

16.07.2021

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# **Multidisciplinary approaches towards an inclusive, circular urban built environment**

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# Challenges of the 21st century

## Human and societal



Armed  
crises

Hunger

Health

Migration

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# Challenges of the 21st century

## Technical and environmental

**Habitat**

**Infra-  
structure**

**Urbanisation**

**Environ-  
ment**

**Sustain-  
ability**



# Challenges of the 21st century

## Technical and environmental

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# Challenges of the 21st century

## Technical and environmental

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# Challenges of the 21st century

## Technical and environmental

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# Challenges of the 21st century

## Technical and environmental

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Urbani-  
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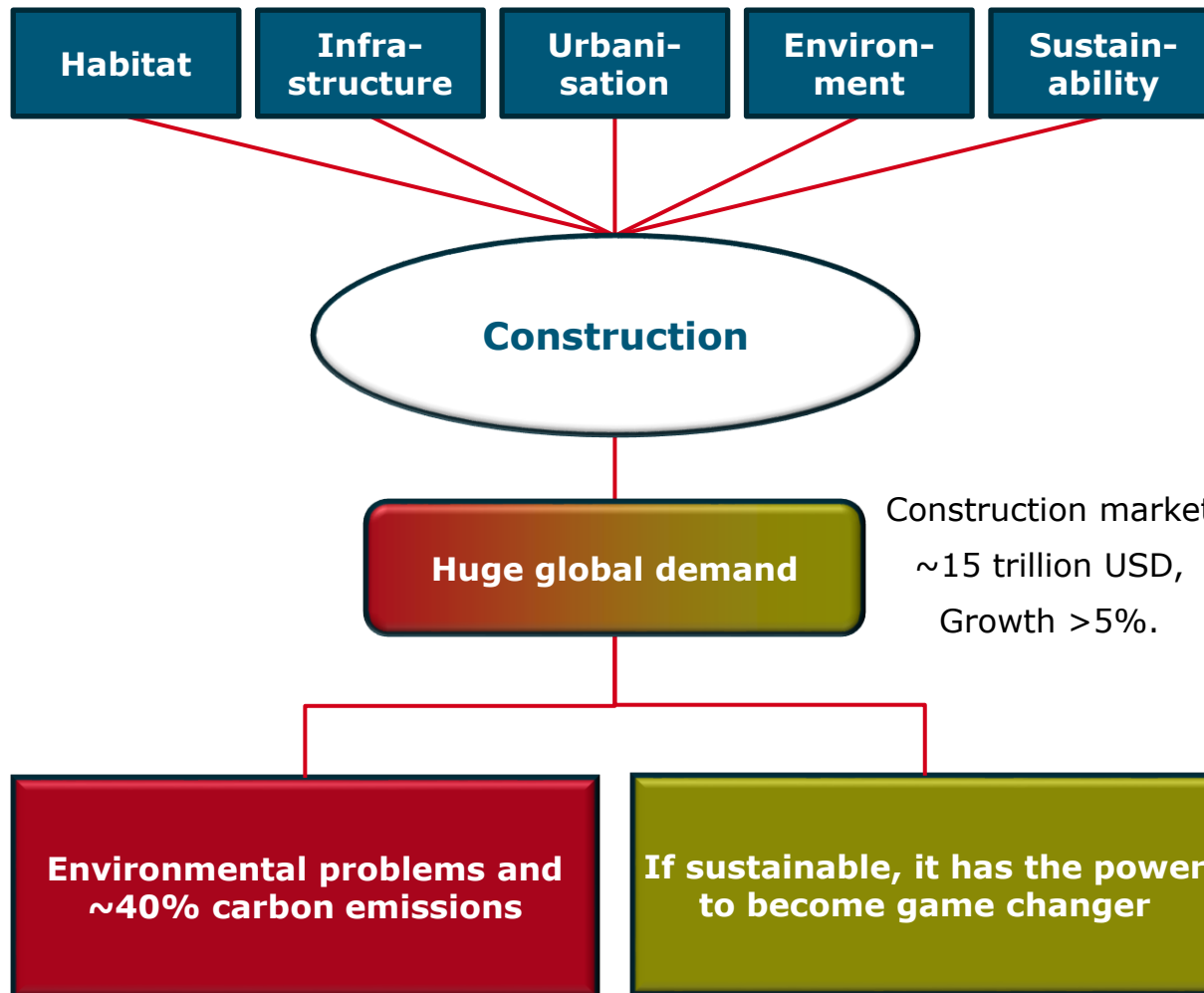
Environ-  
ment

Sustain-  
ability



# Challenges of the 21st century

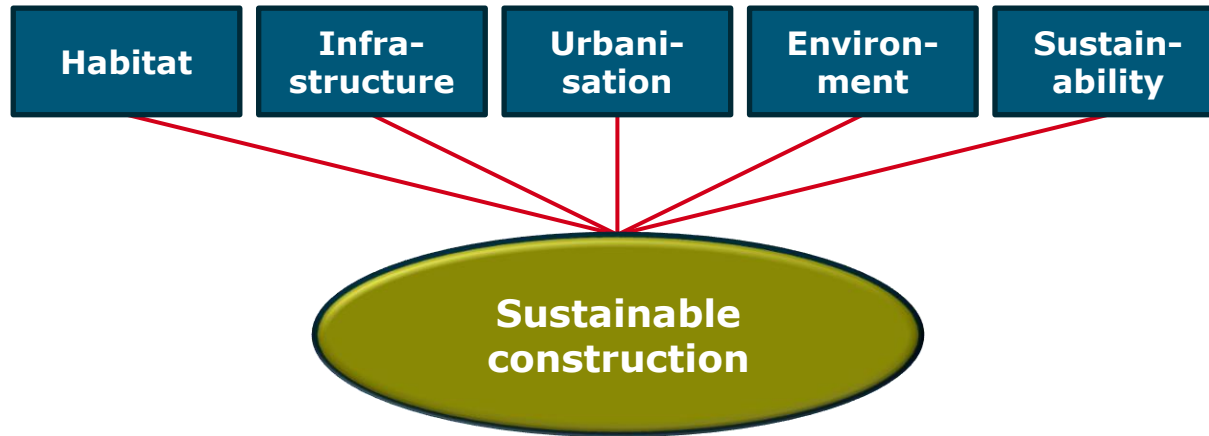
## The role of construction





# Challenges of the 21st century

## The role of construction



Armed crises

Hunger

Health

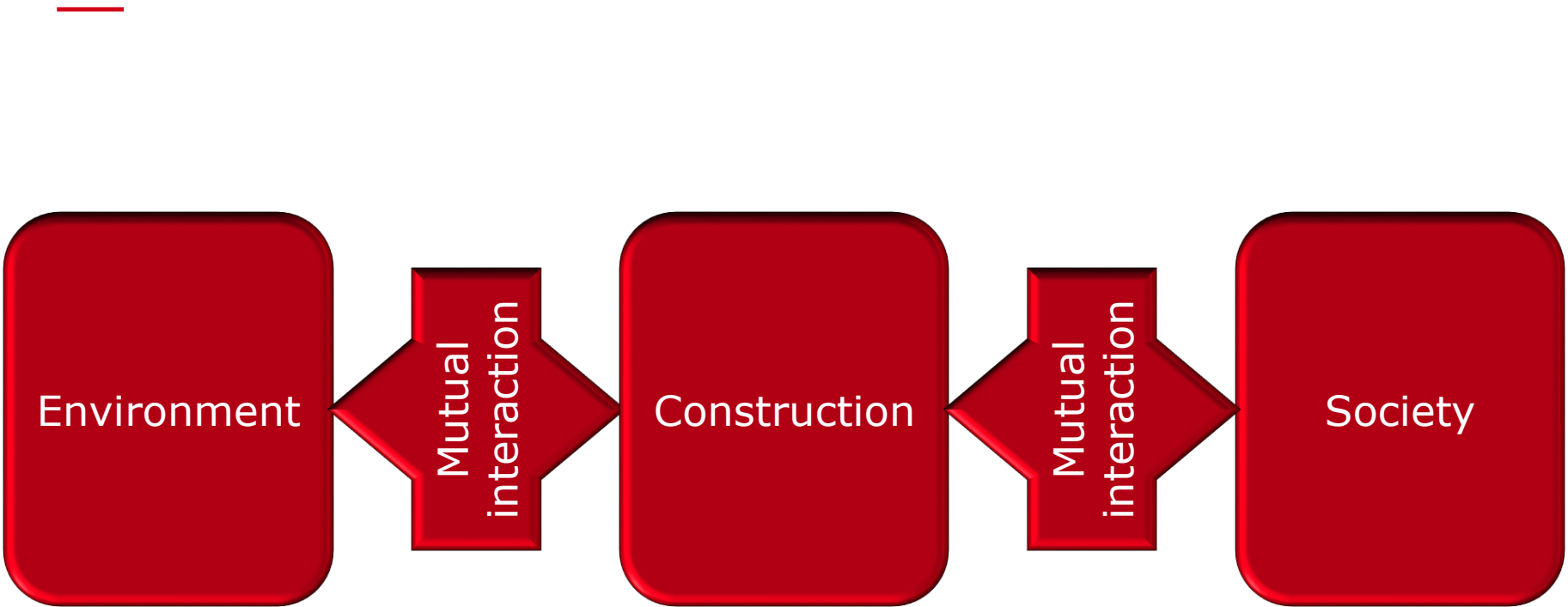
Migration



W. Schmidt, M.J. Barucker- Sturzenbecher, Bio-based concrete (<https://vimeo.com/310549146>). Berlin, 2019, 7:51.

# Urban construction demand

## Interrelations



# Challenges of the 21st century

## The potential of sustainable concrete



# Urban construction demands

## Resilient and sustainable cities

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**Structurally  
safe**



# Urban construction demands

## Resilient and sustainable cities

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**Structurally  
safe**

**Environmentally  
friendly**



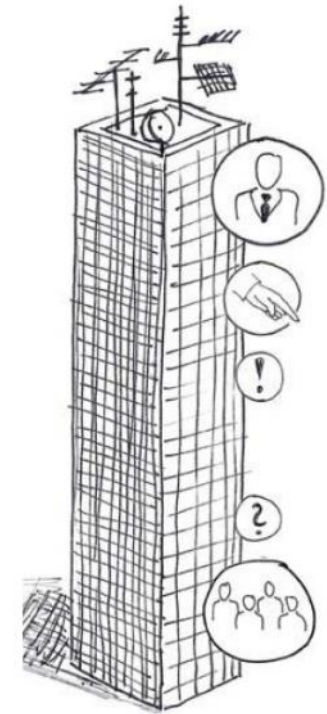
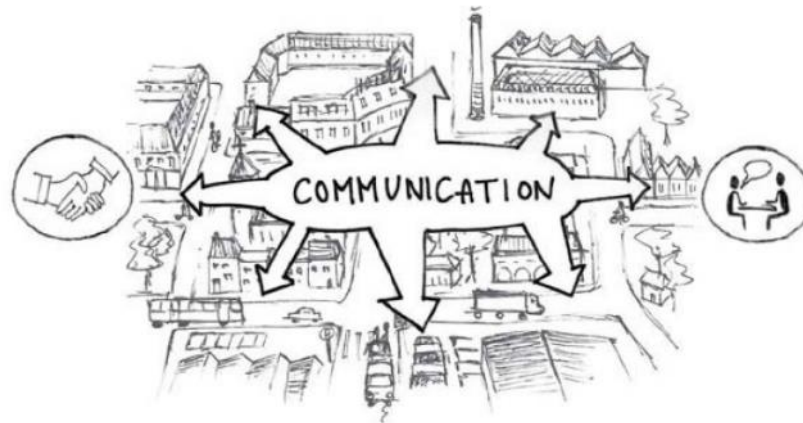
# Urban construction demands

## Resilient and sustainable cities

**Structurally  
safe**

**Environmentally  
friendly**

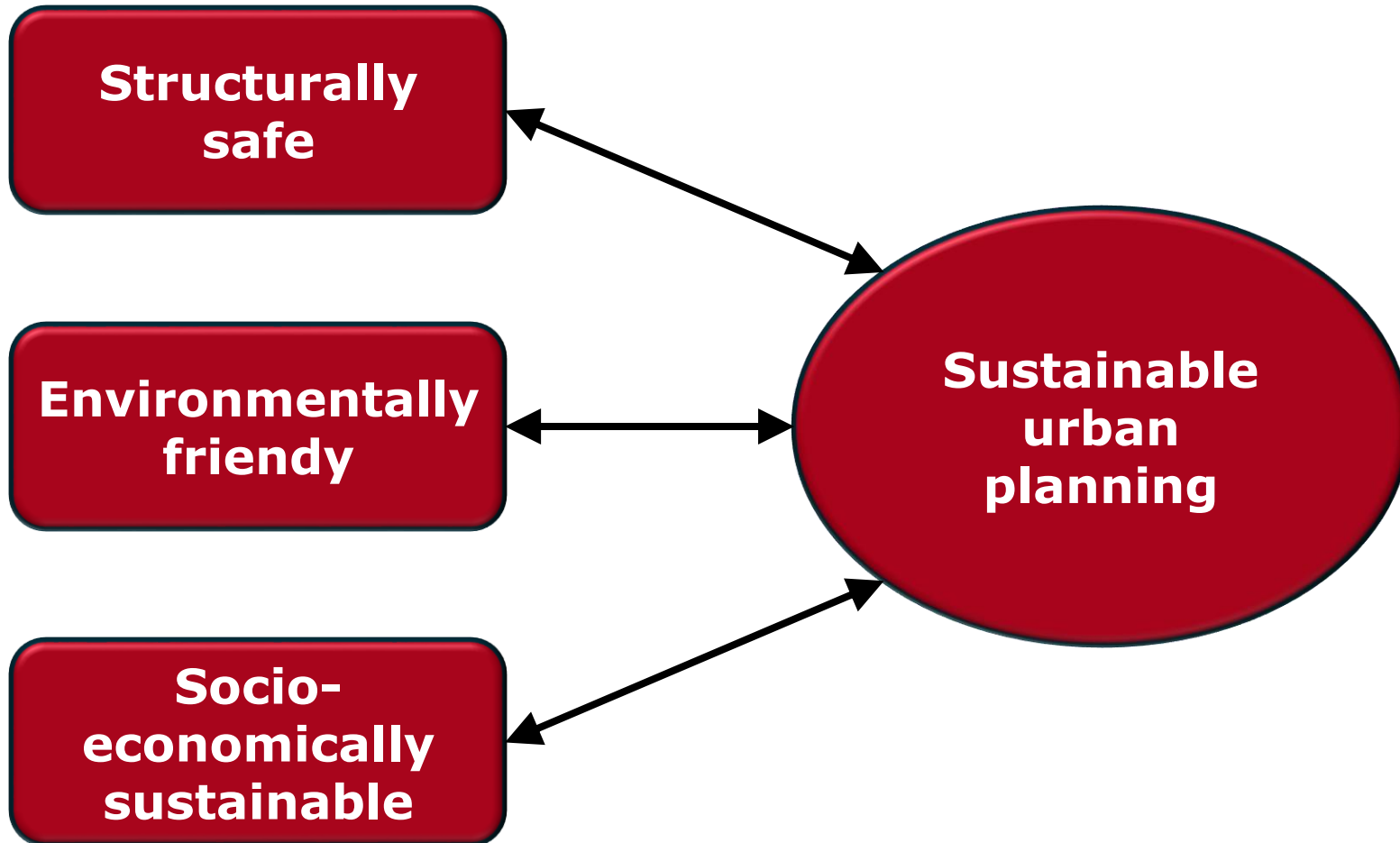
**Socio-  
economically  
sustainable**



W. Schmidt, J. Anniser, and K. Manful, "A sustainability point of view on horizontal and vertical urban growth," ISEE - Innovation, Science, Engineering, Education, 2019

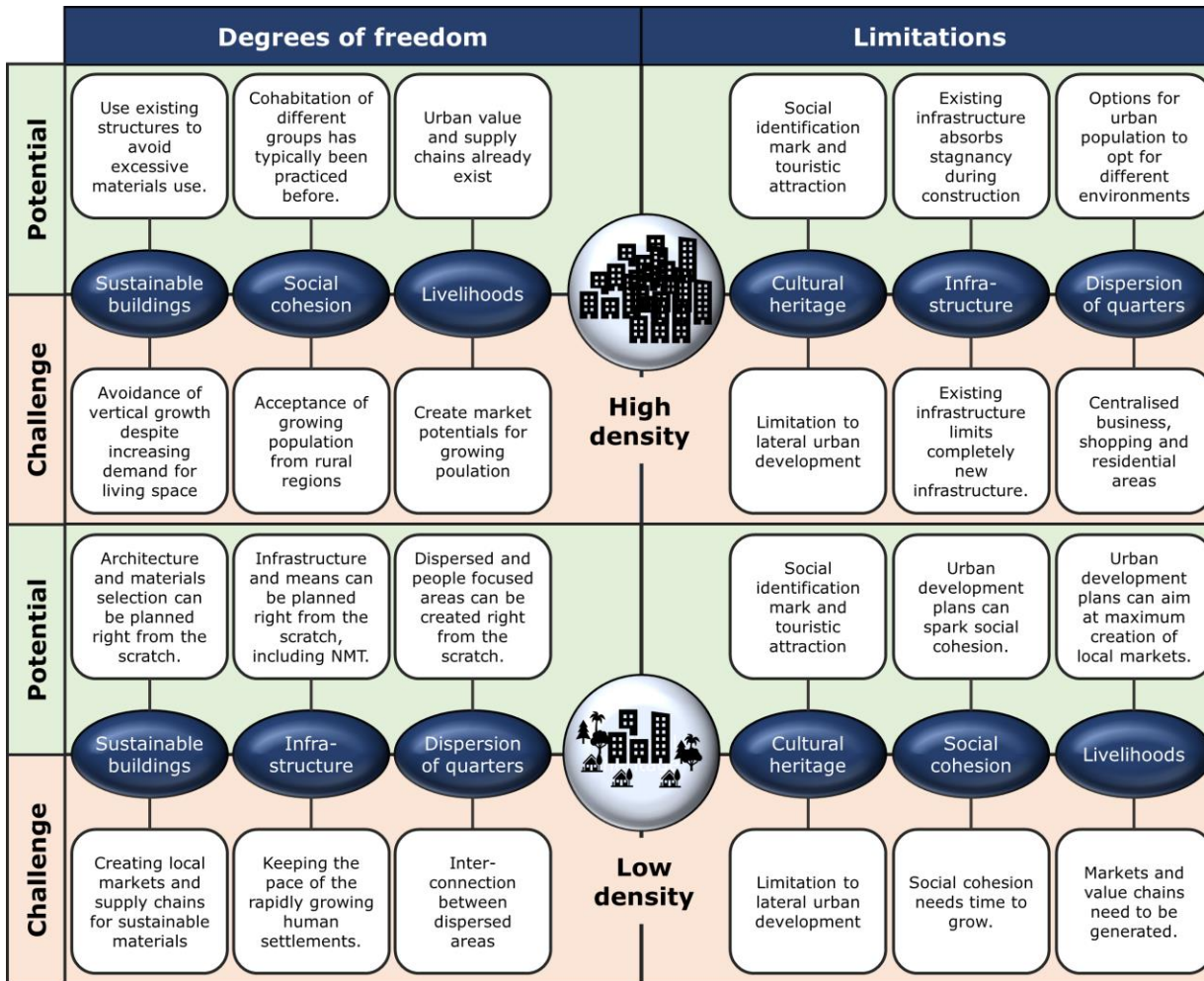
# Urban construction demands

## Resilient and sustainable cities



# Urban construction demands

## High density vs. low density



W. Schmidt, N.W. Radebe, M.O. Otieno, K.A. Olonade, S. Fataei, F. Mohamed, G.L. Schiewer, M. Thiedeitz, A. Tetteh Tawiah, R. Dauda, G. Bassioni, M. Telong, A. Rogge, Challenges, opportunities and potential solution strategies for environmentally and socially responsible urban development of megacities in Africa. 3RD RILEM Spring Convention 2020 - ambitioning a sustainable future for built environment: comprehensive strategies for unprecedented challenges, RILEM, Guimaraes, Portugal, 2020,



# Urban construction demands

## High density vs. low density

### Urban children from Mukuru Estates in Nairobi, Kenya



Star Kids Initiative

(<http://www.starkidsinitiative.org>)

- More space
- More green
- More animals

**Rather rural wish**

### Girls and young mothers in the rural Bagamoyo, Tanzania



Forward Step Organization

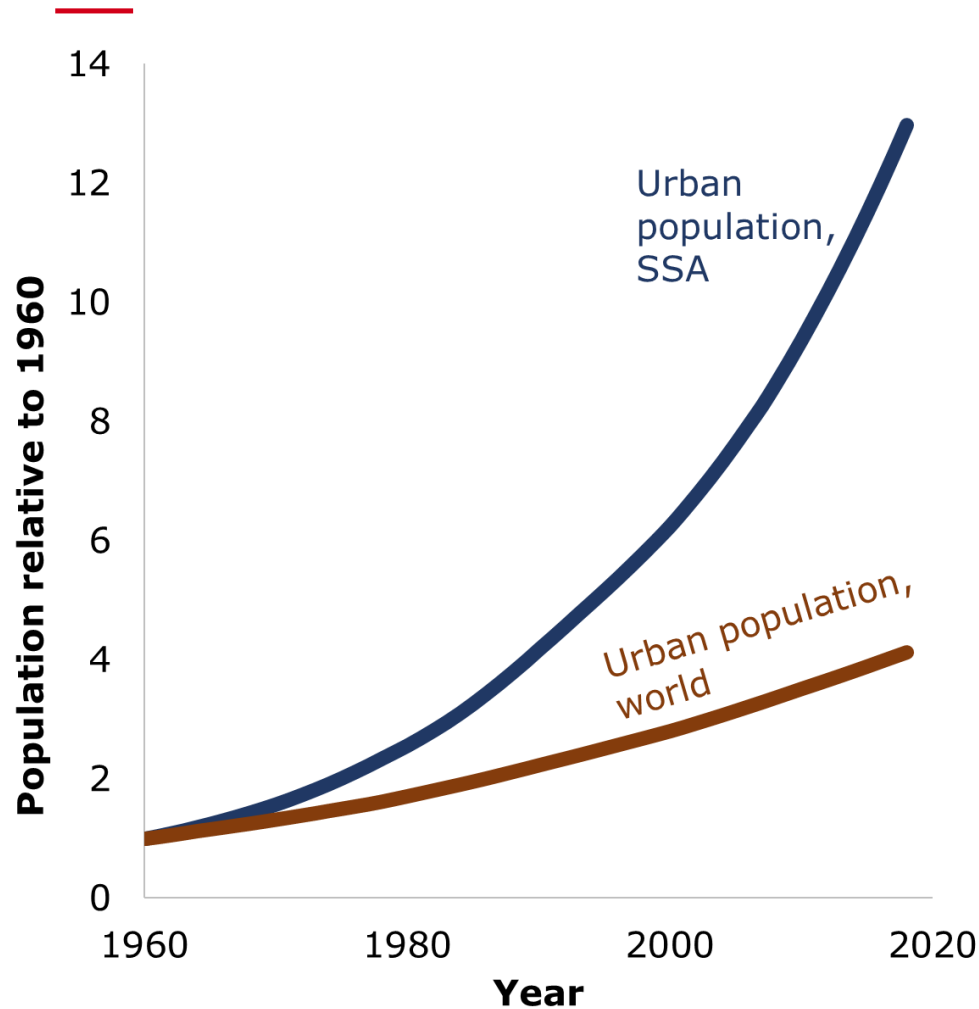
(<https://de-de.facebook.com/fso.coast>)

- Short distances
- Service and health facilities
- Educational institutions

**Rather urban wish**

# Urbanisation in Africa

## Comparison to the world



W. Schmidt *et al.*, "Sustainable circular value chains: from rural waste to high-tech urban construction materials," *Developments in the Built Environment*, 2021.

# Urbanisation in Africa

## African mega-cities in 2100

### 13 out of the 20 most populated cities will be in Africa

After D. Hoornweg, and K. Pope, Global Cities Institute, Ontario, 2014

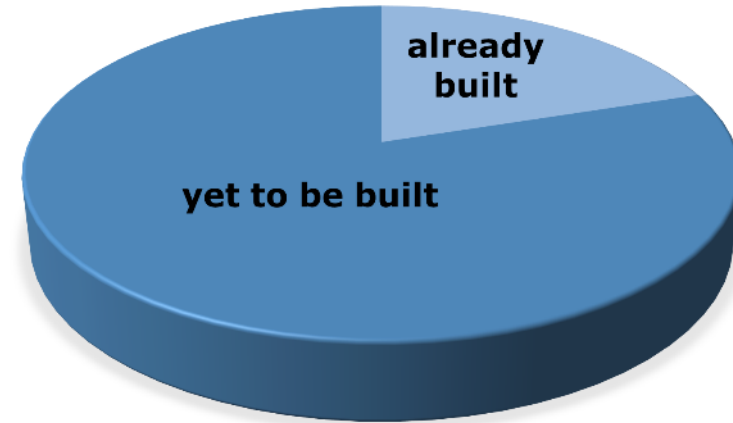
	City	Country	Mio.
1	Lagos	Nigeria	88
2	Kinshasa	DRC	83
3	Dar es Salaam	Tanzania	74
6	Khartoum	Sudan	57
7	Niamey	Niger	56
12	Nairobi	Kenya	47
13	Lilongwe	Malawi	41
14	Blantyre City	Malawi	41
15	Cairo	Egypt	41
16	Kampala	Uganda	40
18	Lusaka	Zambia	38
19	Mogadishu	Somalia	36
20	Addis Ababa	Ethiopia	36

# Urbanisation in Africa

## Urgent need for action – NOW!

- 
- 80% of all African urban buildings in 2050 have not yet been built.
  - In 30 years it will be too late to change towards more sustainable approaches.
  - Theoretical “if → then” approaches cannot help for the moment.
  - A second best solution today is better than the best solution in 30 years.

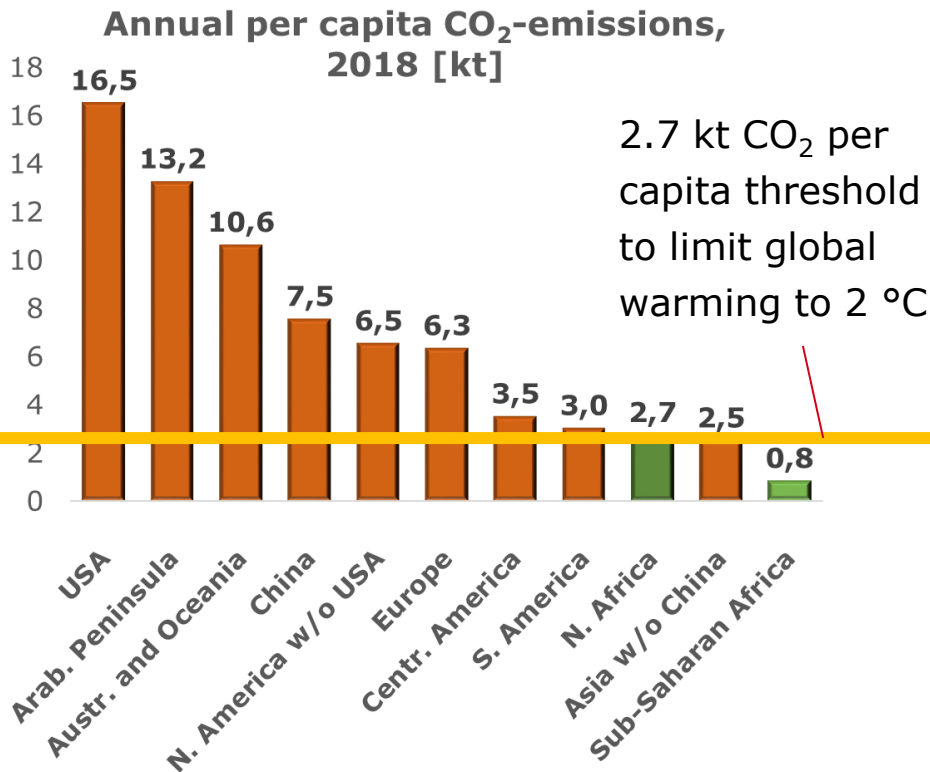
TOTAL URBAN BUILDINGS IN 2050



W. Schmidt et al., "Challenges, opportunities and potential solution strategies for environmentally and socially responsible urban development of megacities in Africa," in 3RD RILEM Spring Convention 2020 - ambitioning a sustainable future for built environment: comprehensive strategies for unprecedented challenges. Guimaraes, Portugal: RILEM, 2020.

# Urbanisation in Africa

## Per-capita carbon emissions per region

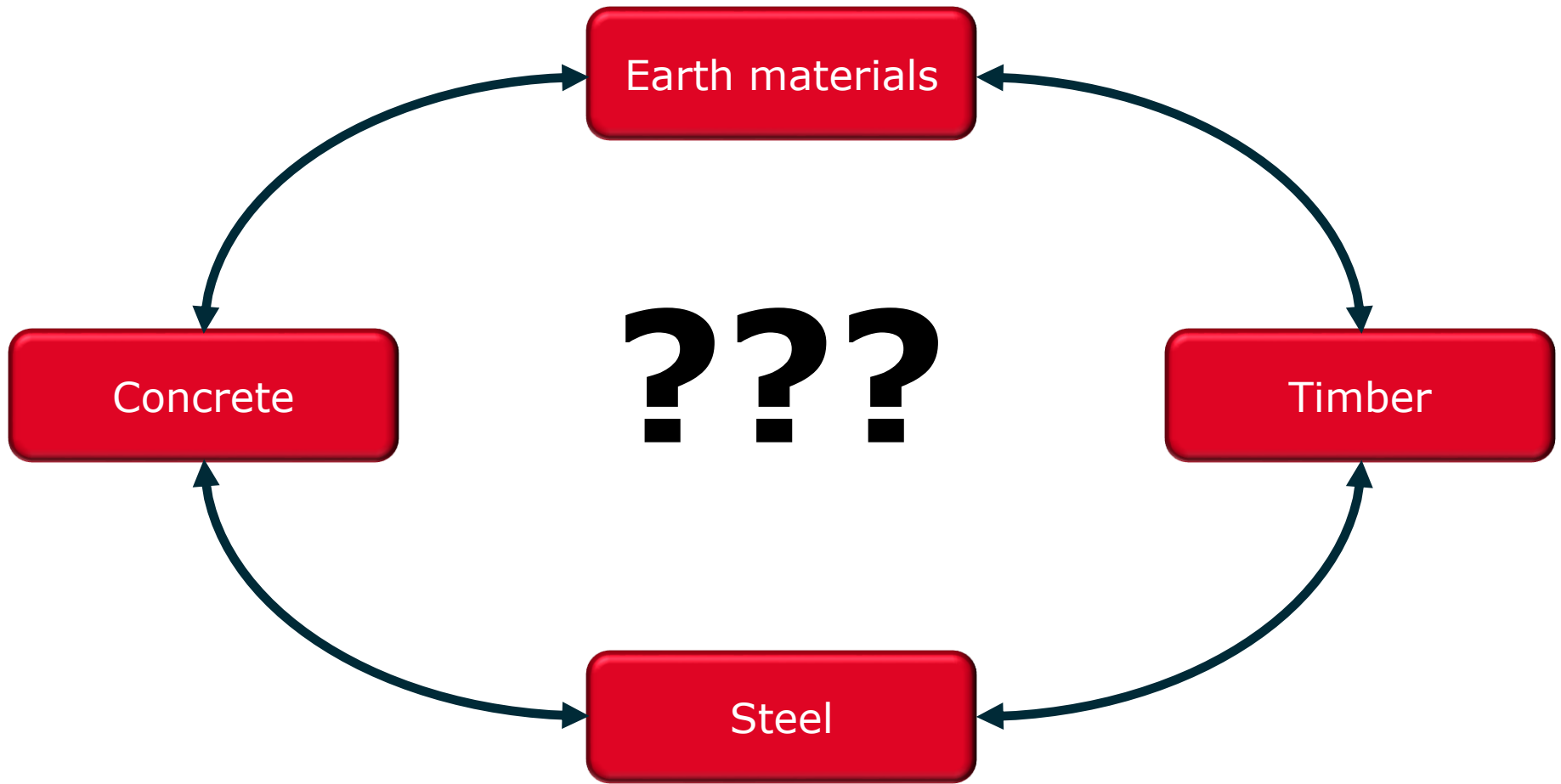


Sub-Saharan Africa can become role model for sustainable urbanisation.

Schmidt, W., et al. (2020) "Innovation potentials for construction materials with specific focus on the challenges in Africa ", RILEM Technical Letters, 50, pp. 63-74. doi: 10.21809/rilemtechlett.2020.112.

# Sustainable materials solutions

## Options for structural materials



# Sustainable materials solutions

## Timber

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- Provided the timber comes from sustainable production, the carbon footprint of timber construction can be very good.
  - However, today, we do not have sufficient timber, and many regions in the world suffer from deforestation



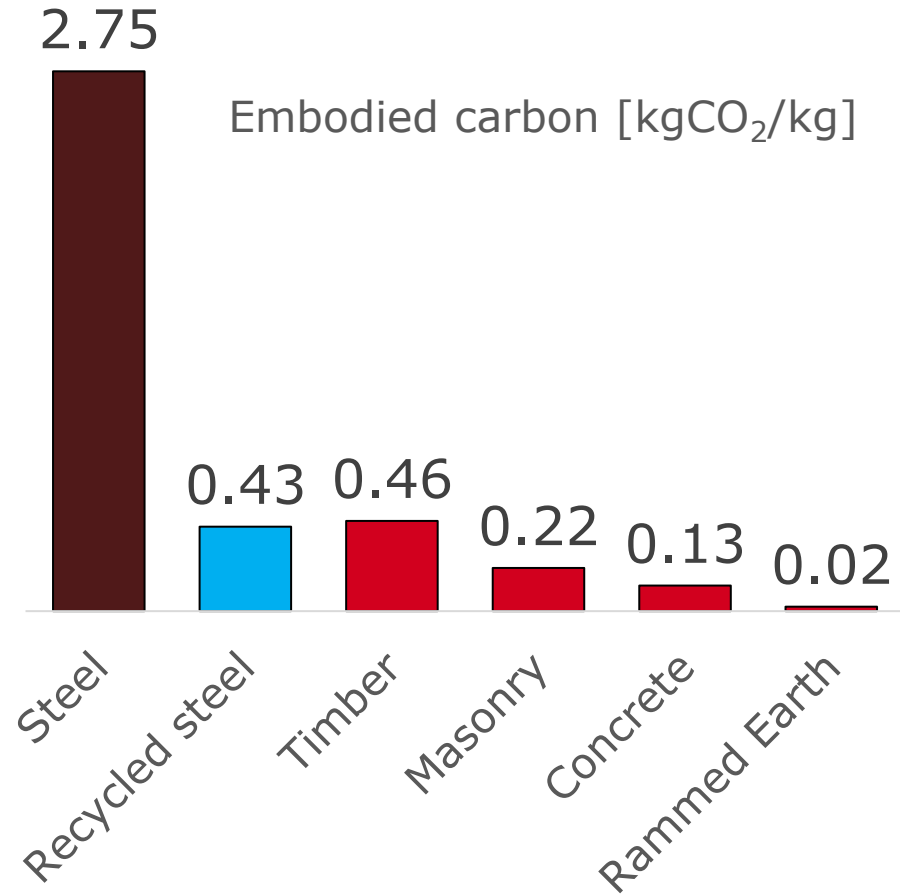
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76979668  
23

# Sustainable materials solutions

## Steel

- Steel has a high carbon footprint
- But with increased use of recycled steel it is getting better.
- No alternatives for tensile loads



Embodied carbon data taken from:  
G. Hammond and C. Jones, "Inventory of Carbon & Energy (ICE) - Version 1.6a," Department of Mechanical Engineering, UNiversity of Bath, UK, Bath, UK, 2008



# Sustainable materials solutions

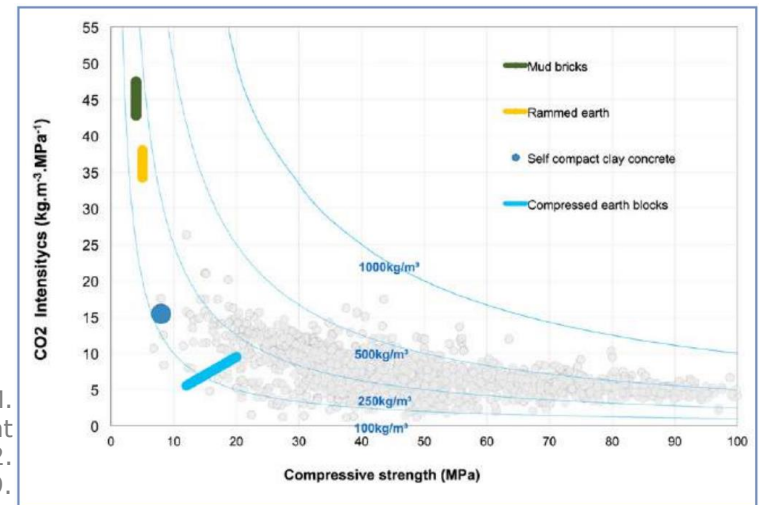
## Earth materials

- Remarkably low carbon footprint
- But requires maintenance.
- Cement stabilisation is no option, because the strength is too low for the cement used.



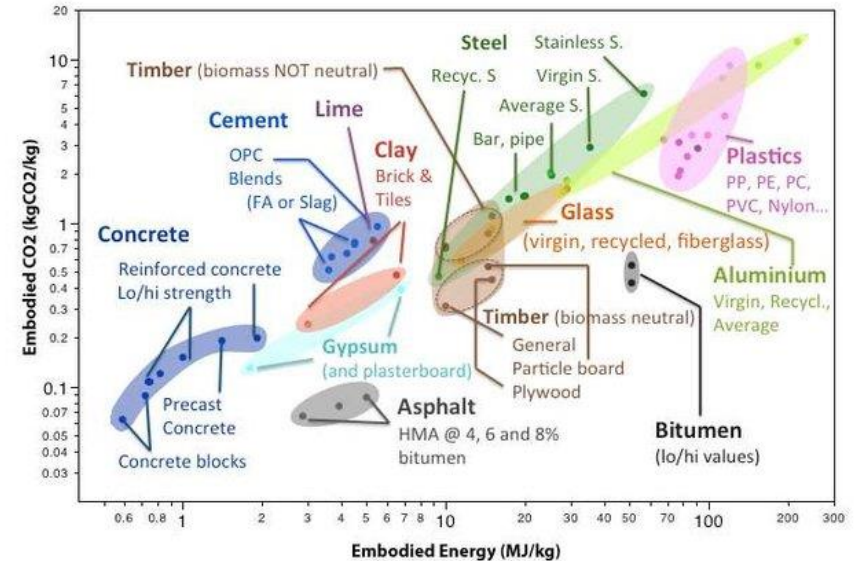
By Ruud Zwart - Photo taken by Ruud Zwart, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=3326719>

B.L. Damineli, F.M. Kemeid, P.S. Aguiar, V.M. John, Measuring the eco-efficiency of cement use, *Cem. Concr. Compos.* 32 (2010) 555–562. doi:10.1016/j.cemconcomp.2010.07.009.



## Concrete

- High carbon emissions because of vast use.
- But much better carbon footprint than generally assumed.
- Outstanding properties:
  - Everywhere doable
  - Local business
  - Easy to handle
  - Reasonably cheap



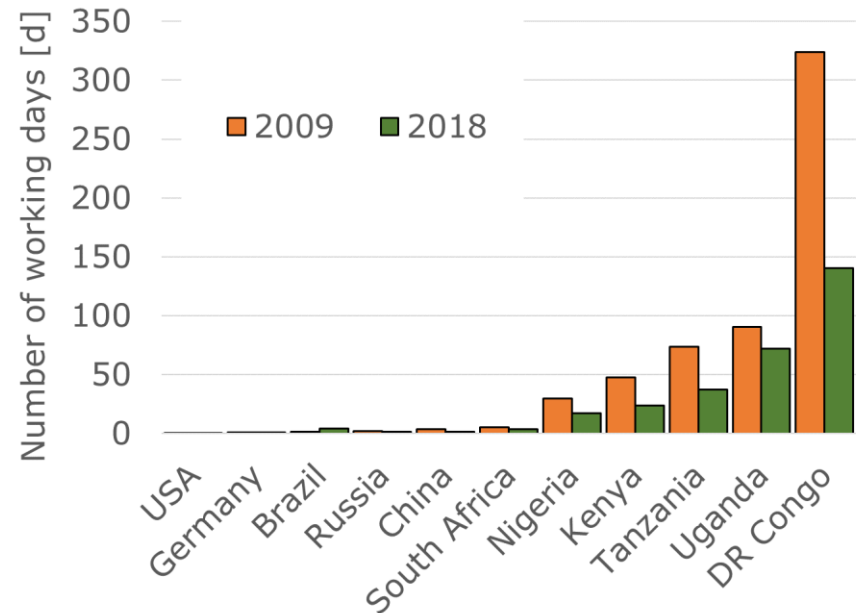
Barcelo, Laurent & Kline, John & Walenta, Günther & Gartner, Ellis. (2014). Cement and carbon emissions. Materials and Structures. 47. 10.1617/s11527-013-0114-5.

# Sustainable materials solutions

## Concrete

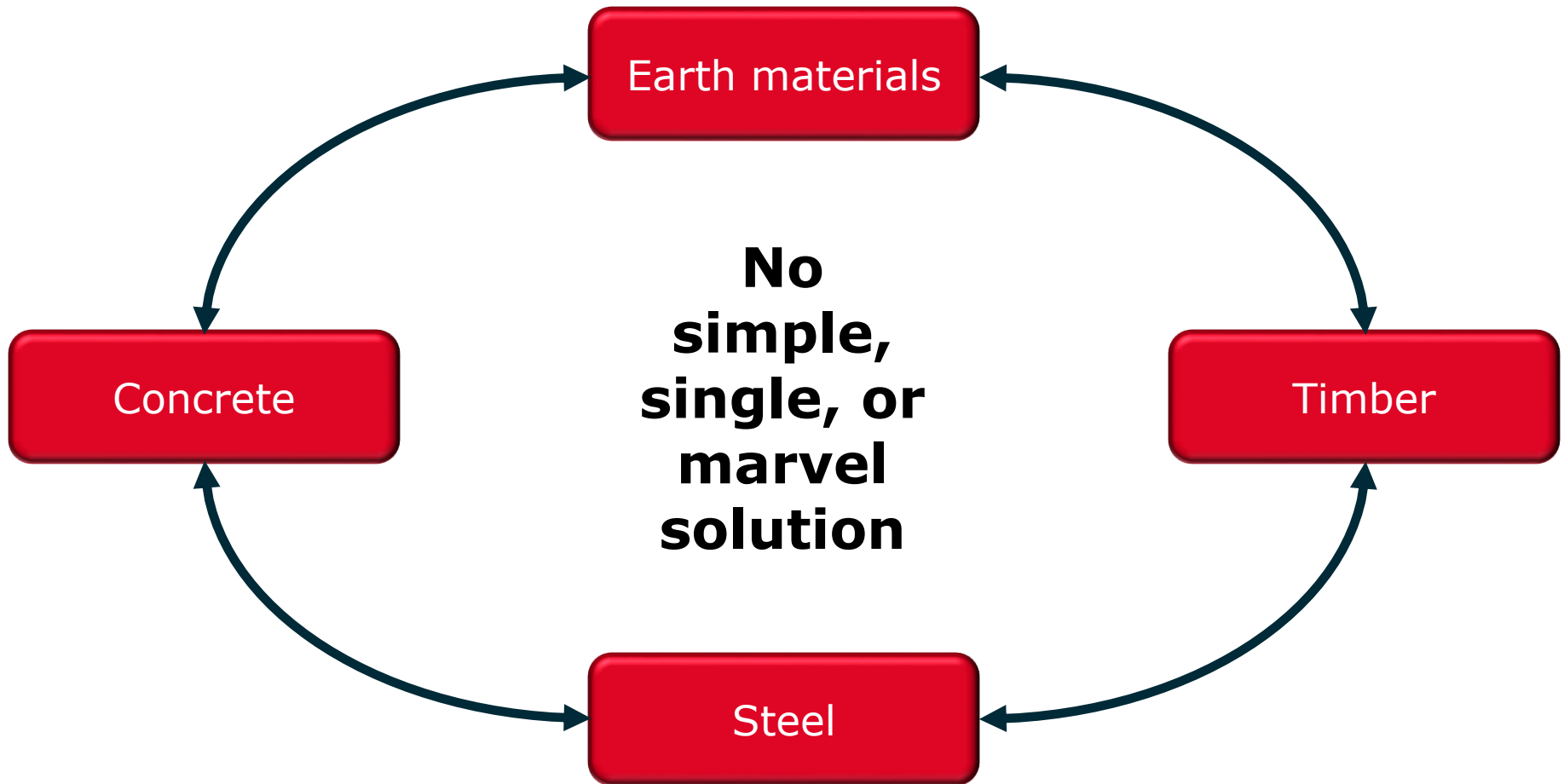
- High carbon emissions because of vast use.
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Number of working days for an average income earner to purchase 1 ton of cement locally.



# Sustainable materials solutions

## What are sustainable materials?



# Reasonable materials and structures

## The three L's to consider

**Load-case dependent materials selection**

**Low-key structural design**

**Local materials**



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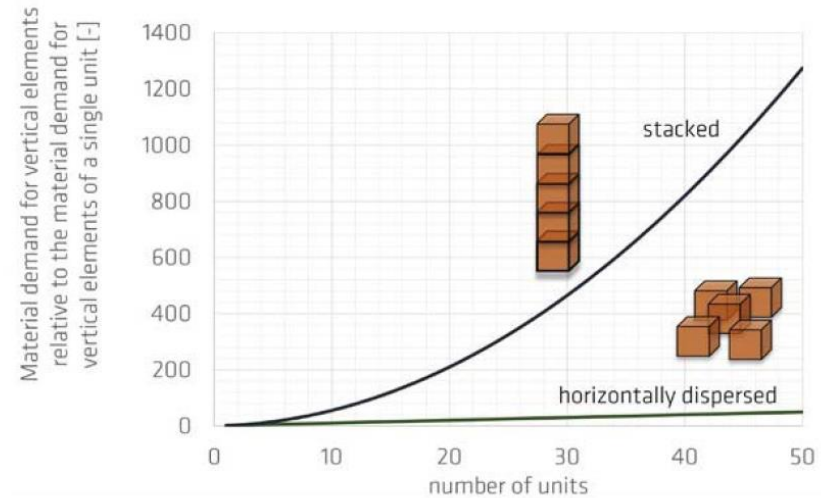
# Reasonable materials and structures

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Load-case dependent materials selection

Low-key structural design

Local materials



W. Schmidt, J. Anniser, and K. Manful, "A sustainability point of view on horizontal and vertical urban growth," in ISEE - Innovation, Science, Engineering, Education, 2019, pp. 189-193.



# Reasonable materials and structures

## The three L's to consider

Load-case dependent materials selection

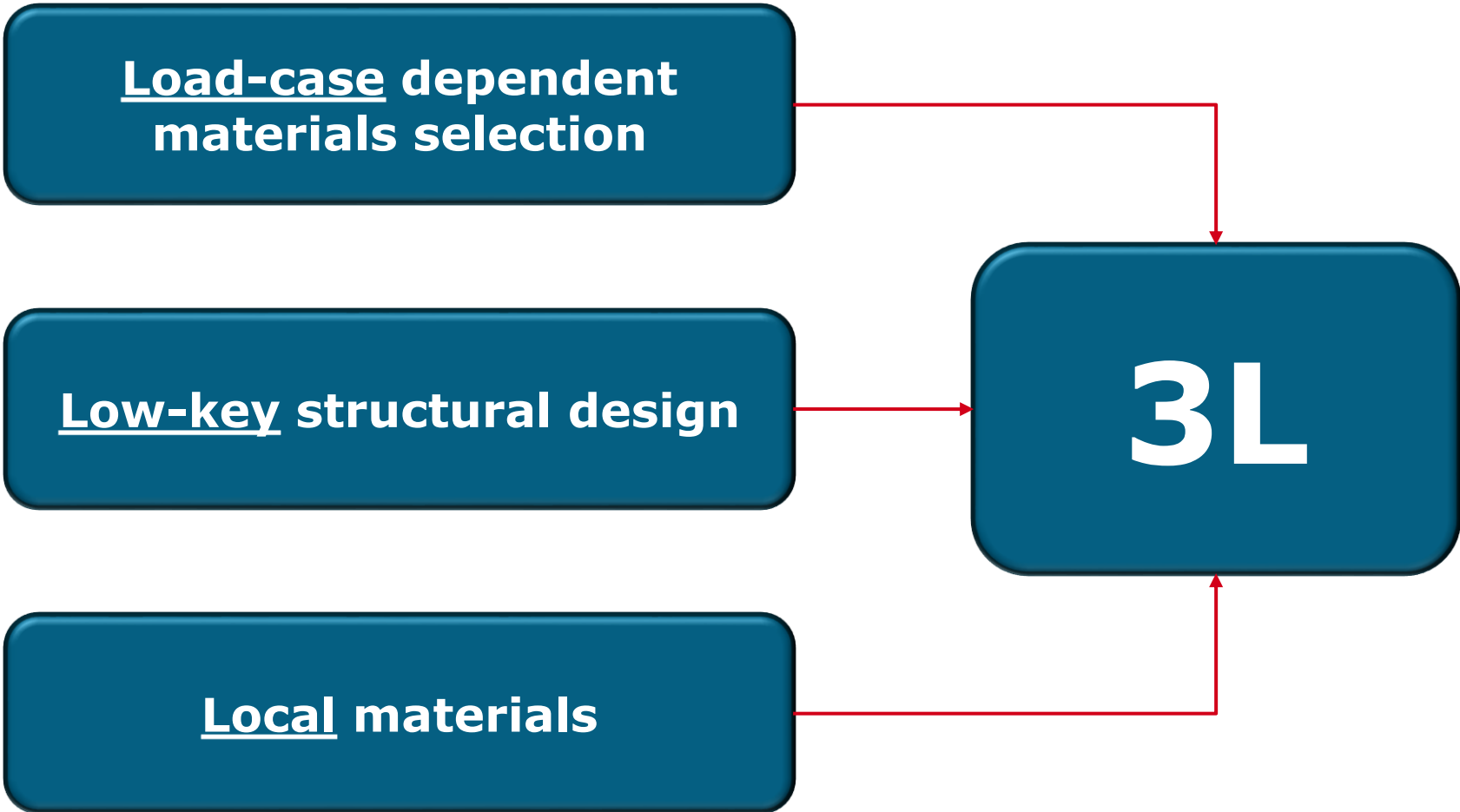
Low-key structural design

Local materials



# Reasonable materials and structures

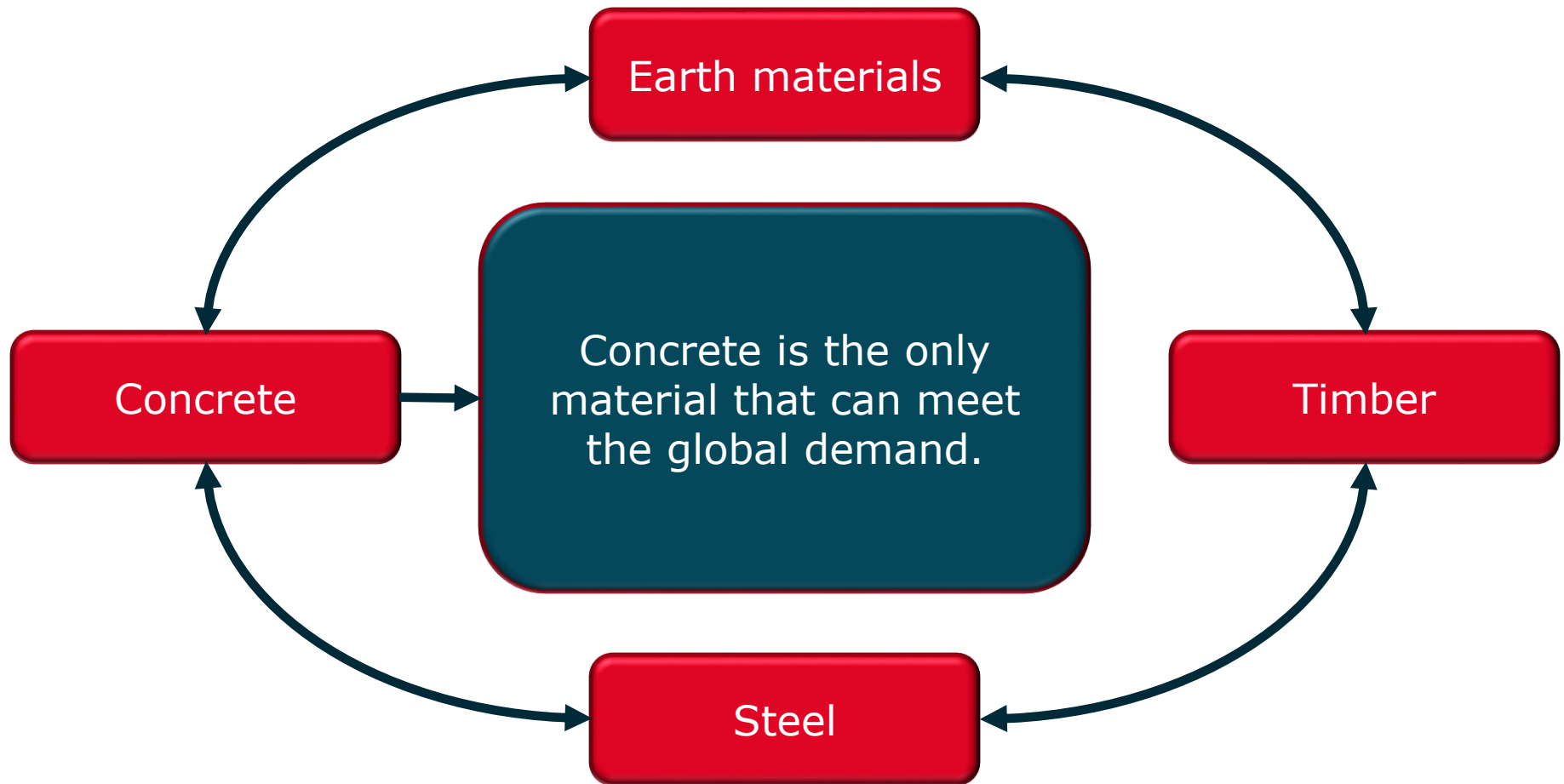
## The three L's to consider





# Sustainable materials solutions

## Example concrete



# Sustainable materials solutions

## Example concrete



# Bio-based concrete solutions

## Sustainable concrete



# Bio-based concrete solutions

## Sustainable concrete – Africa's potentials

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### Bio-based cement replacements

e.g. ashes from maize cobs, rice husks, sugar cane bagasse, cassava peels,...



### Bio-based chemical admixtures (polysaccharides)

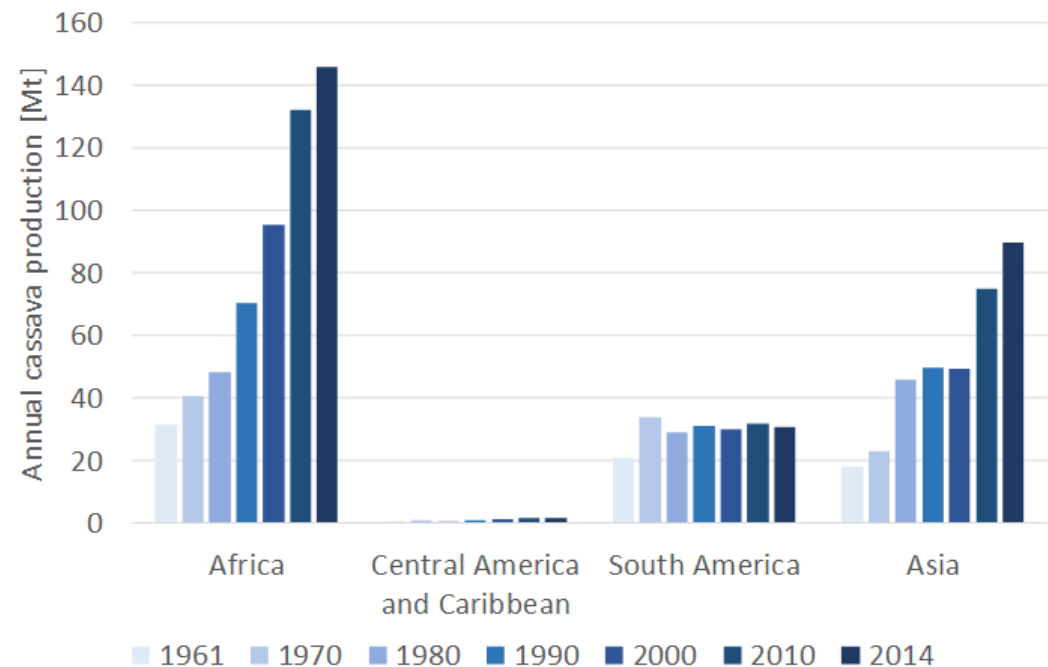
e.g. acacia gum, bark of triumphetta pendrata A.Rich, cassava starch, cocoa wastes,...



# Circularity potentials

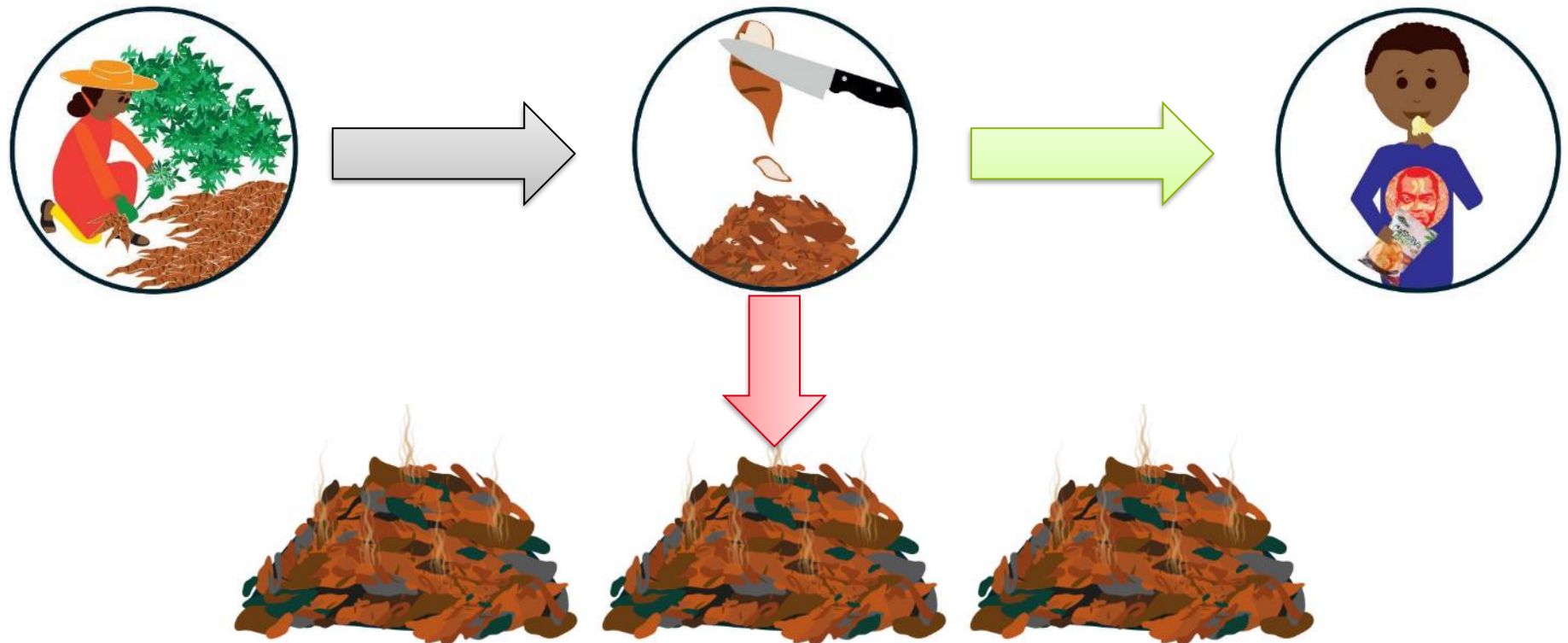
## Relevance of cassava

Cassava can be found nearly everywhere in the Southern hemisphere. In Africa and Asia it is particularly of importance.



# Circularity potentials

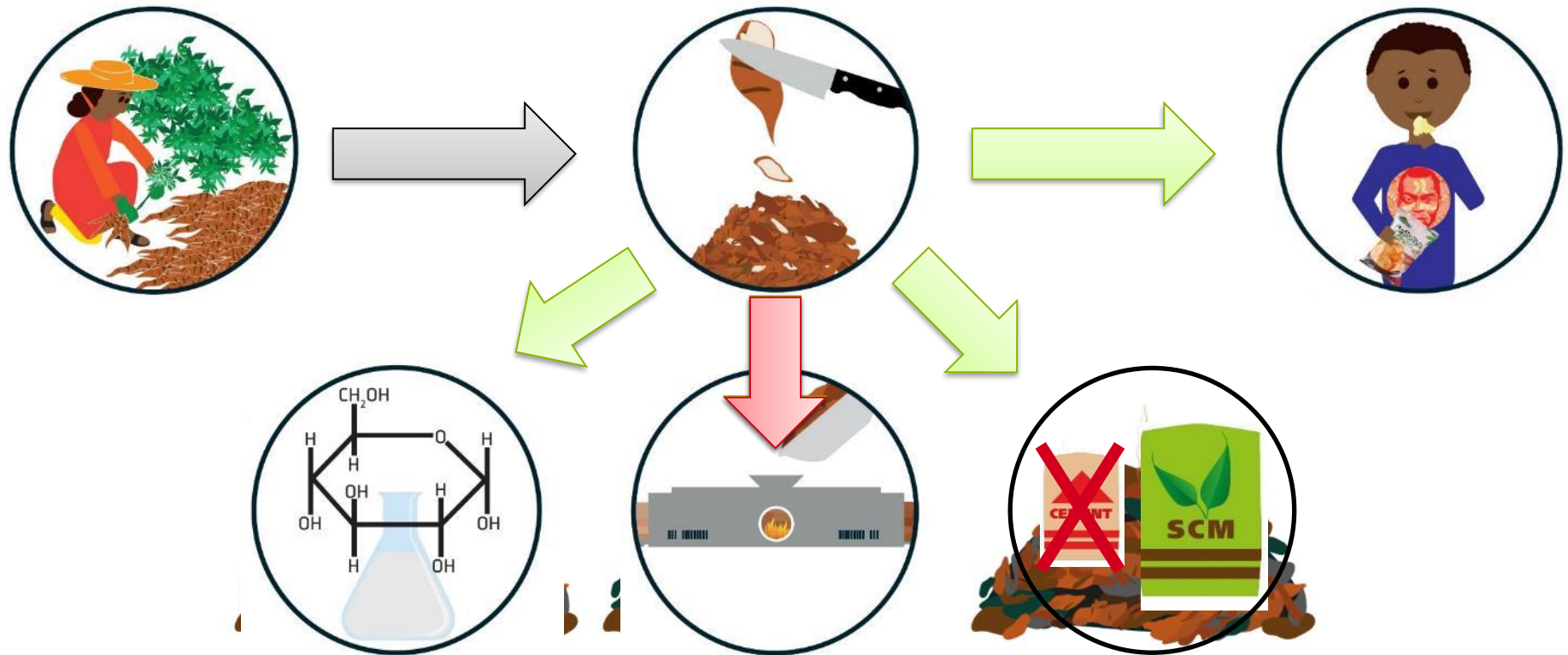
## Novel value chain potentials of cassava waste



W. Schmidt, and M. J. Barucker-Sturzenbecher, "Bio-based concrete (<https://vimeo.com/310549146>)," 2019, 7:51

# Circularity potentials

## Novel value chain potentials of cassava waste



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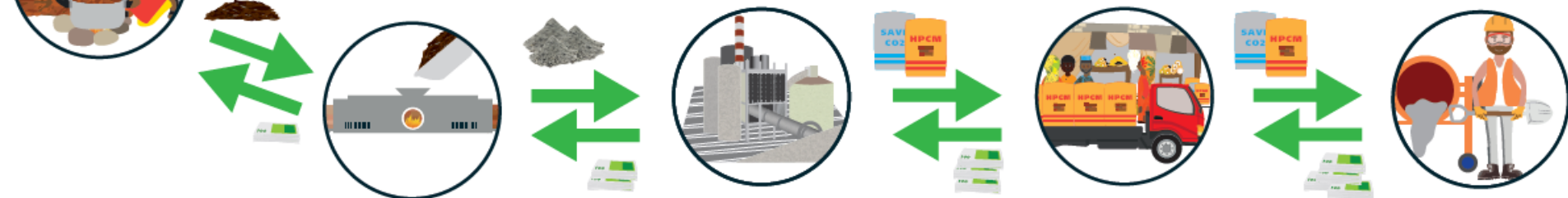
# Circularity potentials

## Novel value chain potentials of cassava waste

### Chemical value chain



### Value chain in construction materials

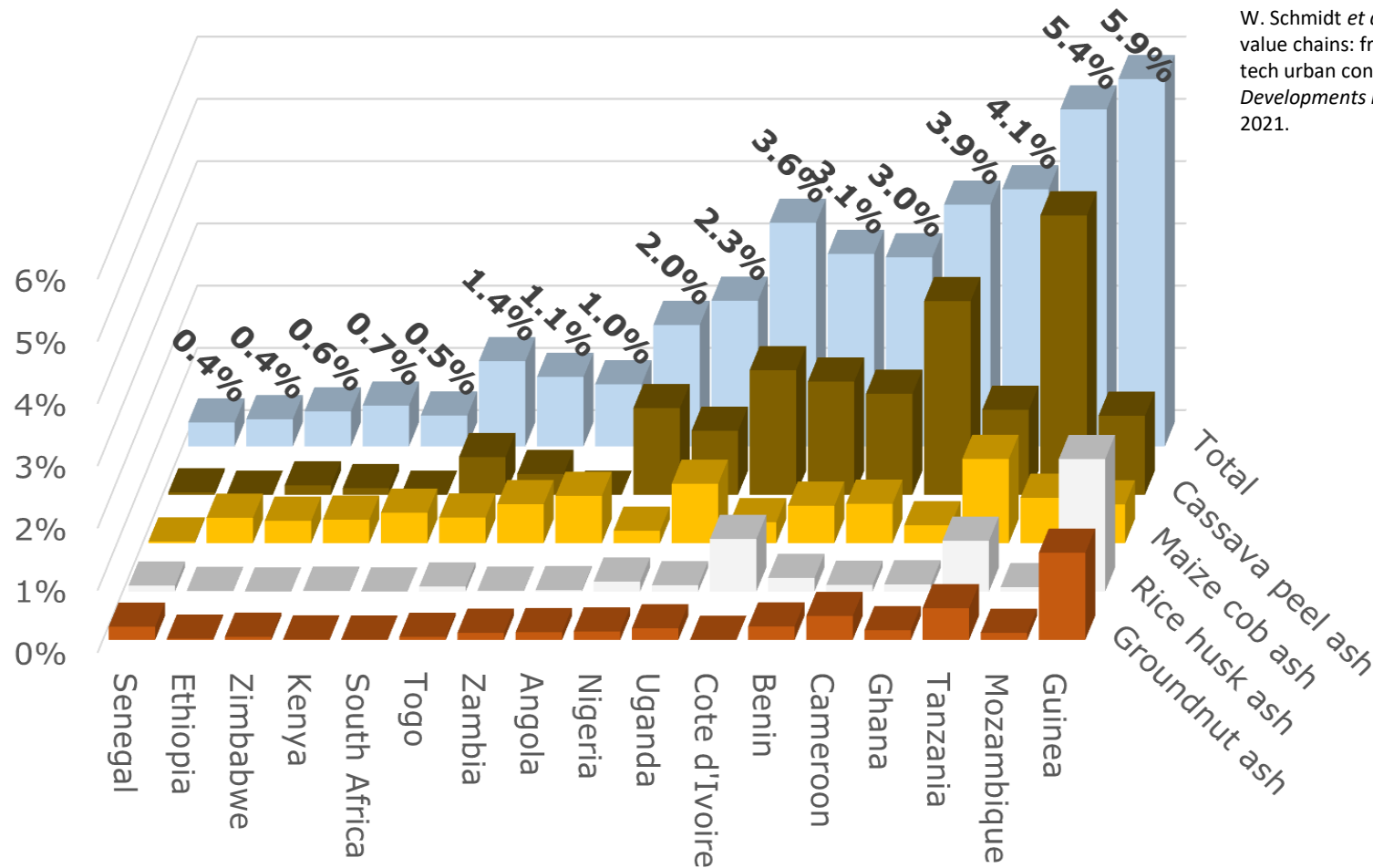


W. Schmidt, and M. J. Barucker-Sturzenbecher, "Bio-based concrete (<https://vimeo.com/310549146>)", 2019, 7:51



# Circularity potentials

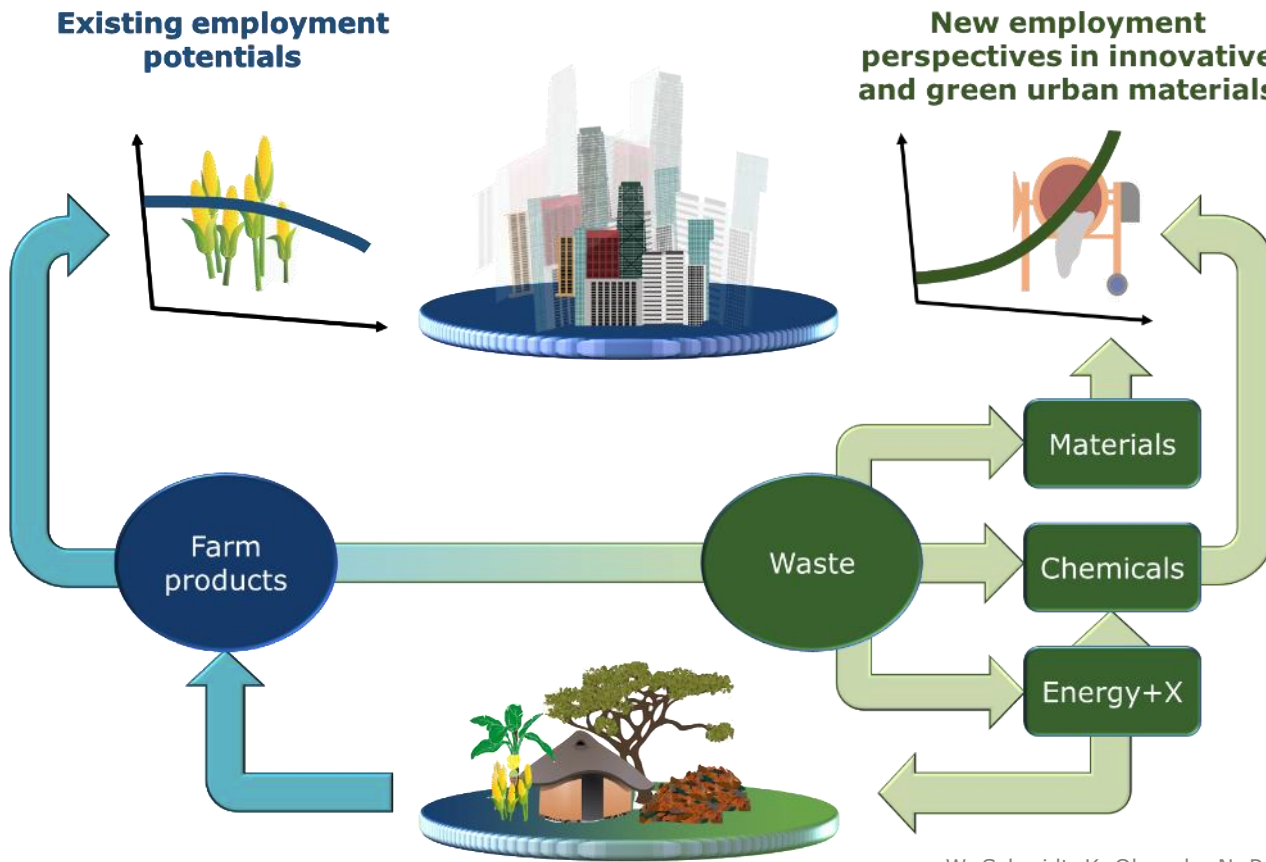
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W. Schmidt *et al.*, "Sustainable circular value chains: from rural waste to high-tech urban construction materials," *Developments in the Built Environment*, 2021.

# Circularity potentials

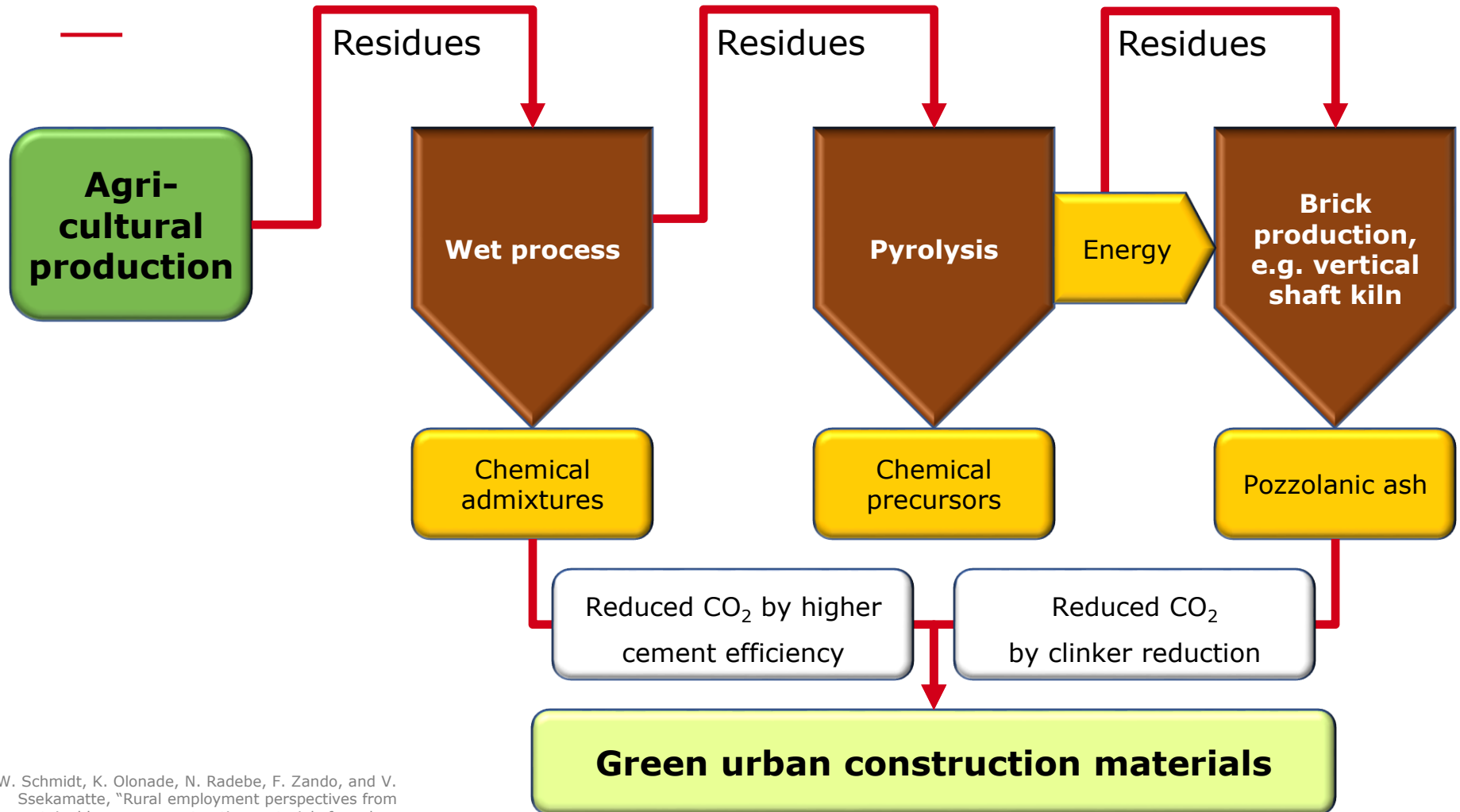
## Circularity between rural and urban processes



W. Schmidt, K. Olonade, N. Radebe, F. Zando, and V. Ssekamatte, "Rural employment perspectives from sustainable, green construction materials for urban development - in press, 6/2020," Rural 21

# Circularity potentials

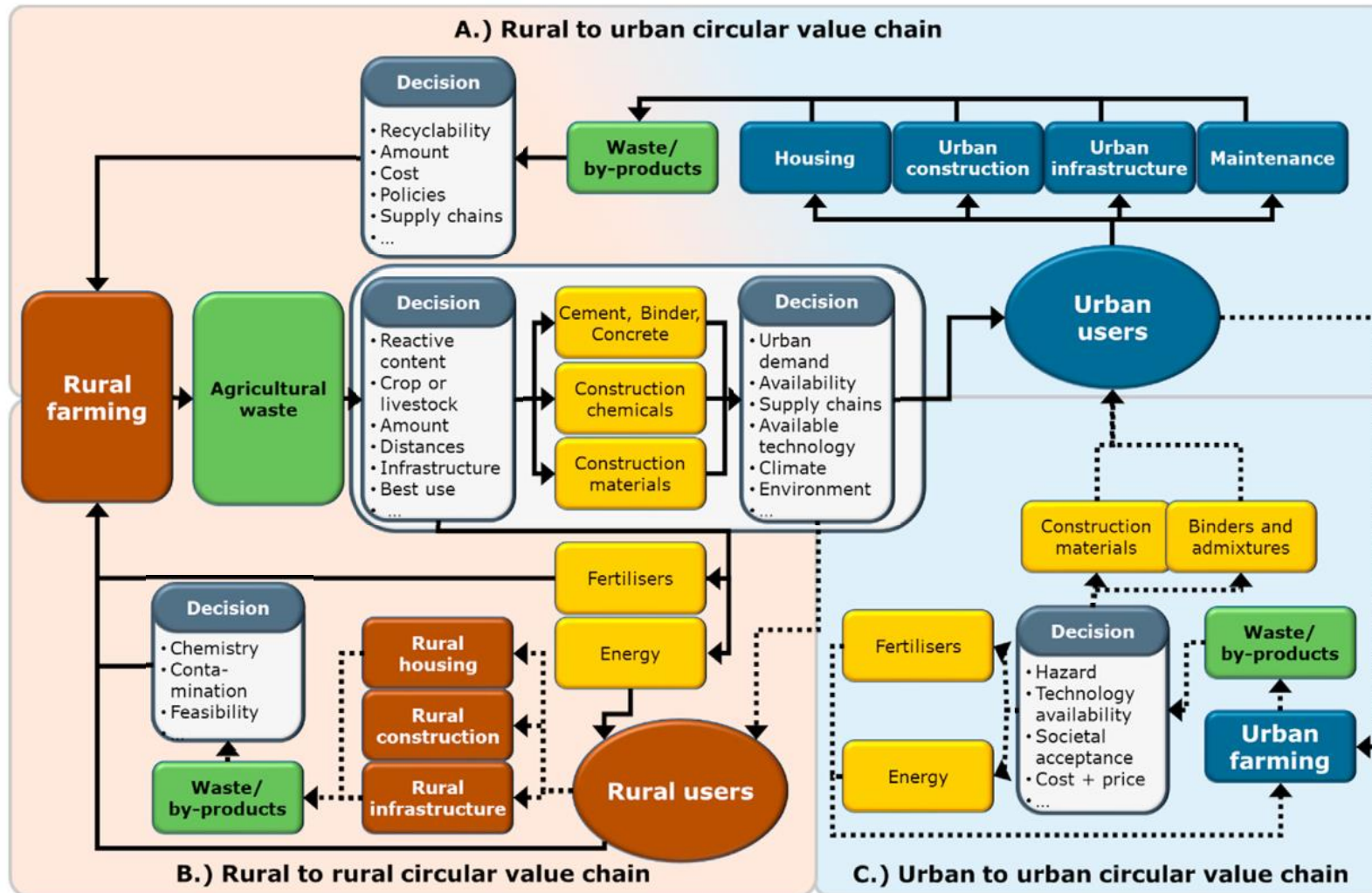
## Novel value chain potentials for agro-waste



W. Schmidt, K. Olonade, N. Radebe, F. Zando, and V. Ssekamatte, "Rural employment perspectives from sustainable, green construction materials for urban development - in press, 6/2020," Rural 21

# Circularity potentials

## Implementation



W. Schmidt *et al.*,  
 "Sustainable circular value chains: from rural waste to high-tech urban construction materials,"  
*Developments in the Built Environment*, 2021.

# Human and interdisciplinarity aspect

## Decision makers

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**Decision making in urban processes depends on many people and the knowledge of multiple disciplines.**



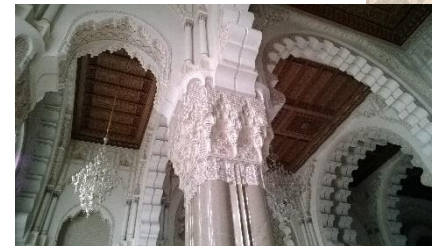
# Human and interdisciplinarity aspect

## Responsible use of technologies

**Will more technology make our world automatically more sustainable?**



<https://tu-dresden.de/bu/bauingenieurwesen/ifb/forschung/spp2005>



# Human and interdisciplinarity aspect

## Realistic assessment of standards

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**Standards are like medicine.**

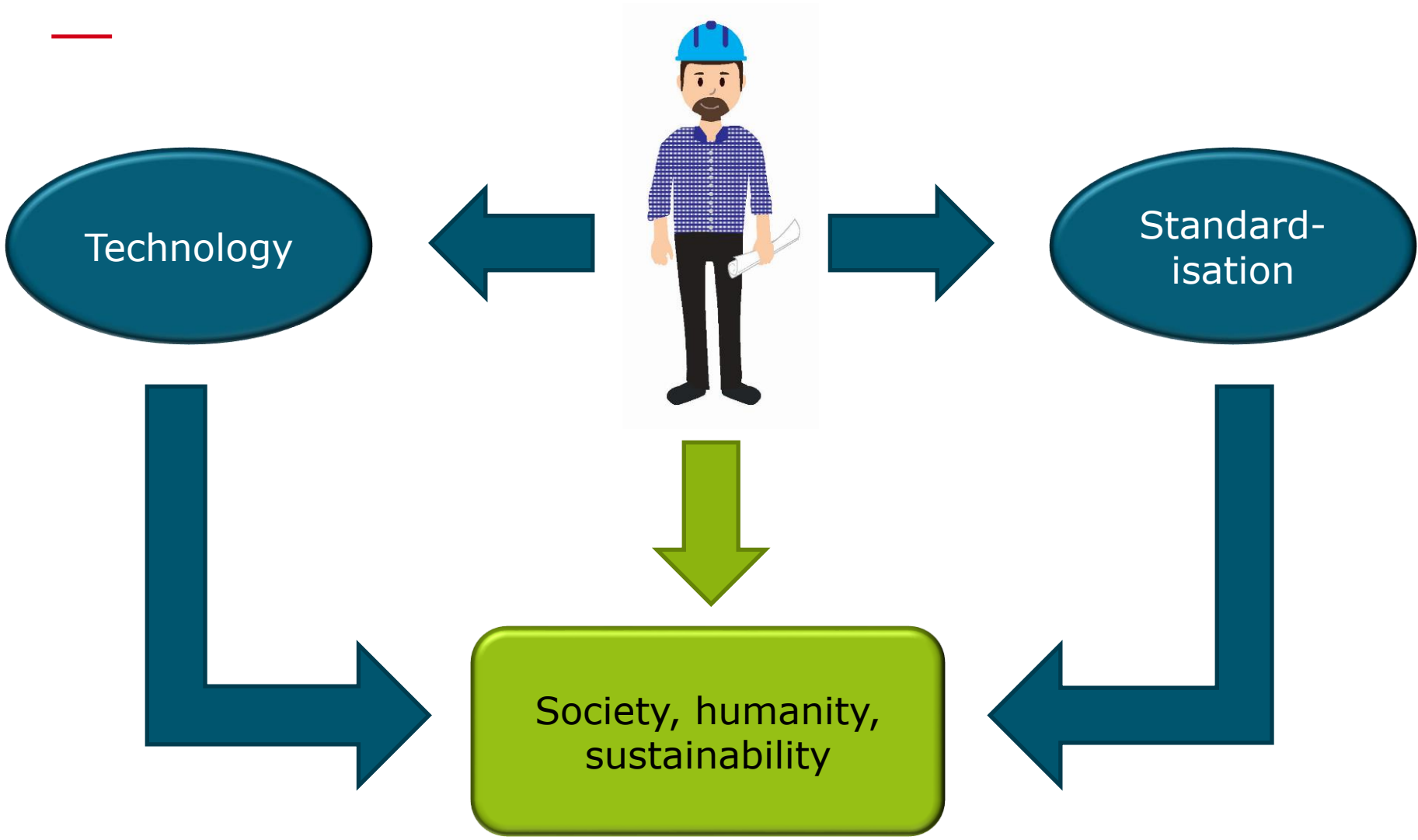
**If they are used in the right dosage, they are helpful.**

**If they are overdosed, they become poisonous.**



# Human and interdisciplinarity aspect

## Technology and standards should serve societies





# Conscious construction

## Consequences of irresponsible construction

**We have to see the full picture.**





# Conscious urbanisation

## Inclusive and multi-disciplinary



Female **A**cademic **L**eadership Network  
for **C**onscious **E**ngineering and **S**cience  
towards **S**ustainable Urbanisation.

[www.falconess.org](http://www.falconess.org)

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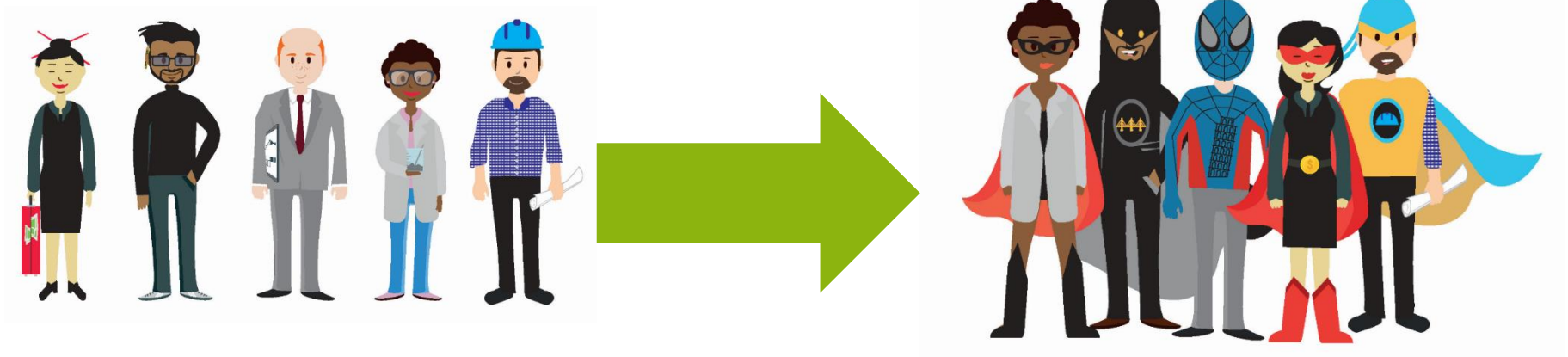


Federal Ministry  
of Education  
and Research

# Conscious urbanisation

## New decision makers are required

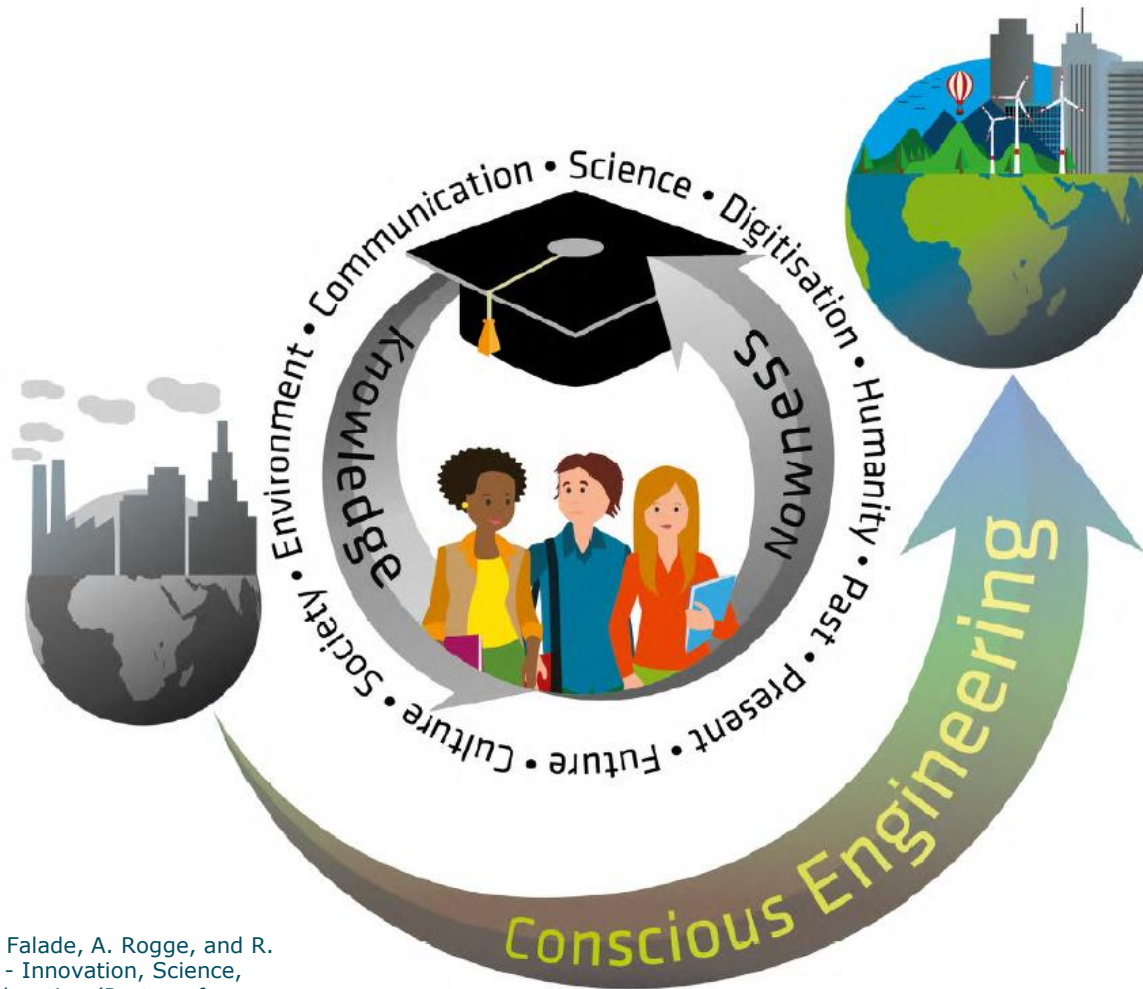
**Instead of being technology appliers, we have to become conscious engineers to have the power to change urban environment to the better!**



[www.isee-africa.com](http://www.isee-africa.com)

# Educational needs

Mutual, holistic, inclusive learning



W. Schmidt, F. Falade, A. Rogge, and R. Tchitnga, ISEE - Innovation, Science, Engineering, Education (Post-conference edition) - [www.isee-africa.com](http://www.isee-africa.com), 2019

# Educational needs

## All generations included

Learn from



Today's decision makers

Future's decision makers

Mentoring



**Thank you very much for your kind attention!**

**[www.isee-africa.com](http://www.isee-africa.com)**