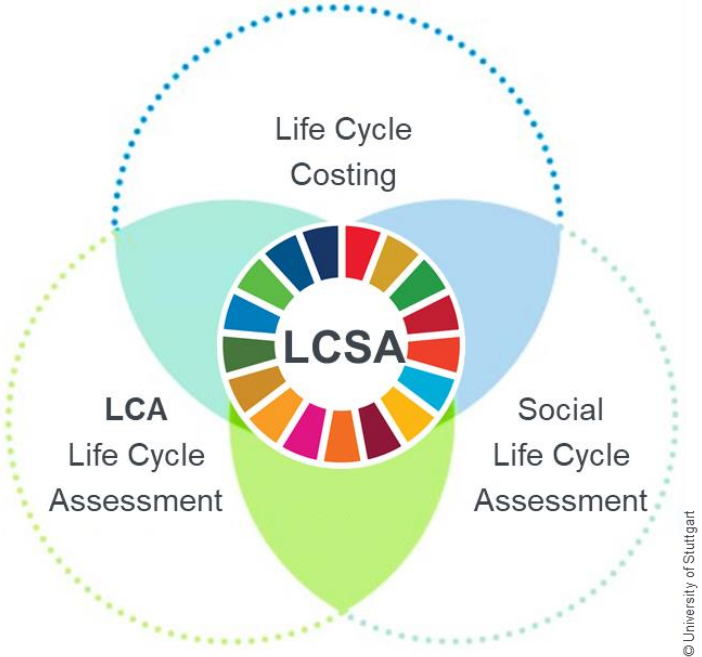
Various approaches, concepts and indicator sets have been developed and are under development.

Common essential element:
→ To measure sustainability, the indicators must consider environmental, social and economic dimensions.

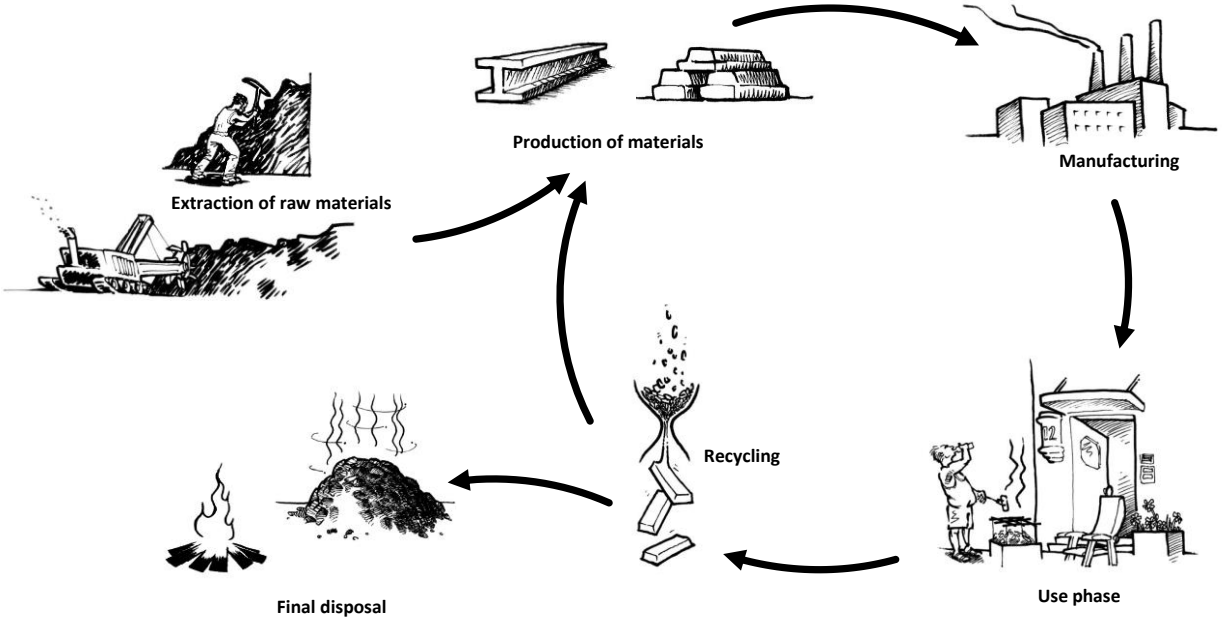
Exemplary approaches such as certification schemes like Fairtrade, Rainforest alliance, FSC, MSC, … have in common:
It requires a set of frameworks or indicators to measure how sustainable something is. E.g.

- SDG indicators
- Sustainability reporting (ESG)
- Triple bottom line (TBL or 3BL)
- Life Cycle Sustainability Assessment (LCSA)

Life Cycle Sustainability Assessment



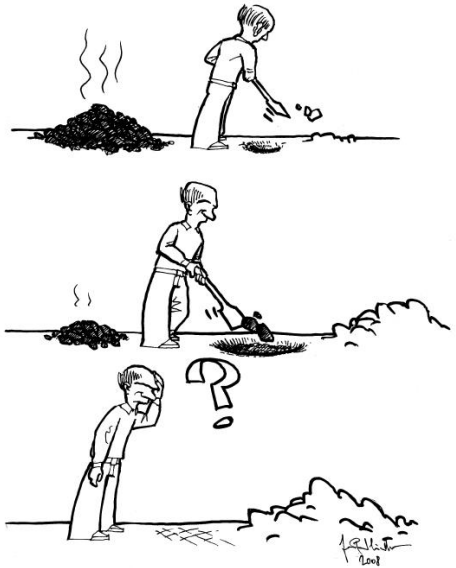
Life Cycle Thinking



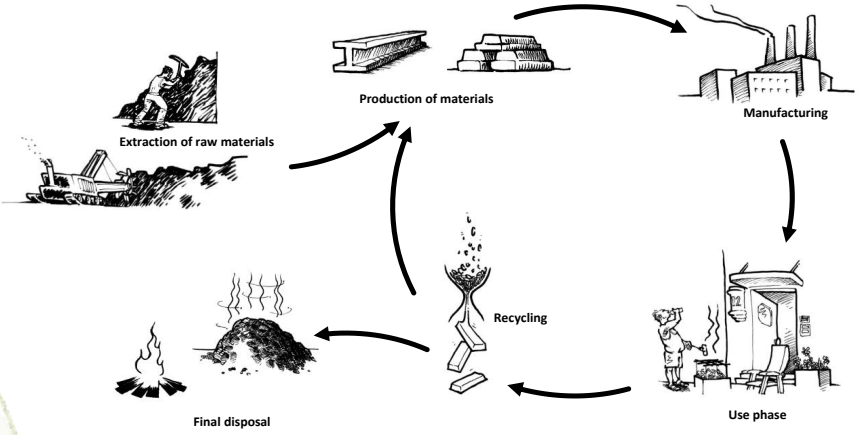
Life Cycle Thinking

Avoid solving a problem…

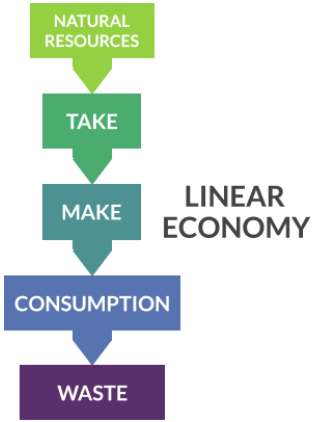
… by creating a new one!



Life Cycle Thinking



→ Moving away from a linear economy into a sustainable circular economy.

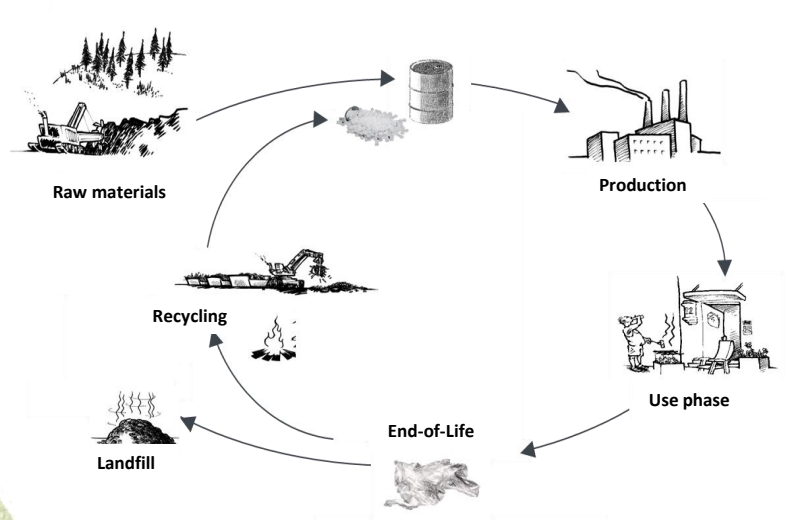


LINEAR ECONOMY

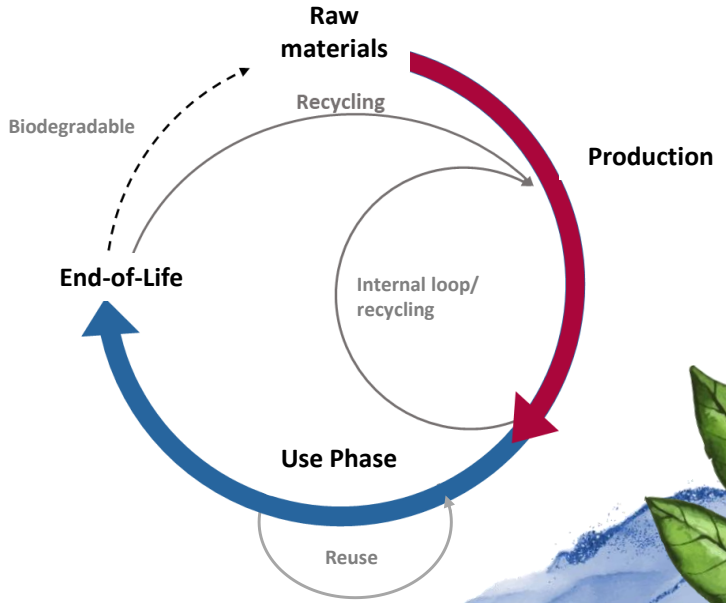
Life Cycle Thinking

Example: Plastic packaging

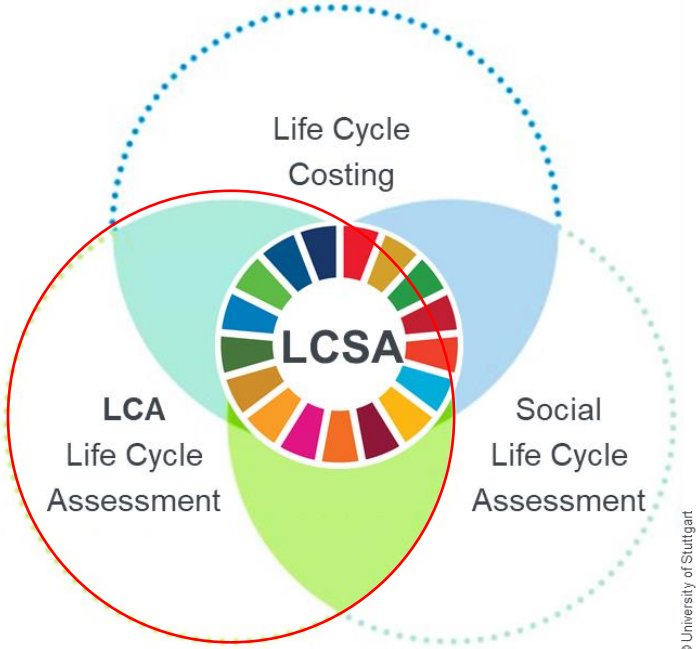
Life cycle of packaging



Circular strategies



Life Cycle Sustainability Assessment



3 min break

Coffee

Questions

Breath

Meditate

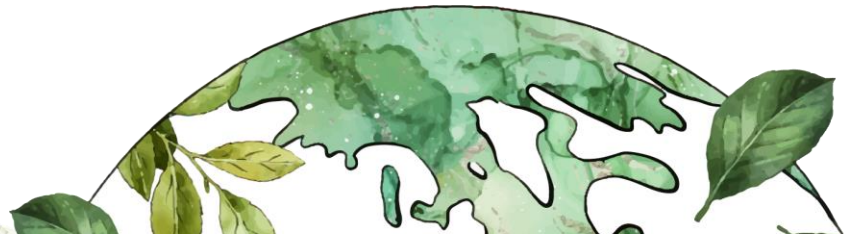
Recap

Something else

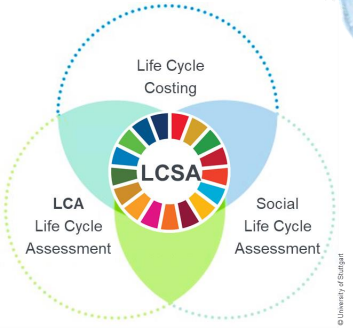
03

Life Cycle Assessment

Methodology



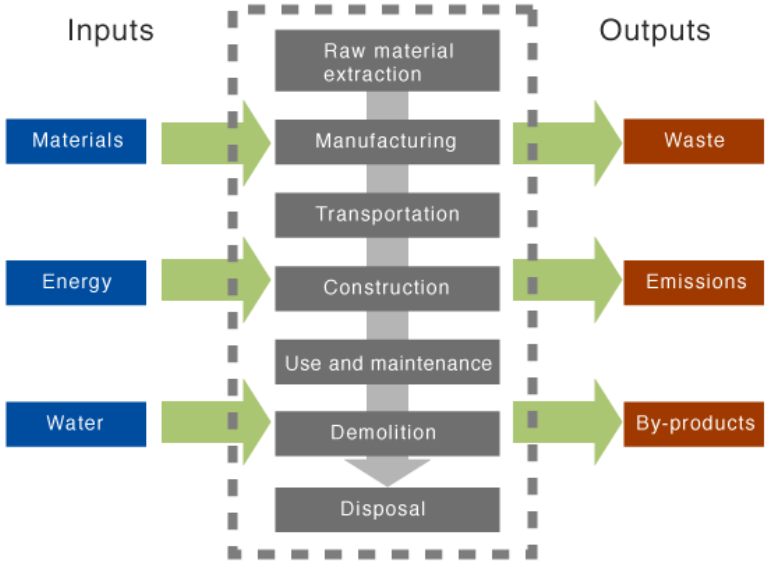
LCA?



- **The definition of the life cycle assessment according to DIN EN ISO 14040:**
  - *"LCA is defined as the compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle."*

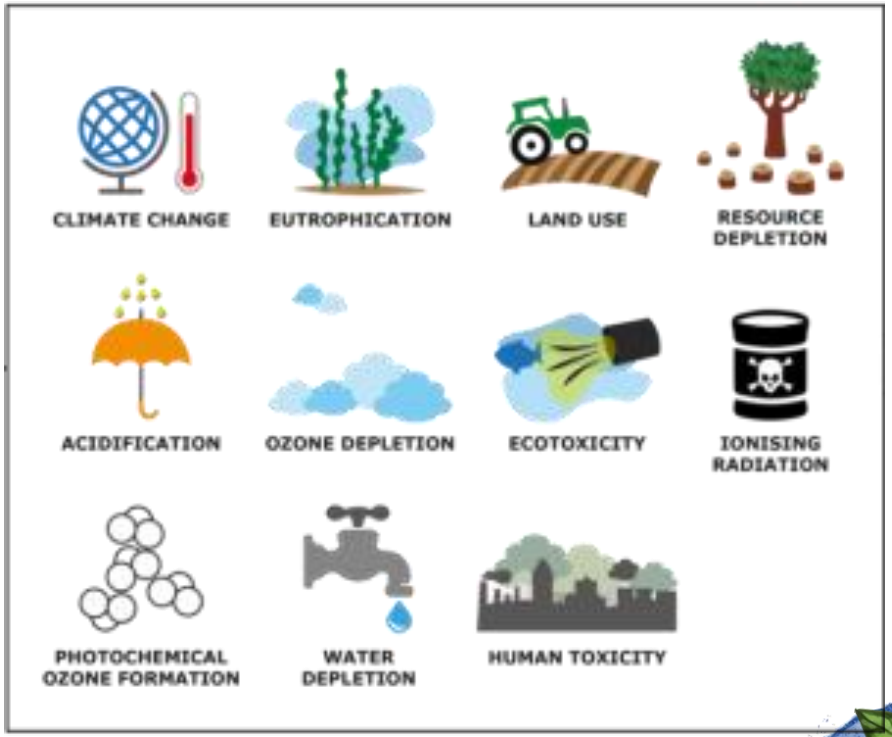
Life Cycle Assessment

1. **compilation of the inputs, outputs**
2. potential environmental impacts
3. throughout its life cycle.



Life Cycle Assessment

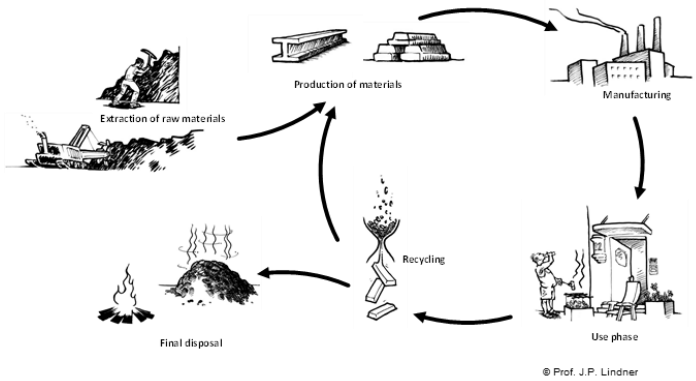
1. compilation of the inputs, outputs
2. **potential environmental impacts**
3. throughout its life cycle.

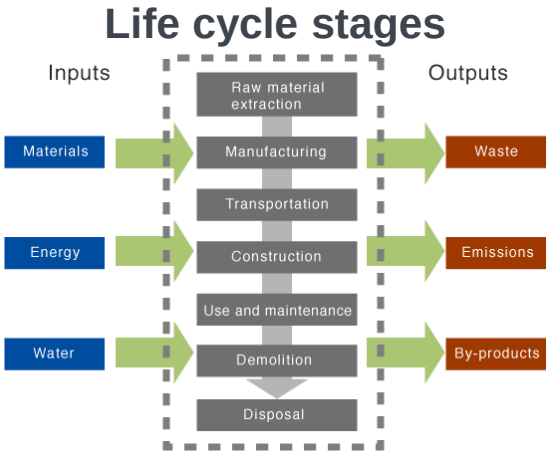


Source: European Platform on LCA | EPLCA

Life Cycle Assessment

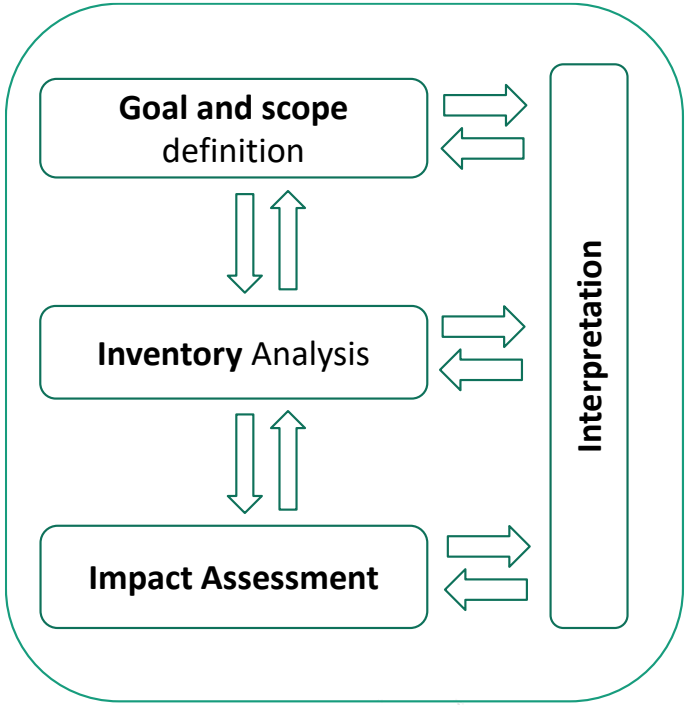
1. compilation of the inputs, outputs
2. potential environmental impacts
3. **throughout its life cycle.**





Life Cycle Assessment - Methodology

DIN EN ISO 14040:



Direct Applications:

- ✓ Product development
- ✓ Strategical plans
- ✓ Public policy planning
- ✓ Marketing
- ✓ others

Figure: LCA framework and four phases to an LCA
Source: adapted from ISO-14040 (2006)

Life Cycle Assessment – Goal & Scope

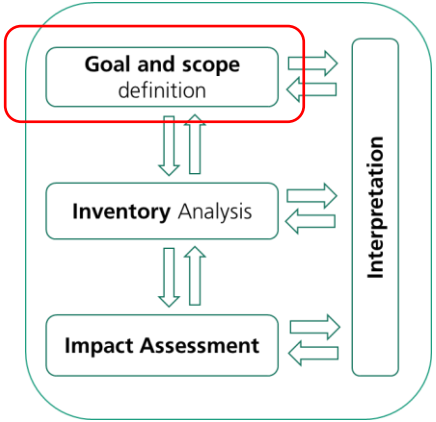
Goal of the LCA study

The goal of the study:
E.g. analysis and comparison of different product options

Intended use:
E.g. decision support, identification of weak points and optimization potential, improved product understanding

Reasons for conducting the study:
E.g. controversial discussions about different alternatives without a scientific background

Target group
E.g. internal or external communication



Life Cycle Assessment – Goal & Scope

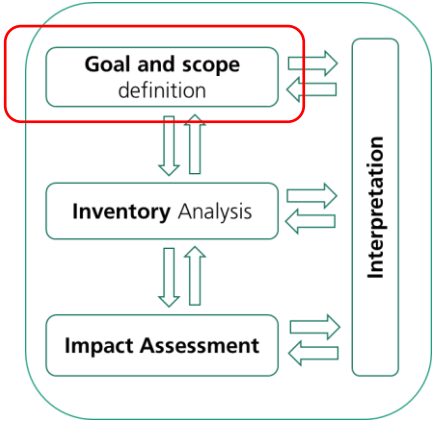
Scope of the LCA study

Essential:

- Function of the system (product or service)
- Functional unit and reference flow
- System description
- System boundaries

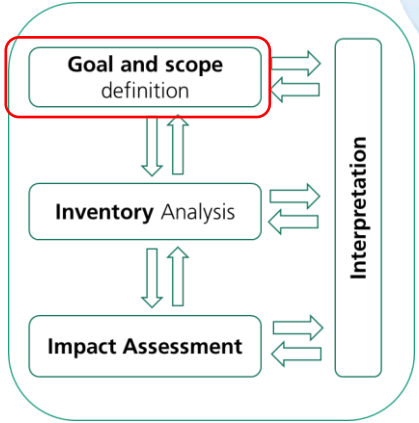
Optional

- Allocations
- Impact categories and models for impact assessment
- Requirements for the data
- Estimates and assumptions for the data used
- Data restrictions
- Data quality requirements
- Critical review
- Type of reporting



Life Cycle Assessment – Goal & Scope

Functional Unit



Definition ISO-14040

> “The functional unit defines the quantification of the identified functions (performance characteristics) of the product. The primary purpose of a functional unit is to provide a reference to which the inputs and outputs are related.”
>
> This reference is necessary to ensure comparability of LCA results.

→ **Reference flow:** amount of a product that is required to provide a functional unit

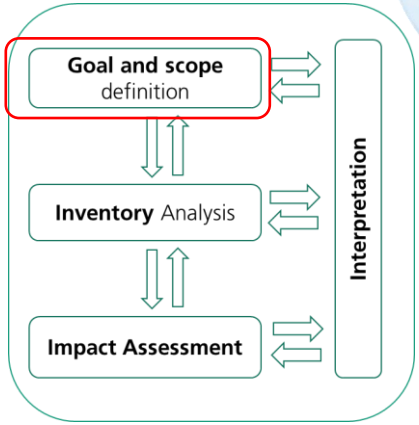
Question		Aspect
1)	**What?**	**Function(s) or service(s) provided**
2)	**How much?**	**Extent of the function(s) or service(s)**
3)	How long?	Duration/lifetime of the function or service
4)	*How well?	Expected level of quality

Source: Product Environmental Footprint Category Rules PEFCR [EU Commission] Document Guidance 2 (*Version 6.3 – May 2018)*

Life Cycle Assessment – Goal & Scope

Example: Comparison of Tomato packaging options

Question		Aspect	Example 1	Example 2	Example 3
1)	**What?**	**Function or service provided**	To buy loose tomatoes in a reusable net	To buy tomatoes packed in plastic	To buy tomatoes in a paper bag
2)	**How much?**	**Extent of the function or service**	1 kg	250 g	500 g
3)	How long?	Duration/lifetime of the function or service	50 times (1 year period)	1 time	1 time
4)	*How well?	Expected level of quality	Food losses < 1%	Food losses < 1%	Food losses < 1%



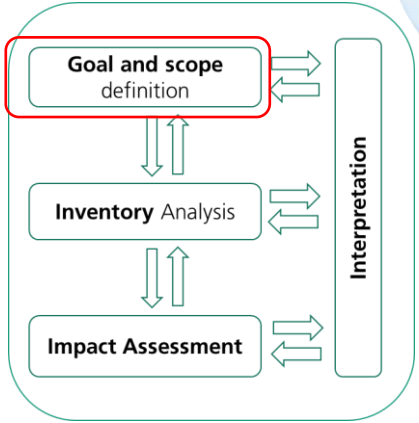
Functional unit: The one-time purchase of 1 kg packed tomatoes, with food losses <1%.

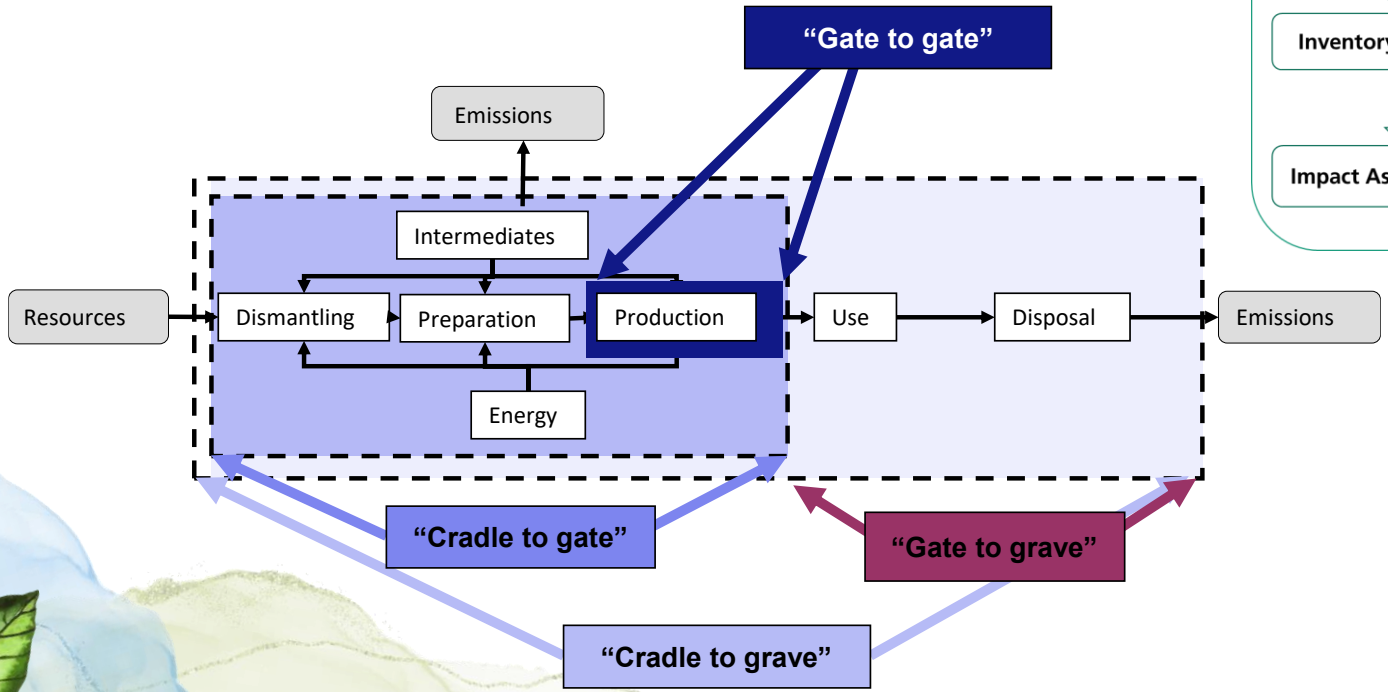
Reference flow: 1 kg tomatoes

Life Cycle Assessment – Goal & Scope

System boundary

Definition ISO-14040:
“Set of criteria specifying which unit processes are part of a product system”





Life Cycle Assessment – Inventory

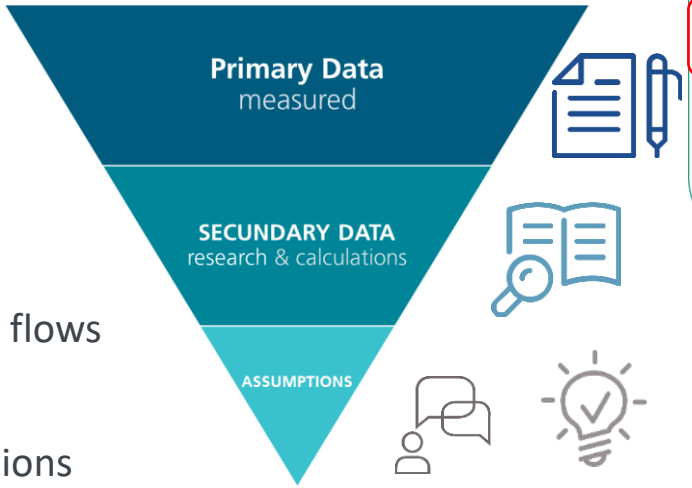
“Where do I get the data for the Life Cycle Inventory (LCI)?”

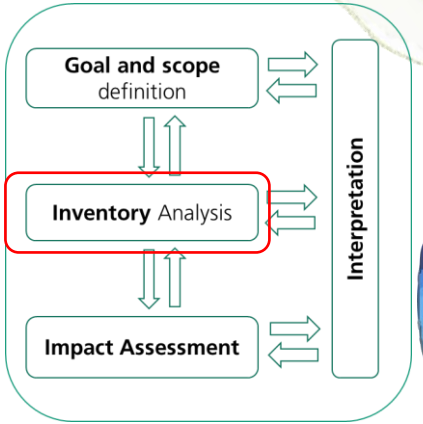
Primary data

- Direct measurement

Secondary data

- Data collection from the data owner (e.g., process owner)
- Calculation methods to quantify relevant flows
- Literature research
- (Expert) estimates and qualified assumptions



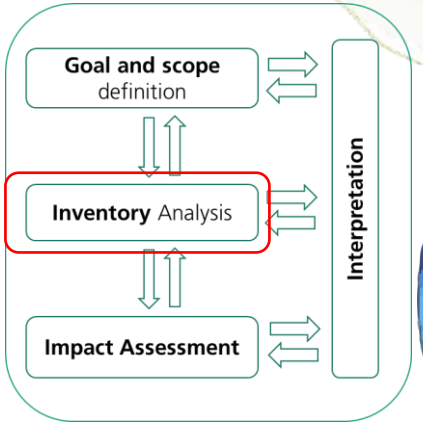


Life Cycle Assessment – Inventory

“What is important during the data collection?“

- Requirements must be defined at the beginning of the study
- **Data quality** should be recorded for the following parameters:
  - Time-related coverage (year, and time interval of data collection)
  - Geographical coverage (local, regional, global...)
  - Technological coverage (technological composition e.g. Best available technology)
- **Data collection** (measured, calculated, estimated)
  - Accuracy (precision and correctness)
  - Completeness (e.g. proportion of primary data)
  - Representativeness, consistency, and traceability

→ Data collection is (usually) the **most time-consuming part of an LCA.**
→ **The more accurate the data, the more reliable are the results.**



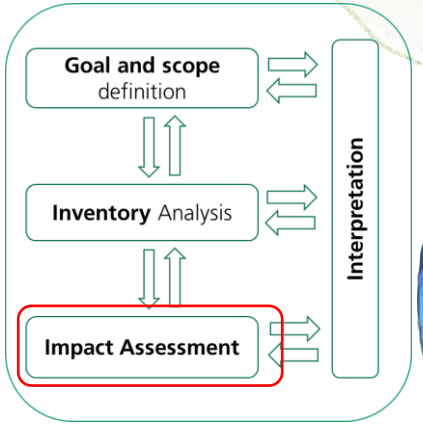
Life Cycle Impact Assessment

Mandatory steps:

- Selection of methodology
  - → Selection of impact categories
  - → Classification
  - → Characterization

Optional steps:

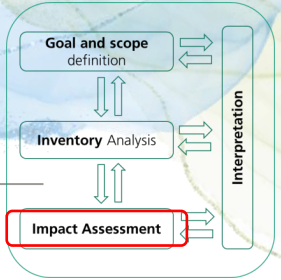
- Normalization
- Weighting
- Data quality analysis



Impact assessment: method selection and application

Methodological approaches are constantly evolving through scientific exchange.
There is no such thing as "the right method", so careful consideration is required when making a selection.

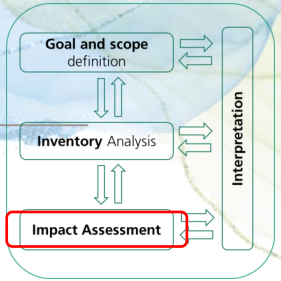
Life Cycle Impact Assessment



Impact assessment:
→ method selection and application

EF	▪ **E**nvironmental **F**ootprint ▪ 16 impact categories	▪ Recommendation European Commission ▪ Latest version: **EF 3.1** (July 2022)
CML	▪ **C**entrum voor **M**ilieukunde, Uni **L**eiden ▪ Relevant for Environmental Product Declarations	▪ Latest version: 2016 ▪ Most impact categories included in EF
TRACI	▪ **T**ool for **r**eduction and **a**ssessment of **c**hemicals and other environmental **i**mpacts	▪ US Environmental Protection Agency ▪ Latest version: TRACI 2.1 (2012)
ReCiPe	▪ 18 midpoint impact categories and 3 endpoint categories	▪ Latest version: ReCiPe 2016

Life Cycle Impact Assessment

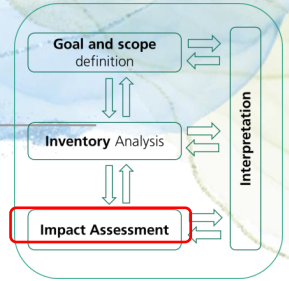


Impact assessment:
→ Selection of impact categories

EF 3.1 midpoint indicators as an example of impact categories

Impact category	Indicator	Unit
Climate change	Radiative forcing as Global Warming Potential (GWP100)	kg CO_2 eq.
Acidification	Accumulated Exceedance (AE)	mol H^+ eq.
Photochemical ozone formation	Tropospheric ozone concentration increase	kg NMVOC eq.
Water use	User deprivation potential (deprivation weighted water consumption)	kg world eq. deprived
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserves)	kg Sb eq.
Resource use, energy carriers	Abiotic resource depletion – fossil fuels (ADP-fossil)*	MJ

Life Cycle Impact Assessment

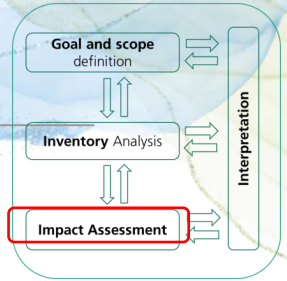


Impact assessment: → Selection of impact categories

EF 3.1 midpoint indicators as an example of impact categories

Impact category	Indicator	Unit
Ozone depletion	Depletion potential of the stratospheric ozone layer, ODP	kg CFC-11 eq.
Ecotoxicity for aquatic fresh water	an estimate of the potentially affected fraction of species (PAF) integrated over time and volume per unit mass of a chemical emitted (PAF m3 year/kg)	CTUe (Comparative Toxic Unit for ecosystems)
Human Toxicity – cancer effects	the estimated increase in morbidity in the total human population per unit mass of a chemical emitted	CTUh (Comparative Toxic Unit for humans)
Human Toxicity – non-cancer effects	the estimated increase in morbidity in the total human population per unit mass of a chemical emitted	CTUh (Comparative Toxic Unit for humans)
Particulate Matter/Respiratory Inorganics	Intake fraction for fine particles	kg PM2.5 eq.
Eutrophication – terrestrial	Accumulated Exceedance (AE)	mol H^+ eq.
Eutrophication – aquatic	Phosphorus equivalents	Fresh water: kg P eq. Marine: kg N eq.
Land Transformation	Soil Organic Matter (SOM)	Kg (deficit)

Life Cycle Impact Assessment



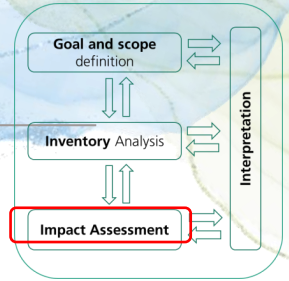
Impact assessment: → Classification and Characterization
Those steps are often completed using LCA software.

Classification: LCI results are *assigned to the chosen impact categories* based on their known environmental effects.

Characterization: LCI results are *transformed within each impact category* via "characterization factors" (also referred to as equivalency factors) to create "impact category indicators.

CHARACTERIZATION FACTORS ARE SNAPSHOTS OF THE CURRENT STATE OF SCIENCE WITH RESPECT TO DISPERSION, EXPOSURE AND EFFECTS OF THE CHEMICAL SUBSTANCES IN QUESTION.

Life Cycle Impact Assessment



Impact assessment: → Classification and Characterization

.....

Emissions to Air

- CO_2
- CF_4
- CH_4
- N_2O
- NO_x
- SO_2
- HCl
- HF

.....

Emissions to water

- Phosphat
- NH_3
- NH_4

.....

Quantity * CF

Climate Change GWP-100 [kg CO_2-eq.]

CO_2	1
CF_4	5700
CH_4	27.9
N_2O	273

Σ GWP-Factor$_i$ * Emission$_i$ [kg] → Σ GWP

Acidification Potential (AP) [kg SO_2-eq.]

NO_x	0.7
SO_2	1
HCl	0.88
HF	1.6

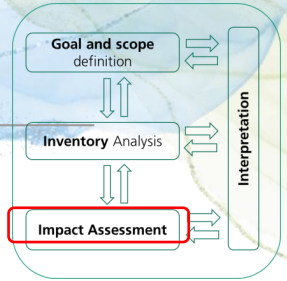
Σ AP-Factor$_i$ * Emission$_i$ [kg] → Σ AP

Eutrification Potential (EP) [kg PO_4-eq.]

NO_x	0.13
Phosphat	1
NH_3	0.35
NH_4	0.33

Σ EP-Factor$_i$ * Emission$_i$ [kg] → Σ EP

Life Cycle Impact Assessment



Impact assessment: → Classification and Characterization

Example: Climate Change as GWP100

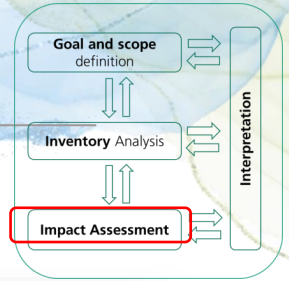
Inventory (GHG)	*	Characterization Factor	=	Impact potential (impact indicator value)
25 kg CO_2	*	1	=	25.0 [kg CO_2-equivalent]
2 kg CH_4	*	27.9	=	55.8 [kg CO_2-equivalent]
0.1 kg N_2O	*	273	=	27.3 [kg CO_2-equivalent]
...	*	...	=	...
			Total:	Σ 108.1 [CO_2-eq.]

1 kg CH_4 emissions are equivalent to 28 kg CO_2

1 kg N_2O emissions are equivalent to 265 kg CO_2

(Source: Global warming potential 100 years; *IPPC Fifth Assessment Report (AR6) (tbc)*

Life Cycle Impact Assessment



Limitations of LCA: accidents and disasters

Example: Accident on the Deepwater Horizon oil rig.

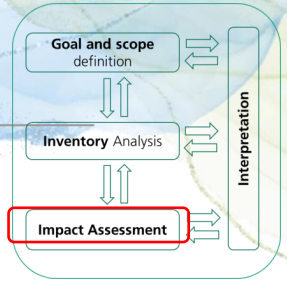
Oil from the platform flows unhindered from three different leaks at a depth of 1,500 meters. Every day, around 5,000 barrels (approx. 800,000 liters) flow into the sea, five times as much as initially suspected.

What is the environmental impact?
Is this considered when calculating the impact of using and producing oil?

→ **NO!**

In general: LCA assumes "normal case scenarios"

Life Cycle Impact Assessment



Limitations of LCA: accidents and disasters

In general: LCA assumes "normal case scenarios“

Statistically occurring effects are handled with probability and damag potentials

Low probability

e.g. total loss of an oil platform, GAU in nuclear power

→ *probability close to zero*

High damage potential

e.g. widespread contamination of waters, radiation of la

→ *damage potential close to infinity*

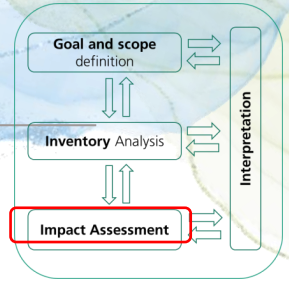
Expected value of the damage

"zero times infinity“

Theoretically calculable, but without statement

www.timetoast.com

Life Cycle Impact Assessment

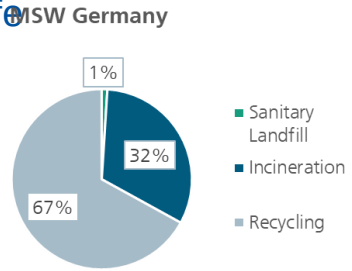


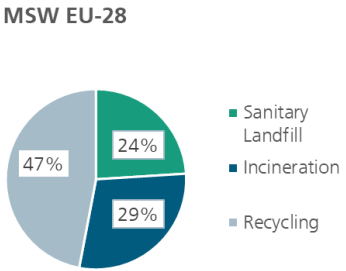
Limitations of LCA: unplanned scenarios

Example: Disposal is foreseen for municipal solid waste (MSW)?

Modelled disposal options at the end of life

1. Recycling
2. Incineration
3. Sanitary landfill

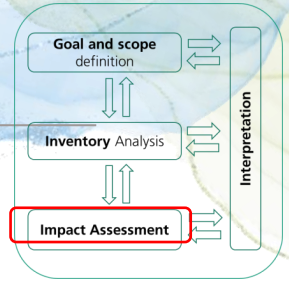




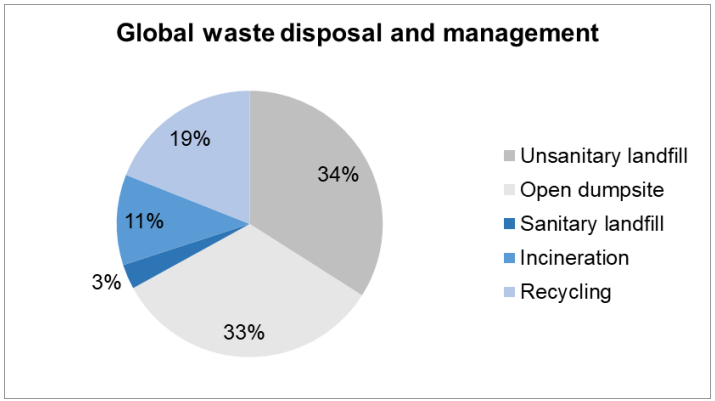
- **What (real) scenarios is not considered?**
  - **Incineration without flue gas cleaning**
  - **Unsanitary landfill, dumpsite**
  - **Unregulated disposal: littering!**

Source: *Eurostat* Database on MunicipalSolid Waste (MSW) Treatment © European Union, 1995-2019

Life Cycle Impact Assessment



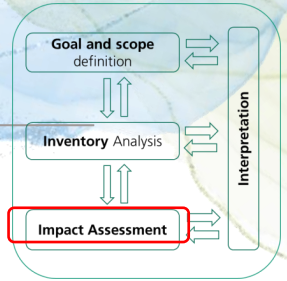
Limitations of LCA: unplanned scenarios
→ unregulated disposal: Littering



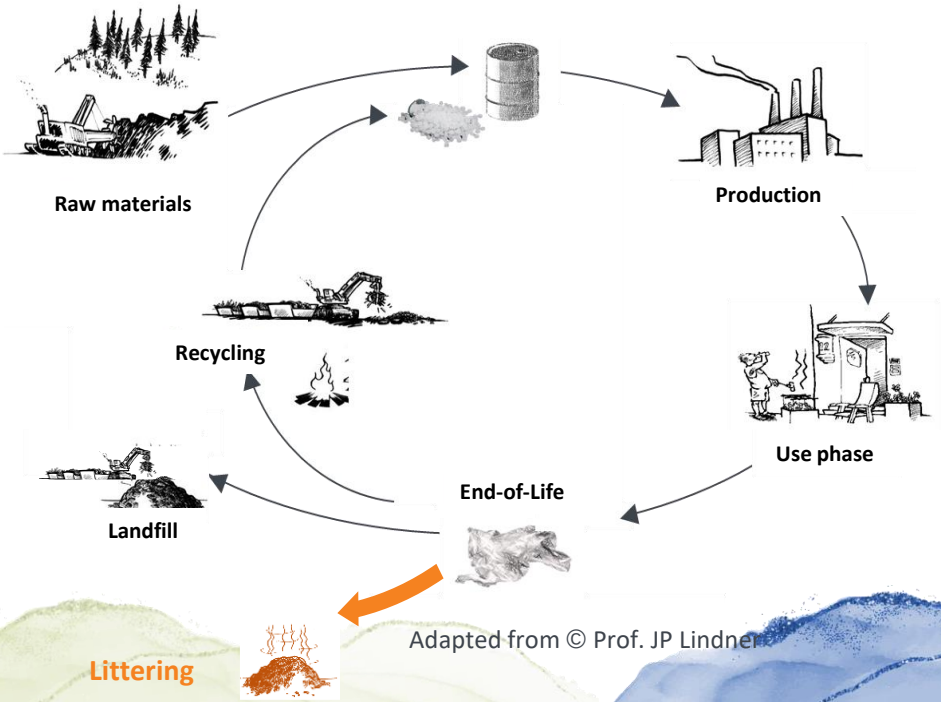
Source: What a Waste 2.0 A Global Snapshot of Solid Waste Management to 2050

- → Currently life cycle assessment models only represent approx. 33% of the current disposal situation (globally).
- → Not a statistical extreme
- → Urgent need in method development

Life Cycle Impact Assessment



Limitations of LCA: unplanned scenarios
→ unregulated disposal: Littering



Adapted from © Prof. JP Lindner

Littering can occur at any point in the life cycle, and some of the resulting effects that are not fully understood and therefore cannot be reflected in the life cycle assessment.

3 min break

Questions

Breath

Meditate

Coffee

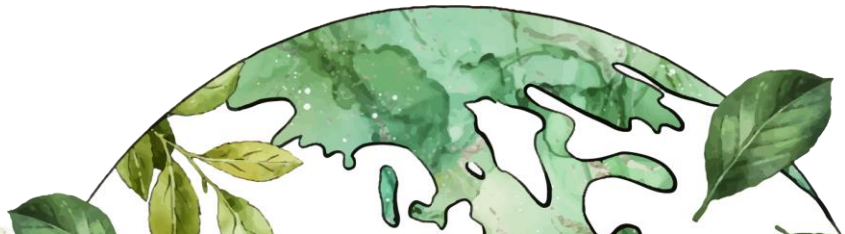
Recap

Something else

04

Climate Change

Principle, Potentials and Waste



Climate Change

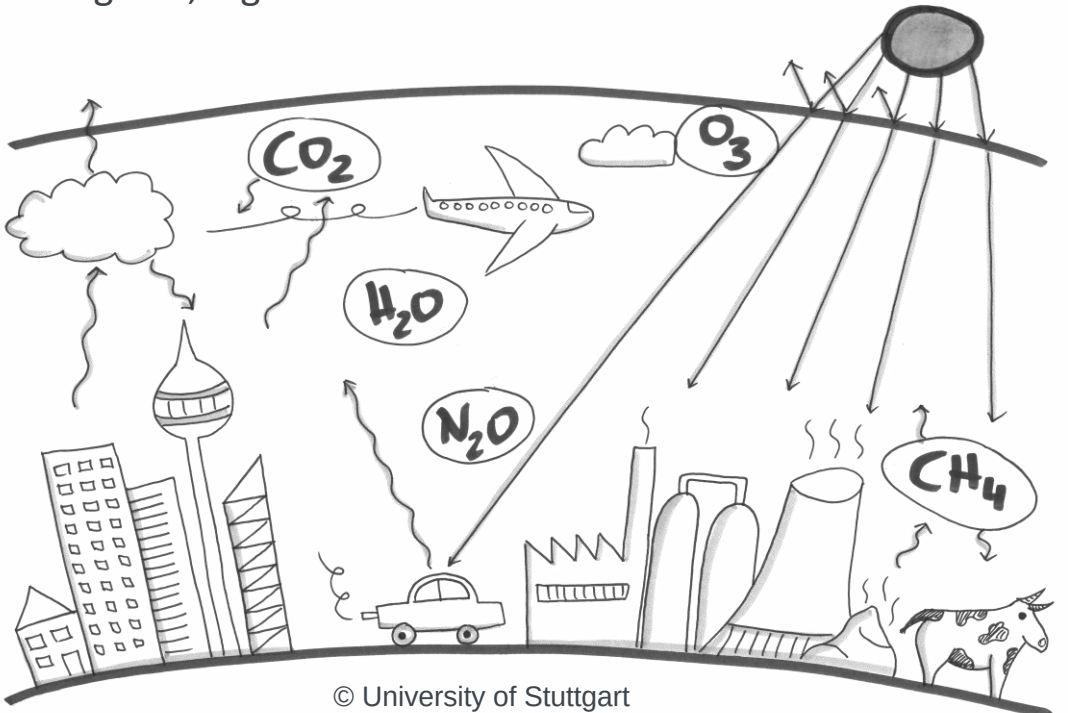
Climate change is any change occurring to the planet's climate either permanently or lasting for long periods of time. It is the cumulative total of
two related sources: anthropogenic greenhouse effect and natural greenhouse effect

Greenhouse effect:

- Natural process that warms the Earths surface
- Sun energy reaches Earths atmosphere, some is reflected, others absorbed and re-radiated by Greenhouse Gases (GHG)
- Allows life on earth
- Planet Earth global average surface temperature:
  - Without natural greenhouse effect: estimated @ - 18°C
  - With natural GH effect: ca. +15°C
- With anthropgenic GH effect → rising within the 21st century to +17, +18 °C or more

Climate Change

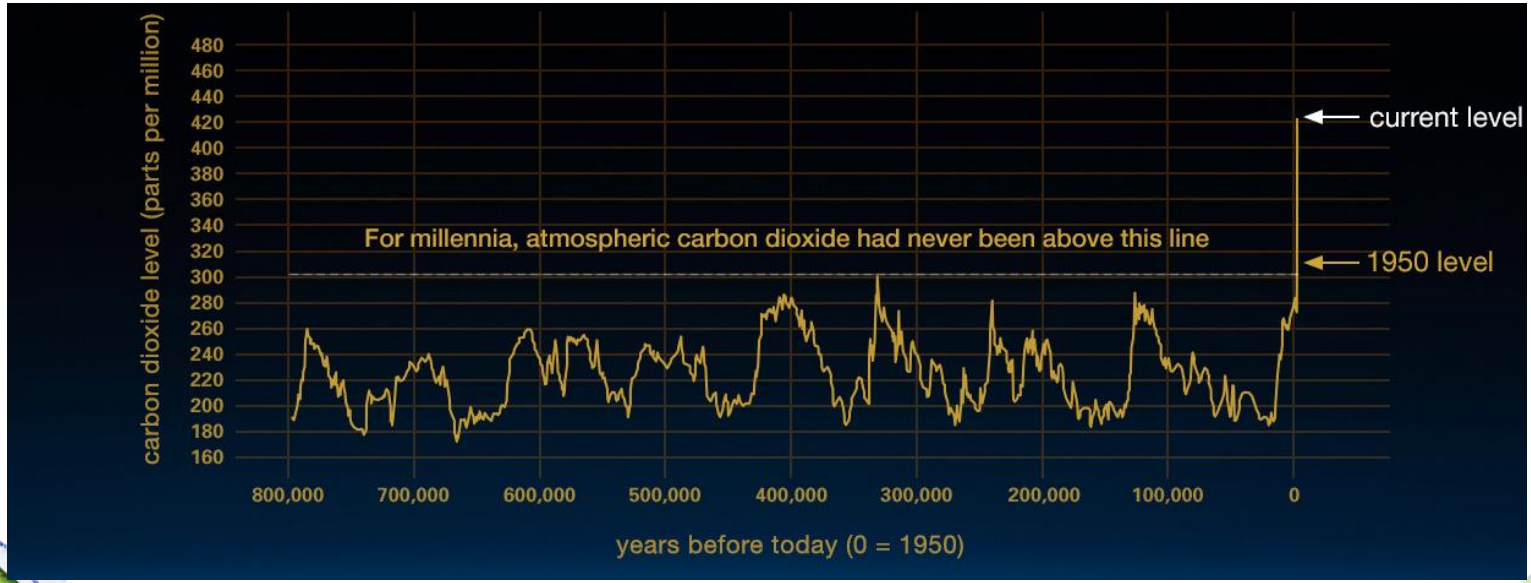
Anthropogenic Greenhouse effect is defined by the human impact on Earth's climate with the contribution to man-made climate change through increasing warming of the troposphere by anthropogenic greenhouse gases, e.g. from the combustion of fossil fuels.



Climate Change

Anthropogenic Greenhouse effect

Carbon dioxide levels over the last 400,000 years have stayed below 300 ppm and skyrocketed from 1950's to present. Note the climate changed quite a bit before the industrial revolution. Those changes were natural, the current climate change is largely anthropogenic.

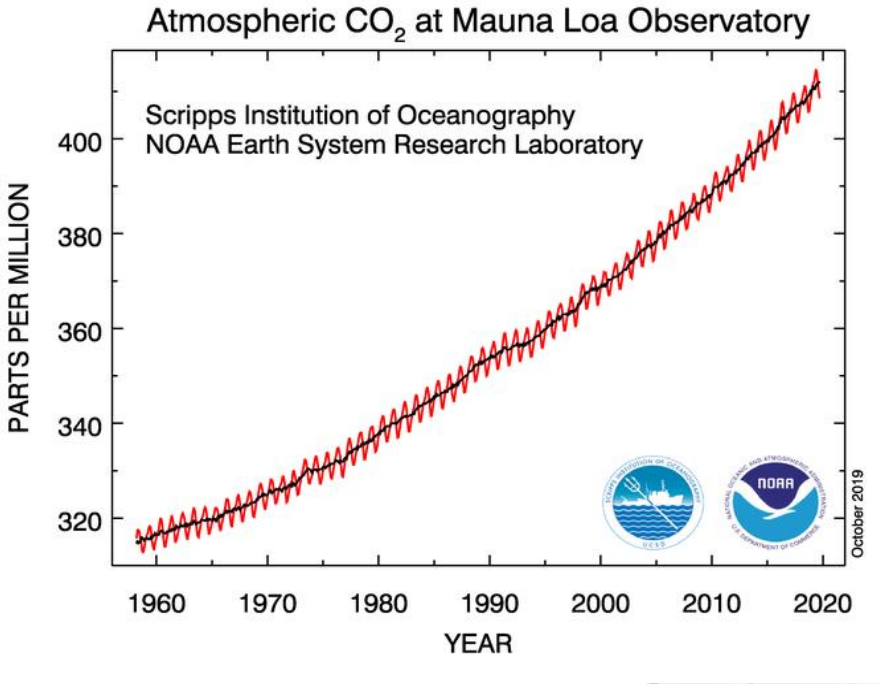


Source: https://climate.nasa.gov/evidence/

Climate Change

CO_2 emissions as indicator for sustainability?

- CO_2 is a greenhouse gas (GHG)
- CO_2 traps the heat close to Earth
- Leads to global warming or climate change
- CO_2 emissions can be measured
- Climate change directly impacts the environment, the society and the economy



Source: Earth System Research Laboratory, Mauna Loa, Hawaii, 2019

Climate Change - Enviromental impact

Reported enviromental impacts linked to climate change

- Changes in rainfall, resulting in more floods, droughts, or intense rain
- Oceans are warming and becoming more acidic
- Ice caps are melting, and sea level is rising.
- More frequent and severe heat waves

→ As these and other changes become more pronounced in the coming decades, they will likely present challenges to the biodiversity, our environment and our society.

(Image credit: NOAA)

Climate Change – Social impact

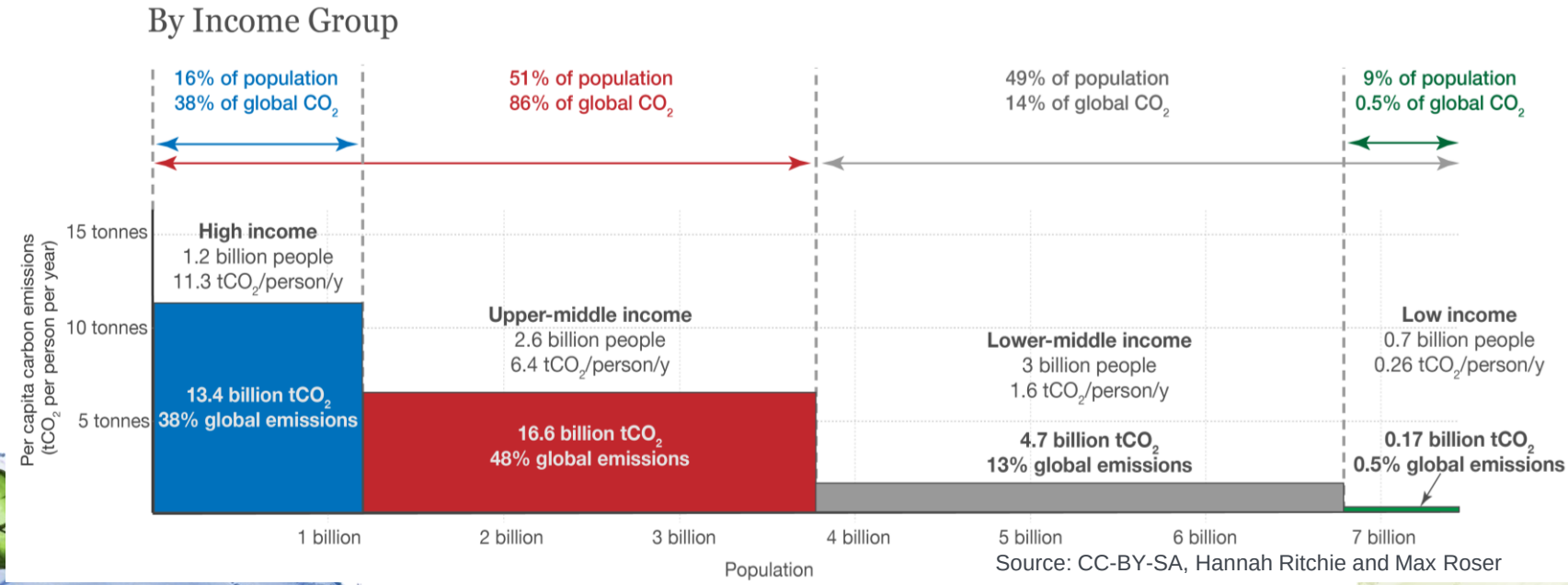
Reported social impacts linked to climate change

• Changes in rainfall, resulting in more floods, droughts, or intense rain	→ agriculture, water supply, floods in cities, losses to property
• Oceans are warming and becoming more acidic	→ fewer animal species (food security)
• Ice caps are melting, and sea level is rising.	→ tourism sector, floods, fresh water supply
• More frequent and severe heat waves	→ Agriculture (food security), health risks

Climate Change – Economic impact

Reported economic impacts linked to climate change

- Inequalities in the distribution of global GHG emissions
- Effects on Agriculture affect food security and hence overall livelyhood
- Contribution to Climate Change is linked to our income

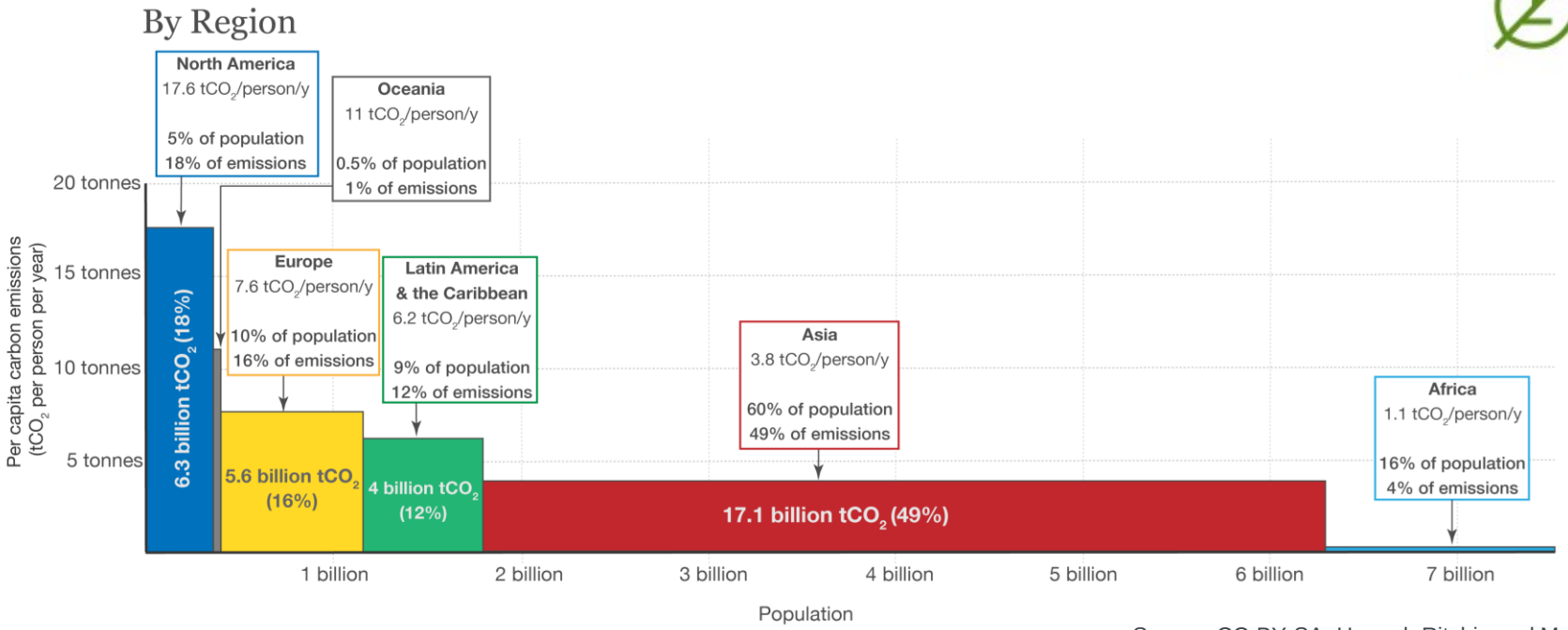


Source: CC-BY-SA, Hannah Ritchie and Max Roser

Climate Change – Economic impact

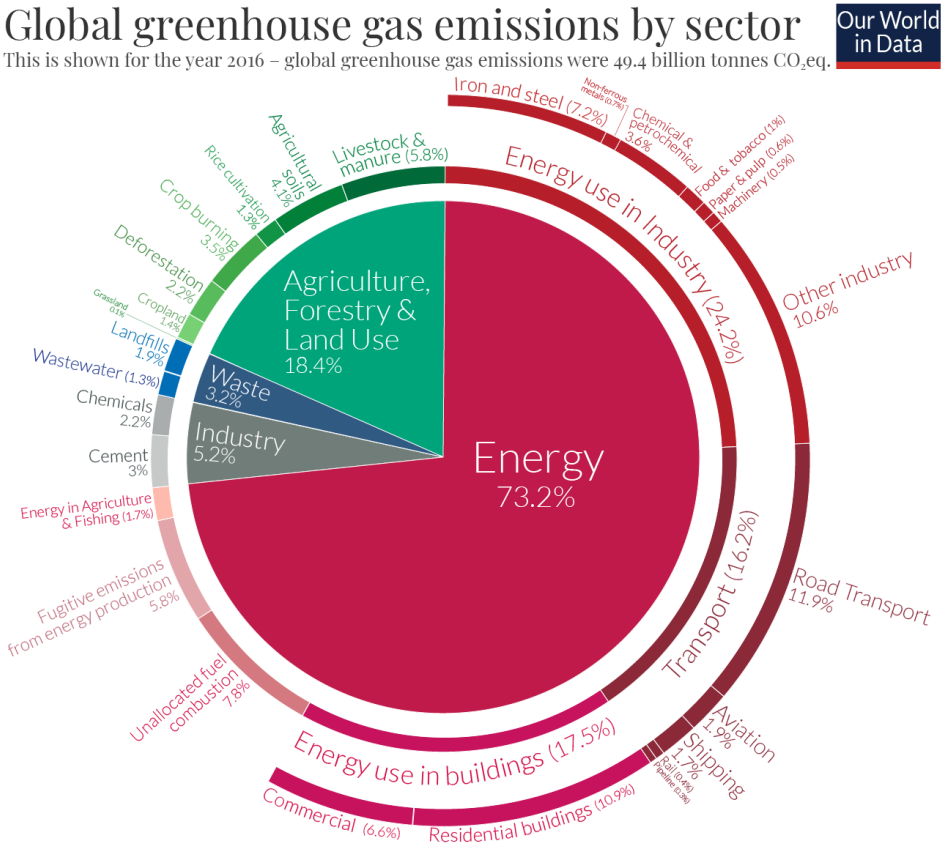
Reported economic impacts linked to climate change

- Inequalities in the distribution of global GHG emissions by region



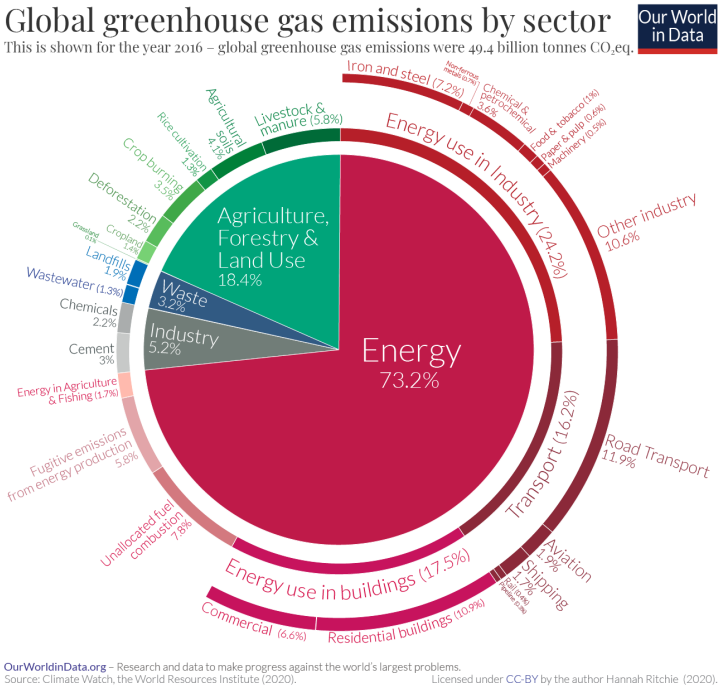
Source: CC-BY-SA, Hannah Ritchie and Max Roser

Climate Change – GHG sources



- almost 3/4 from energy use
- almost 1/5 from agriculture and land use
- remaining 8% from industry and waste.

Climate change and the waste sector



Misleading first impression might be:
Waste sector not so relevant
→ Emissions from waste: Separate lecture

Closer look with a Life cycle perspective on Energy use in Industry and buildings

- Linear economy responsible for the high energy use

Average material	kg CO_2-eq./kg
Cement	0.8
Steel	1.0
Aluminium	8
Plastic	2
Paper	1.5

- Emissions mainly due to the required processing energy

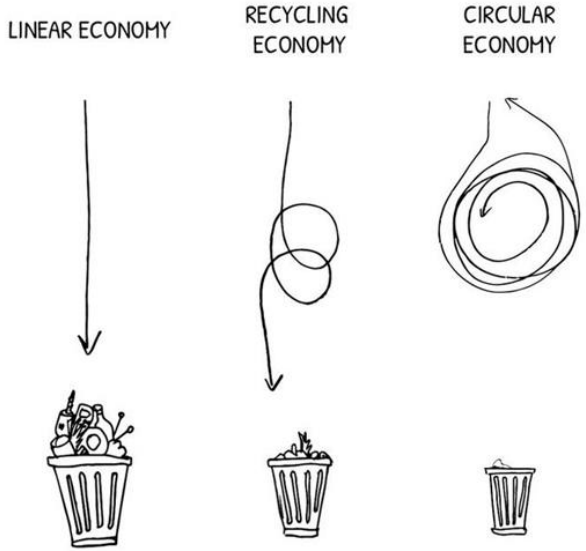
Global Resources Outlook 2019: Global **extraction and processing** of materials, fuels and food contribute **half of total global greenhouse gas emissions** and over 90 per cent of biodiversity loss and water stress

Climate Change – GHG emissions

Climate change and the waste sector

Urgent need to not waste but reuse and recover resources

“TAKE – MAKE – DISPOSE”



Quelle: peopledesignlab @ twitter

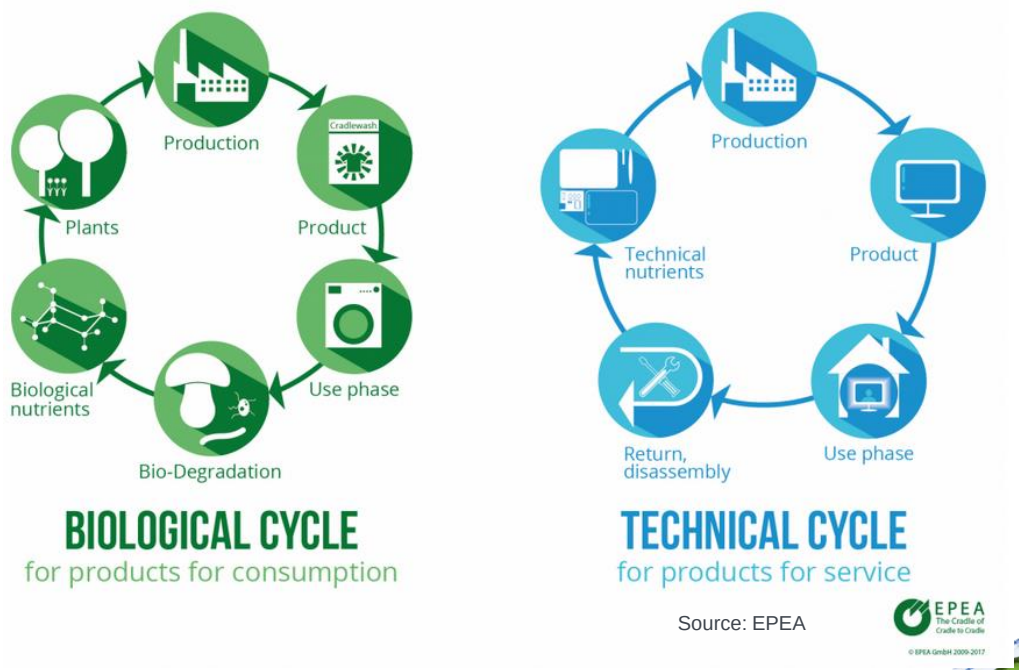
“MAKE – USE – SAVE”

“A circular economy is based on the principles of designing out waste and pollution, keeping products and materials in use, and regenerating natural systems.” [Quote: Ellen MacArthur Foundation 2017]

Climate change and the waste sector

Cradle-to-cradle

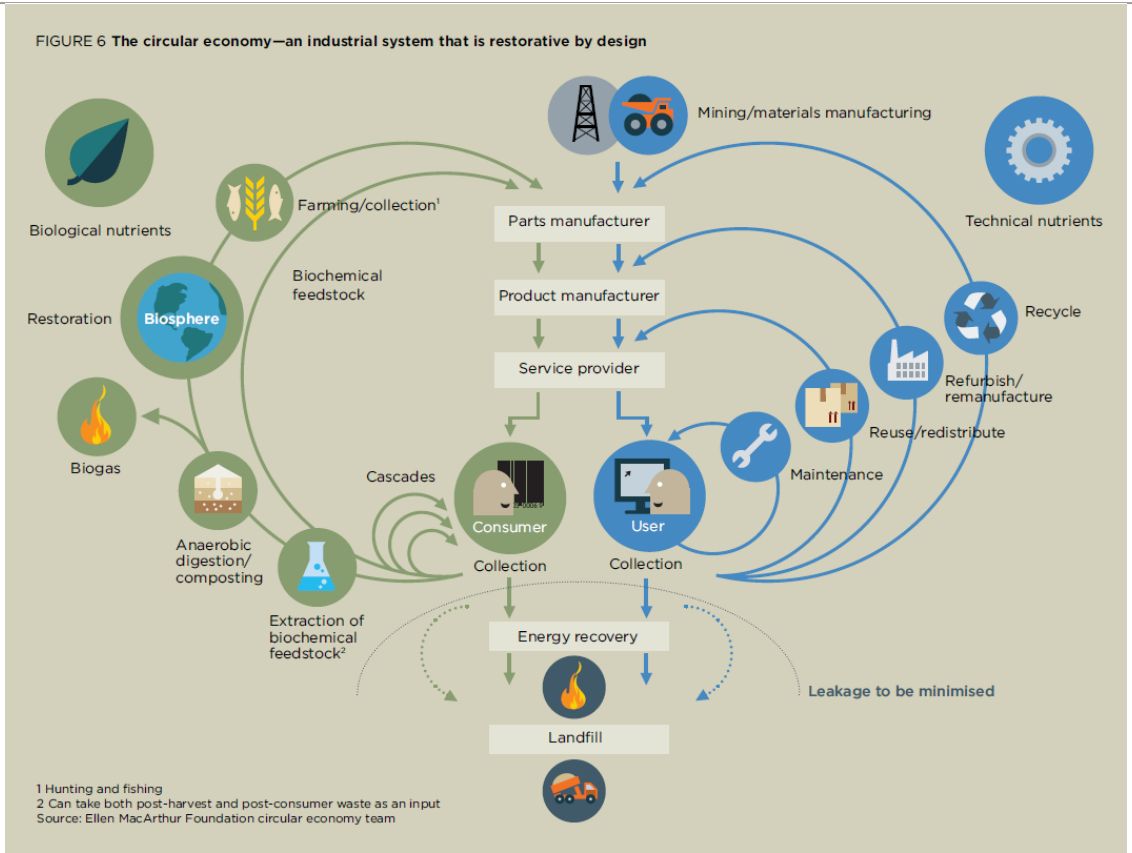
- Developed in the late 1990s by Michael Braungart and William McDonough.
- "From the cradle to the cradle„
- Vision of a waste-free circular economy
- Preservation of raw materials in biological and technical cycles
- No use of materials harmful to health and the environment to keep technical cycles closed



Source: EPEA

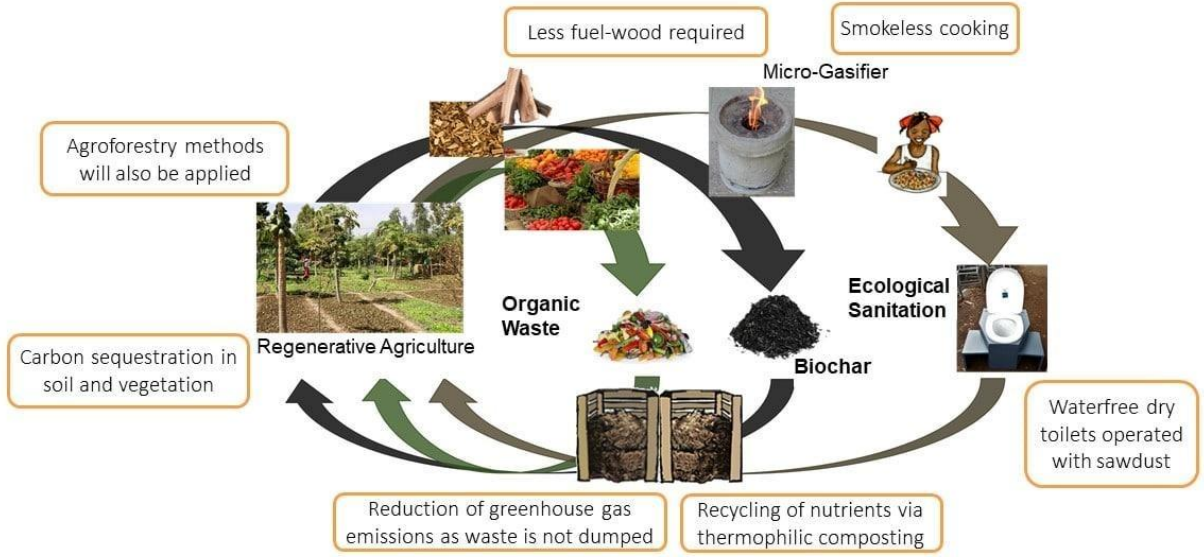
Climate change and the waste sector

Closing the loop and creating a cirular industrial economy



Climate change and the waste sector

Closing the biological loop – Climate action meets waste management



- ✓ Reducing GHG emissions from
  - 3 stone fire
  - Biowaste dumping
  - Pit latrines
  - Agriculture
- ✓ Removing carbon permantly (Biochar)
- ✓ CO_2-Certificates
- ✓ Regenerating ecosystem
- ✓ Food security
- ✓ Job creation

Climate Change – Carbon removals

Link

Thanks!

Any questions? Get in touch!

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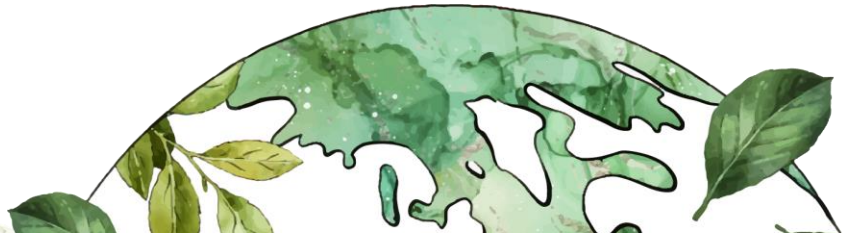
Open space for questions and discussions

Choose wisely in which world you want your children to be living in



15 min break

Questions

Breath

Meditate

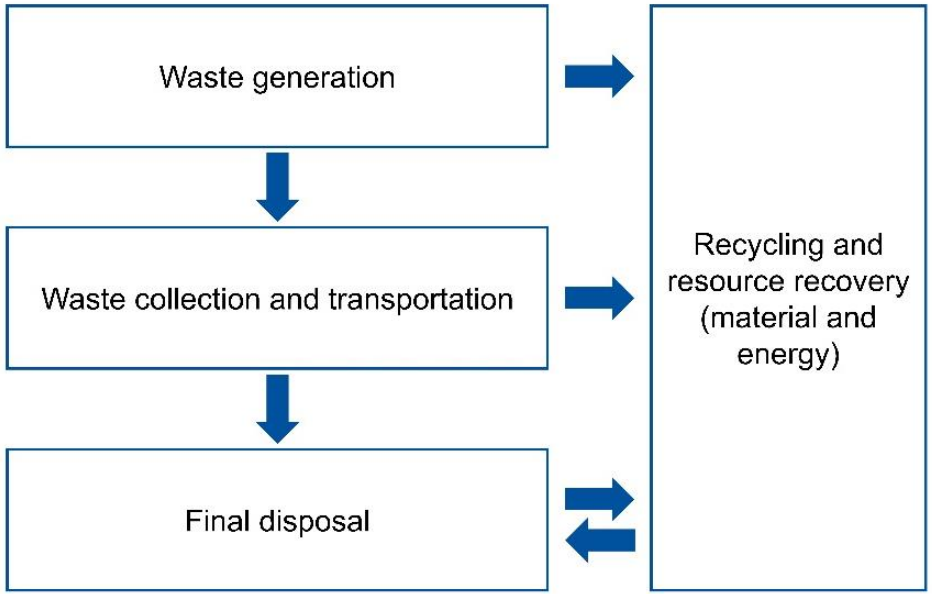
Coffee

Recap

Something else

Sustainability Assessment Framework

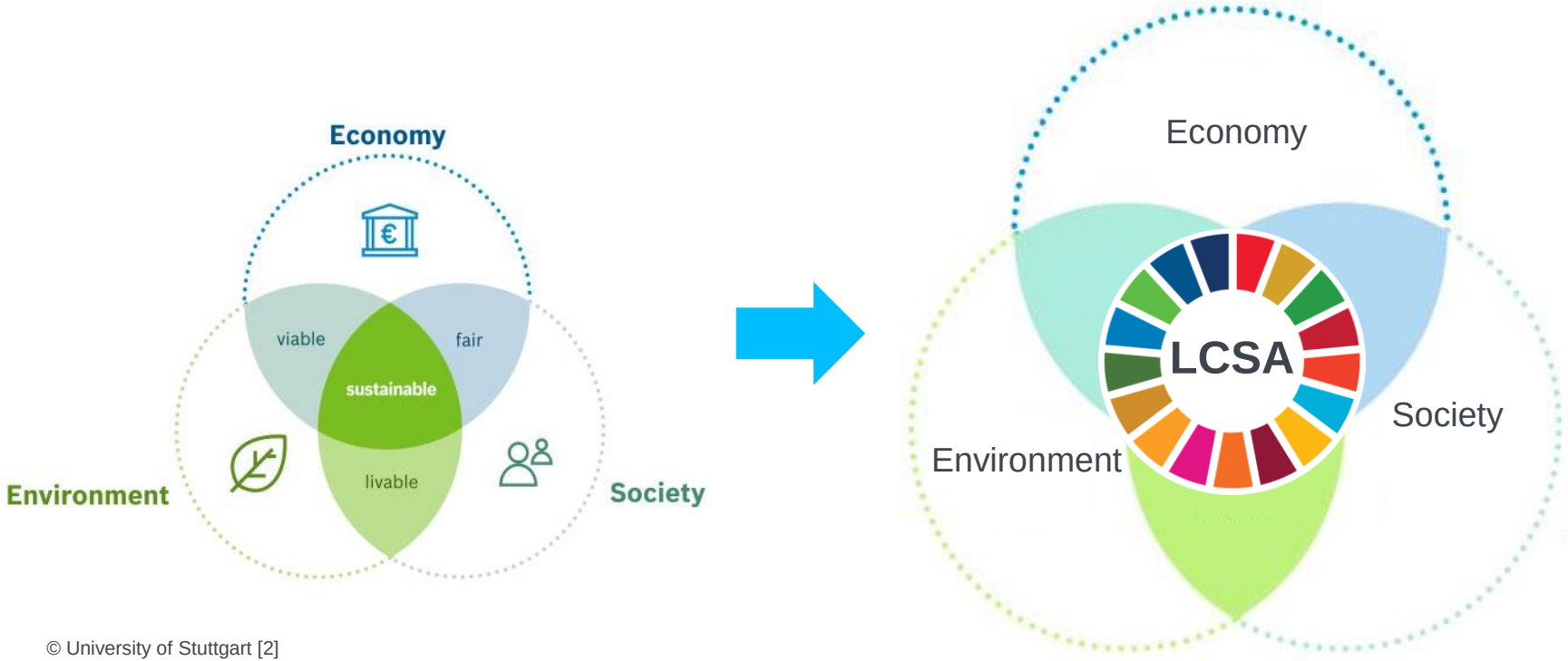
Life Cycle Phases in a MSWM system



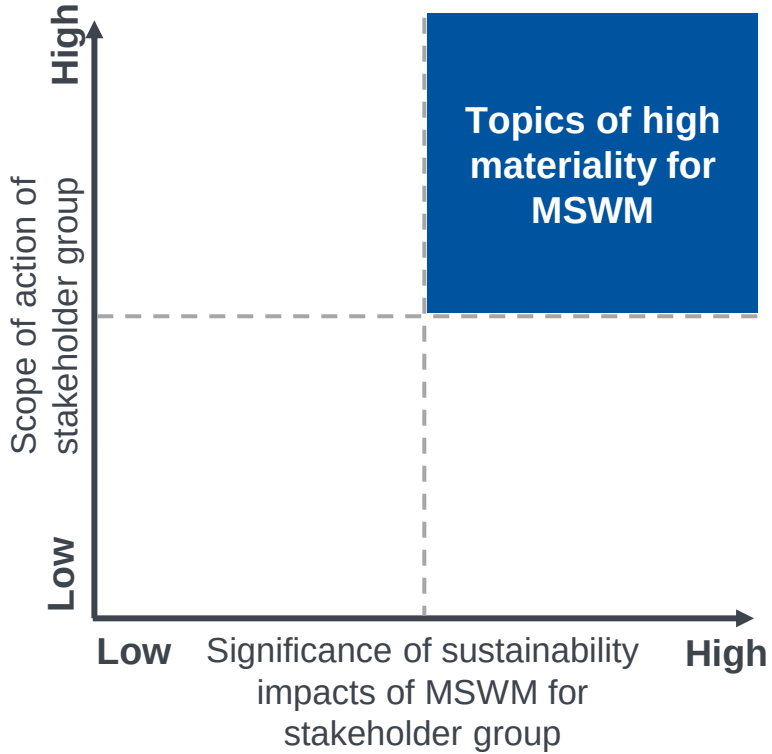
[1]

Life Cycle Sustainability Assessment (LCSA)

Life Cycle Sustainability Assessment (LCSA)



Relevance Definition and materiality matrix



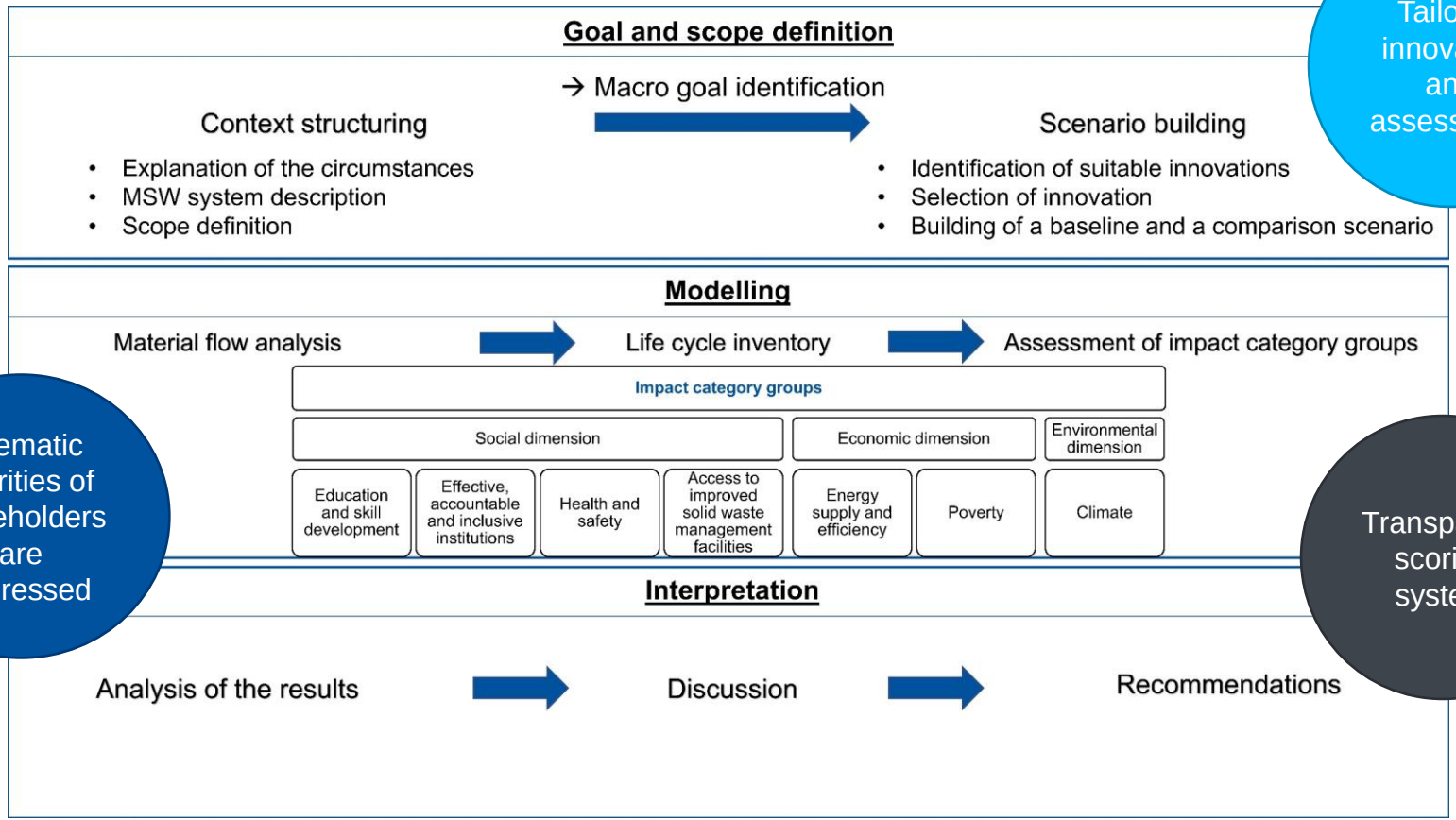
Relevance of a sustainability topic:

1) Stakeholder group can **act effectively** in the field
2) Stakeholder group is **affected** by the economic/ social/environmental **sustainability impacts** of MSWM

MSWM: Municipal Solid Waste Management

[2]

SDGs in the context of municipal solid waste management



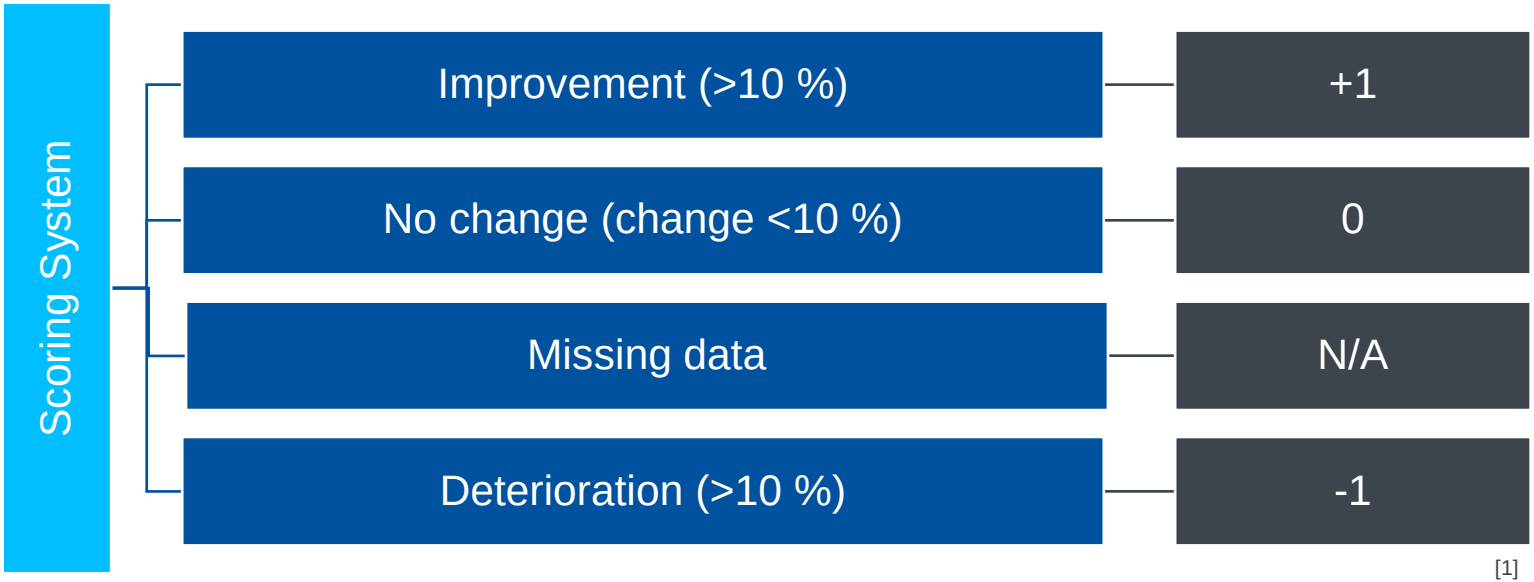
Tailored innovation and assessment

Thematic priorities of stakeholders are addressed

Transparent scoring system

[1]

Scoring System



[1]

SDG Indicators

Indicator workshop

- Goal: "To keep the methodology relatively **simple and clear** the number of indicators is reduced to a **core set** of general indicators".

- Number of indicators → applicability
- Data availability
- Application of indicators for all life cycle phases
- Clear connection between indicator and MSWM

Photo of Indicator Workshop in Stuttgart: SuCCESS24 project

Examples of suitable indicators

Sustainability Topic: Education and skill development
Impact Category: Training / Education

Indicator	**Provision of trainings or campaigns (workers/ residents)**
Unit	Number of trainings and campaigns
Data requirements	Number of trainings and campaigns offered to various stakeholders
Comments	Include formal and informal offers

[2]

Examples of suitable indicators

Sustainability Topic: Effective, accountable and inclusive institute
Impact Category: Cost of waste management services

Indicator	**Costs of waste management services for operating stakeholders involved in the waste management**
Unit	Birr/t or Cedi/t
Data requirements	Expenses of all waste management facilities/ actors for waste management services
Comments	Include questions on specific rates for waste collection services in questionnaires for different neighborhoods/ income levels

[2]

Sustainability Dimension	Impact Category Group	SDG	Impact Category	Indicators
Social	Education and skill development	4	Training / education	1. Provision of training / campaigns (workers / residents)
				2. Participation rate of training / campaigns
			Effectiveness of education / training	3. Number of people applying knowledge
				4. Proportion of workers reporting having personally felt discriminated against or harassed or stigmatized or not appreciated withing a set period of time – based on a ground of discrimination prohibited under international human rights law
				5. Social participation in solid waste separation
				6. Social perception towards waste management
			Quality of training / education	7. Satisfaction of the people with their training
	Effective, accountable, and inclusive institute	16	Cost of waste management services	8. Cost of waste management services for operating stakeholders involved in the waste management (e.g., disaggregated by municipality, associations (formal and informal sector))
			Effectiveness of waste management services	9. Rate of waste collected / transported / recycled / disposed of
			Inclusivity	10. Rate of female and male and diverse workers, by occupation, age and persons with disabilities and ethnicity in decision-making institutions / municipality / associations (formal and informal sector)
			Accountability	11. Proportion of workers who believe that decisions regarding waste management were implemented by the municipality / associations (formal and informal sector) as agreed upon
				12. Number of complaint units and their availability
	Health and safety	3	Accidents and health incidents	13. Workers' risk of accidents (disaggregated by sex and migrant status / ethnicity, etc.)
				14. Workers' perceived risk of health issues
				15. Particular matter formation
			Human toxicity	16. Human toxicity potential
	Access to improved solid waste management facilities	11, 12	Frequency of waste management services	17. Frequency of waste collection (disaggregated into different modes of collection)
			Waste treatment efficiency	18. Proportion of solid waste (disaggregated into different sectors) managed out of total waste generated
				19. Waste collection coverage
				20. Waste recovery and waste recycling rate
Economic	Energy supply and efficiency	7, 8, 9	Energy usage	21. Primary energy consumption (renewable and fossil)
			Energy Intensity	22. Energy intensity
	Poverty	1	Standard of living	23. Decent minimum basket of living compared to real consumption of workers
				24. Expenditure of workers
			Income	25. Income of formal workers by occupation, living below the international / national poverty line (disaggregated into municipality, association, private companies)
				26. Rate of formal workers, by occupation, living below the international / national poverty line
Environmental	Climate	13	Climate change	27. Global warming potential

[1]

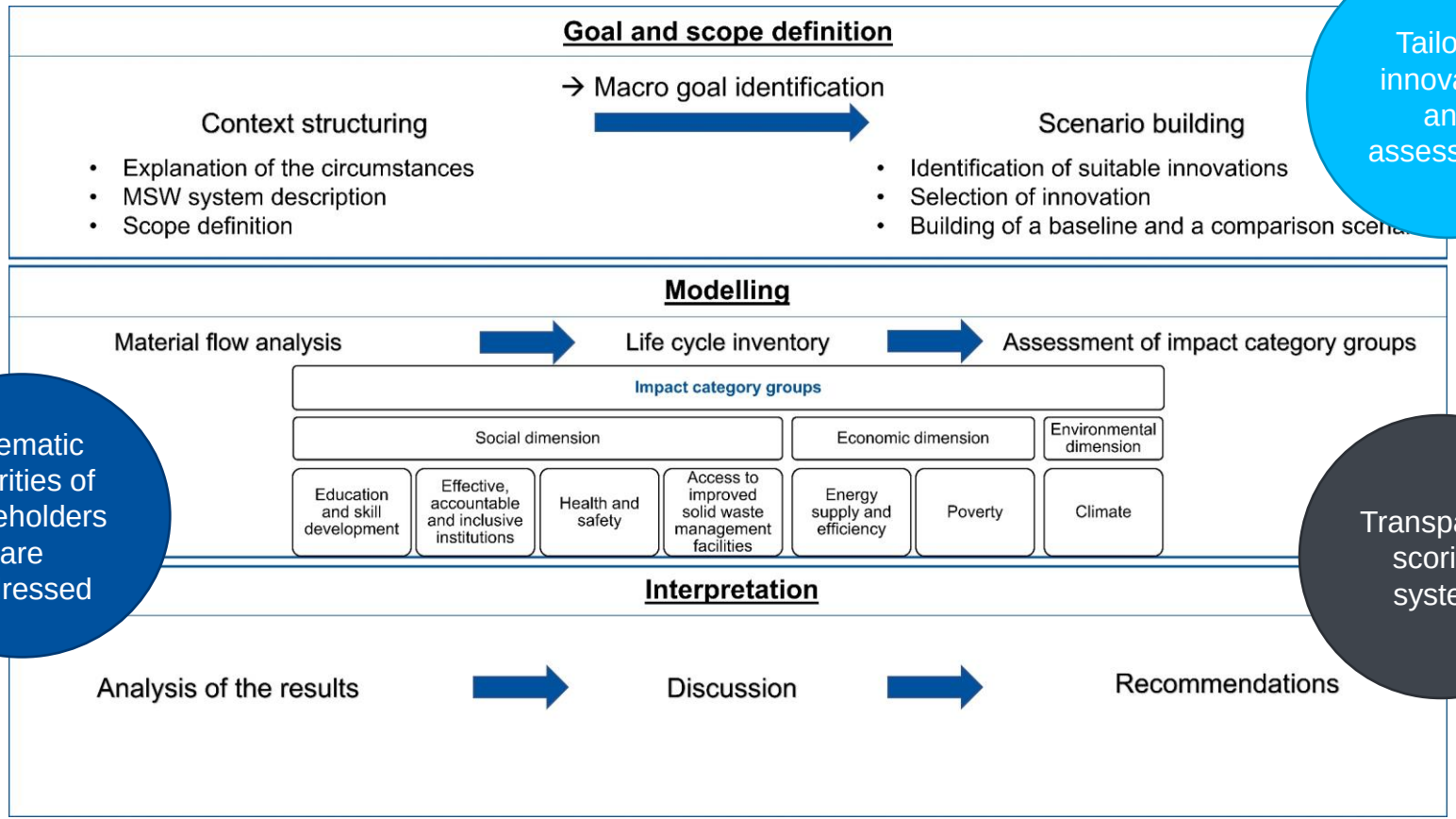
Case Study - Bishoftu Town in Ethiopia

Bishoftu Town, Ethiopia

© GoogleEarth [8]

[1]

SDGs – Thematic priorities of stakeholders



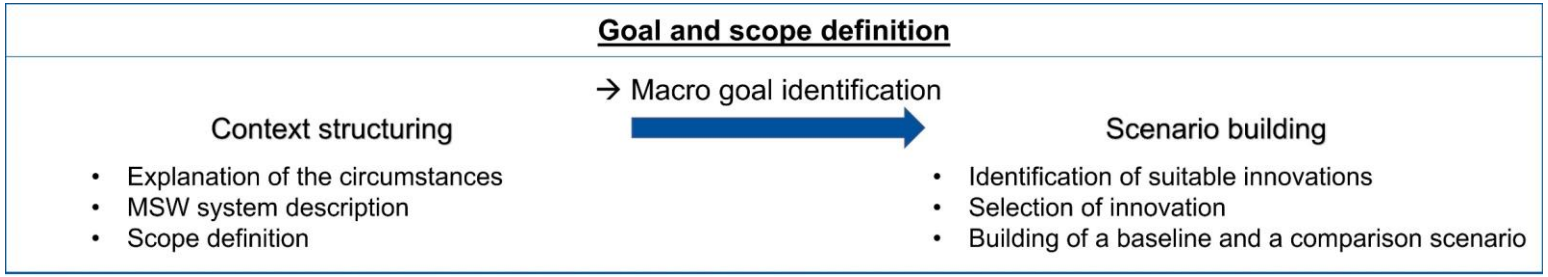
Tailored innovation and assessment

Thematic priorities of stakeholders are addressed

Transparent scoring system

[1]

1. Goal and scope definition



Goal:

- Examine the MSWM system of Bishoftu Town, Ethiopia
- Identify hot spots
- Choose a suitable innovation for the MSWM system

Scope:

- Bishoftu Town, Ethiopia
- 2022

[1]

1. Goal and scope definition

Functional Unit: Total generated MSW with 69,53 % of organic matter

Macro goal identification:

- Large share of organic water
- Expand experiences with composting
- Role model for other cities in sub-Saharan Africa

➢ Focus on composting

[1]

1. Goal and scope definition

Scenario building:

System weaknesses:

- High proportion of landfilled organic matter
- Lack of compost demand
- Physically demanding working conditions at the composting plant
- Low income for all workers
- Lack of investment

System strengths:

- Separation of organic matter at transfer station
- Good quality of compost

[1]

1. Goal and scope definition

Innovation:

Chosen innovation:

- 6 wheelbarrows
- 6 manual, rotating compost sifters
- full utilisation of the composting capacity

Mode of implementation:

– awareness training for farmers in/around Bishoftu Town

– create a higher demand for compost for local agriculture

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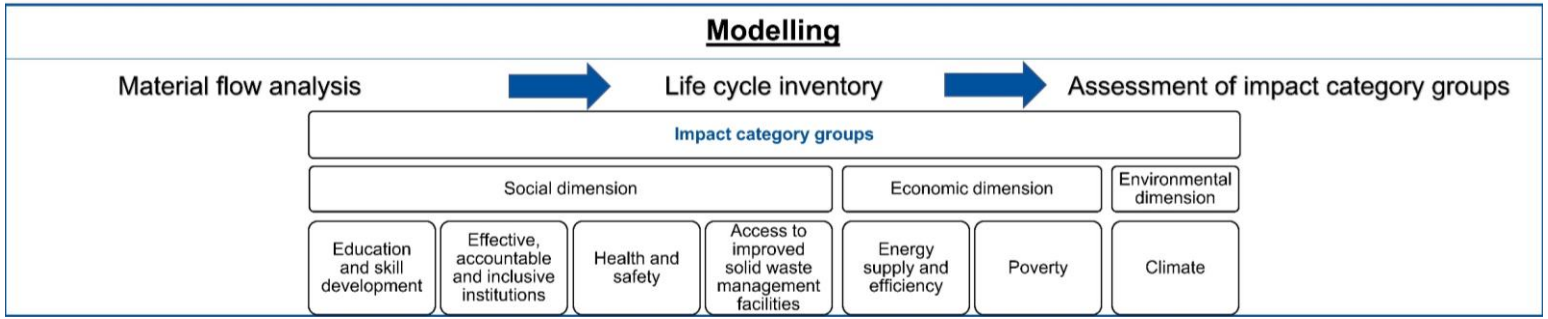
© Clarke Tooling [4]

Kristina Henzler: 16.01.2023

[1]

2. Modelling



7 Impact category groups

16 Impact categories

18 Indicators

[1]

2. Modelling

Data collection:

Workshop Data collection:

- Introduce the stakeholders to the project
- Explain the benefits of the study
- Questions of understandings were discussed

Questionnaires (Primary Data)

Residents	Workers
Enterprises	Municipality

[1]

Questionnaires:

The Questions are all referring to the past year 2022 Date of the interview:_____

1. **Name of the enterprise**:_____

2. **Size of the enterprise (number of workers)**:
( ) small: _____ female and _____male employees
( ) medium: _____ female and _____male employees
( ) other: _____

3. **What are your enterprises tasks/ which area are you working in (multiple answers possible)**
( ) waste collection
( ) transportation
( ) waste separation
( ) recycling
( ) composting
( ) landfilling
( ) other, please specify_____

4. **How many trainings/campaigns have been offered by your enterprise to workers/residents in 2022?**
_____ [number] training/campaigns were offered to workers.
_____ [number] training/campaigns were offered to residents.

5. **What share of the invited workers/residents have participated in the training/campaign offered by your enterprise?**
_____ % of the invited workers/residents have participated in the training/campaign.

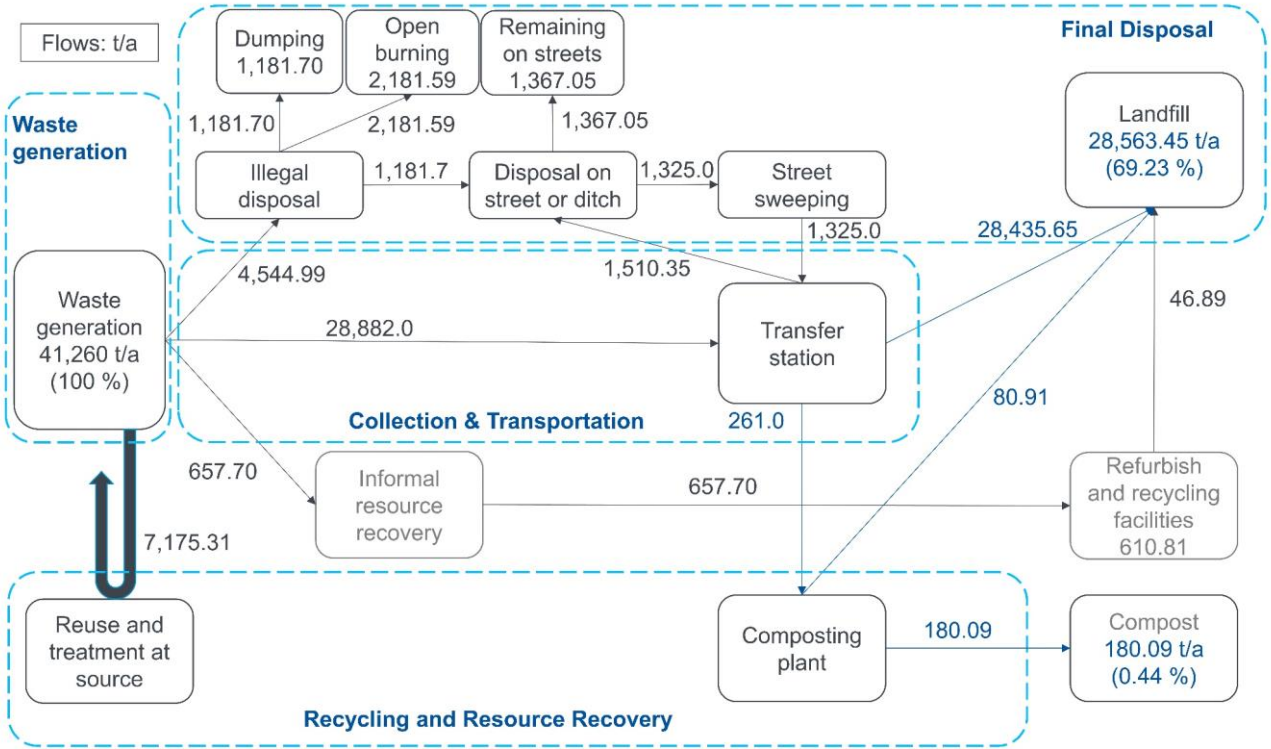
6. **For which topics do you offer training? (o)**
( ) general waste management
( ) safety and health
( ) collection
( ) transportation
( ) waste separation
( ) waste reduction
( ) final disposal
( ) composting
( ) compost
( ) recycling/ waste recovery
( ) environmental impacts of waste
( ) other (please specify)_____
_____
_____
____

7. **What is your enterprise's annual spending in 2022 for municipal solid waste management?**	Spendings:_____ Birr/year (in 2022)
8. **How much did the enterprise spend on the collection of waste in 2022?**	_____Birr/year
9. **How much did your enterprise spend on the composting of waste in 2022?**	_____Birr/year
10. **How much did your enterprise spend on the disposal of waste (landfilling) in 2022?**	

[1]

2. Modelling

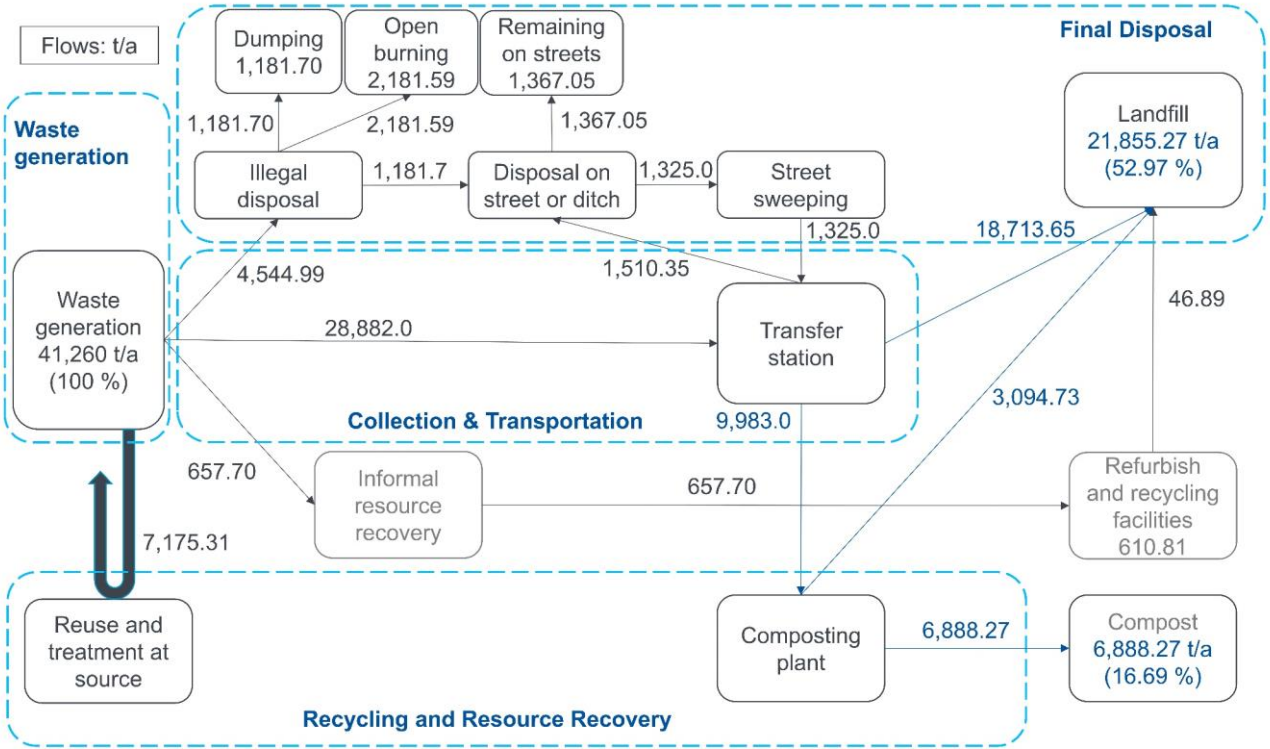
MFA: Baseline scenario – based on Admassu, 2022



[1]

2. Modelling

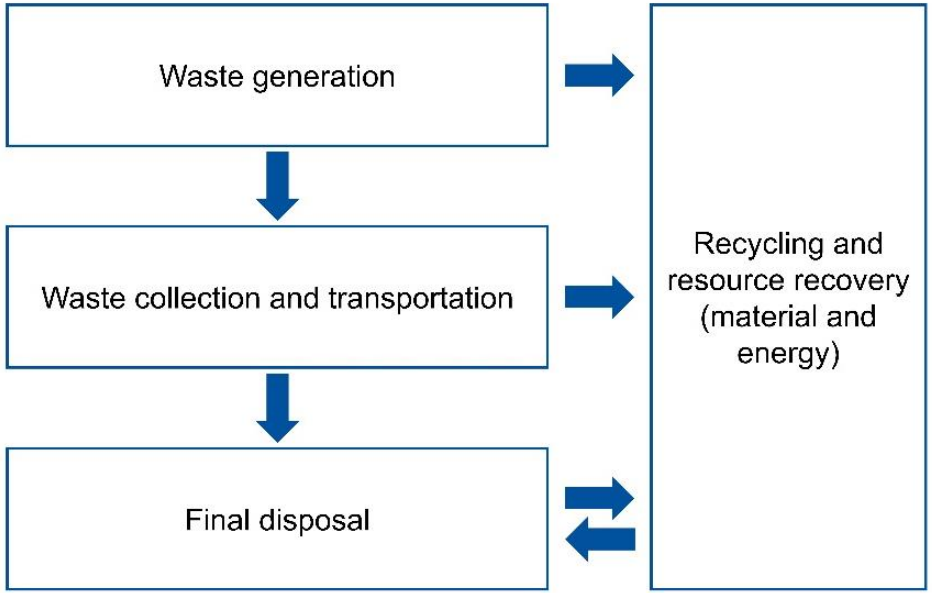
MFA: Comparison scenario



[1]

2. Modelling

Life cycle stages:



[1]

2. Modelling

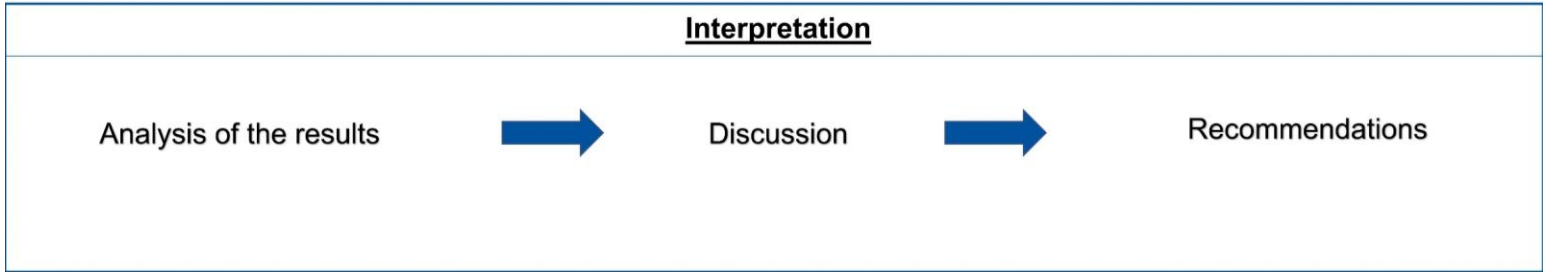
Assessment of impact category groups: Scoring System

- Impact category group: health and safety

Social dimension	Collection & transportation	Recycling	Final disposal
Workers‘ risk of accidents	0	-1	0
Workers‘ preceived risk of health issues	0	-1	+1
Impact category health and safety	**0**	**-1**	**+0.5**

[1]

3. Interpretation

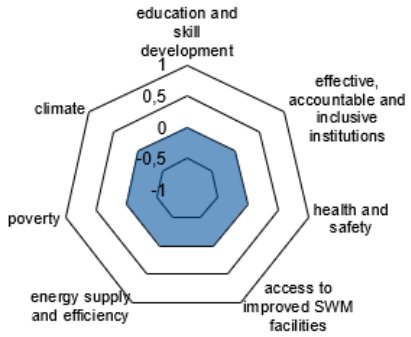


[1]

3. Interpretation

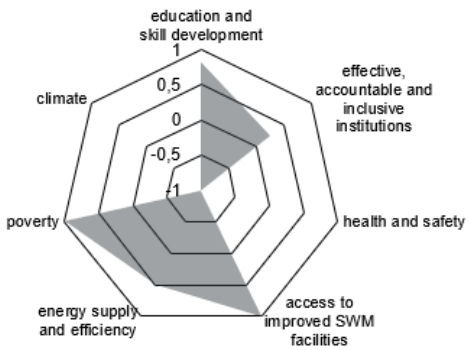
Analysis of the results:

Collection and transportation



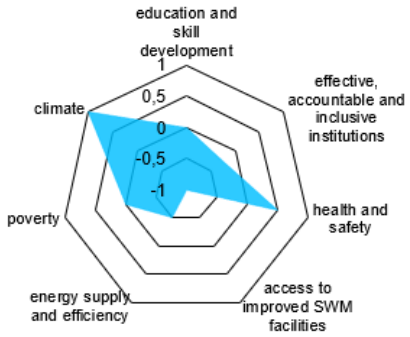
no change

Recycling



positive change

Final disposal



slightly negative change

[1]

3. Interpretation

Discussion:

→ **Key points concerning the whole system**
- → Indicator results over all life cycle stages
- → Overall reduction of greenhouse gas emissions (-15.90 % CO_2 eq. / a)
- → Trade-offs between energy and climate

→ **Data availability and uncertainty**
- → Numbers only show potentials due to lack of data
- → Uncertainty through interviewer bias, data collection through 3rd persons

→ Perspective of **informal workers**

[1]

3. Interpretation

Recommendations for decision-makers:

Based on the results, **the introduction of the innovation is recommended**.

Further recommendations:

- trainings for farmers and composting workers
- safety clothes for composting workers (e.g., masks, shoes, etc.)
- salary according to working hours
- strengthen inclusivity – employment of women

[1]

4. Conclusion and Outlook

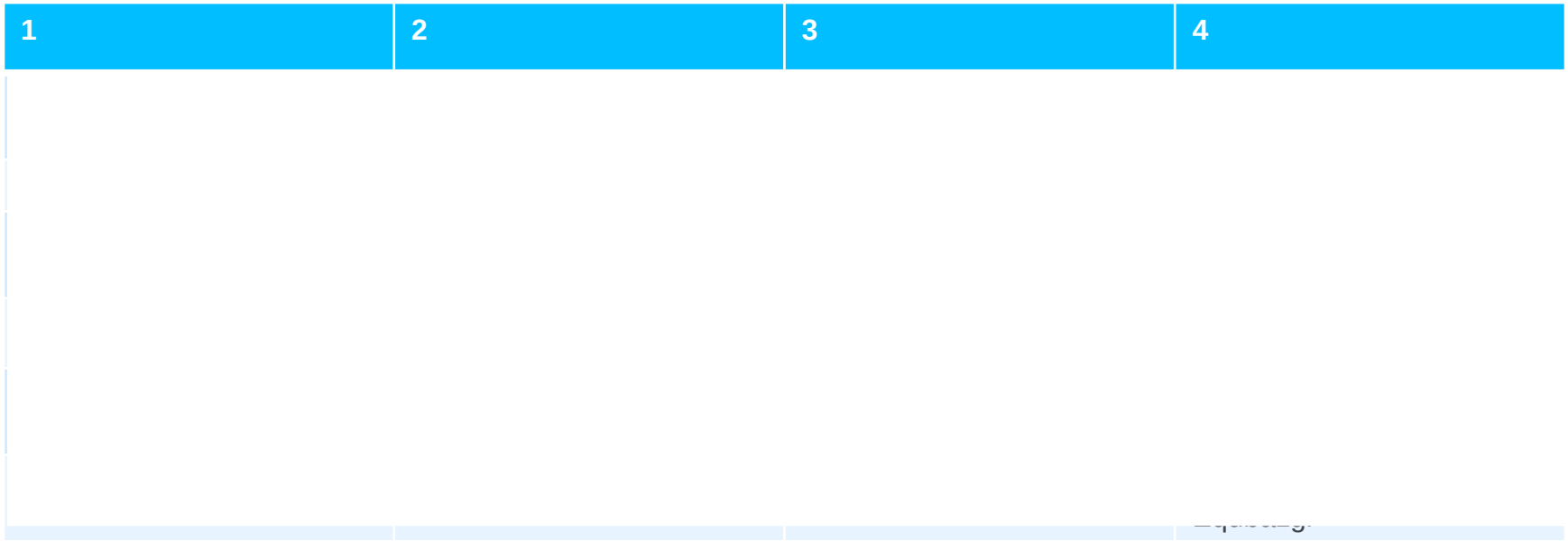
- The developed methodology helps **identify hot spots** and can help **optimise an MSWM** system according to the **stakeholder interests**.
- The case study of **Bishoftu Town** showed the impacts of the current MSWM system and an innovative comparison scenario. **The innovation can be recommended due to its potential positive impacts in the system**.
- **Baseline data is missing** for the Ethiopian and sub-Saharan context.
- The **methodology should be further tested**.

[1]

Group work

Group Work Wednesday July 10th

- Derive tool adaptation requirements from the workshop results
- Define tasks for tool adaptation
- Prioritising the tasks
- Merge your results



Recap – learning outcome of the day

Methodological:

- Understanding of sustainability and SDGs
- Overview of assessment methodologies (LCA, LCSA framework)
- Understanding of the methodology‘s application (step by step)

Tool adaptation

- Clear definition of working tasks

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