Potential of bio-wastes as replacement for cement in Africa

By

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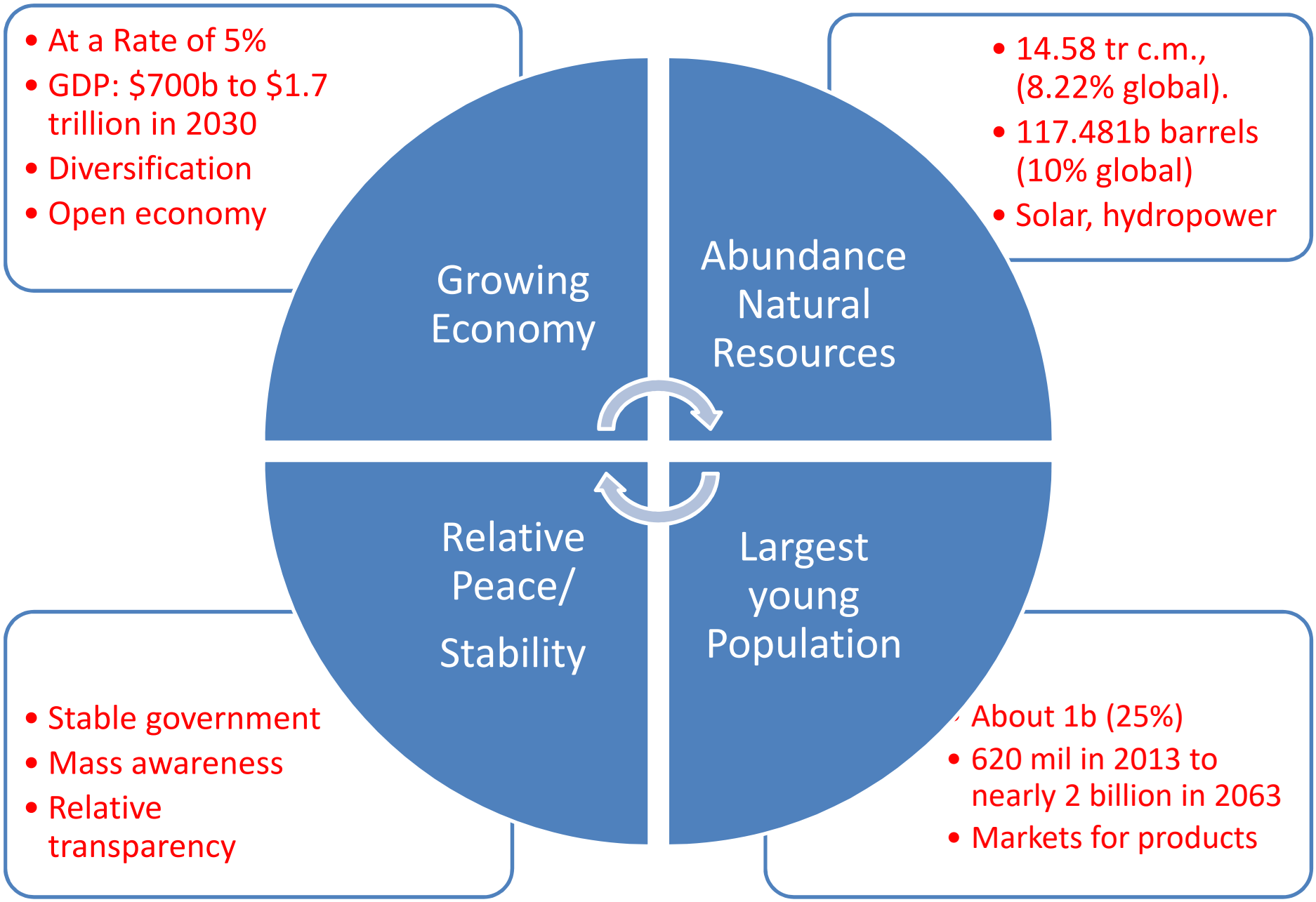
Lecture delivered Online on Friday, 16th February, 2021

AFRICA IS A SUPER BIG CONTINENT

Area (Mln sq km)	
China	9.6
USA	9.4
India	3.3
W Europe	4.9
Argentina	2.8
New Zealand	0.3
	30.2
Africa	**30.3**

(SOPAF HR, 2019)



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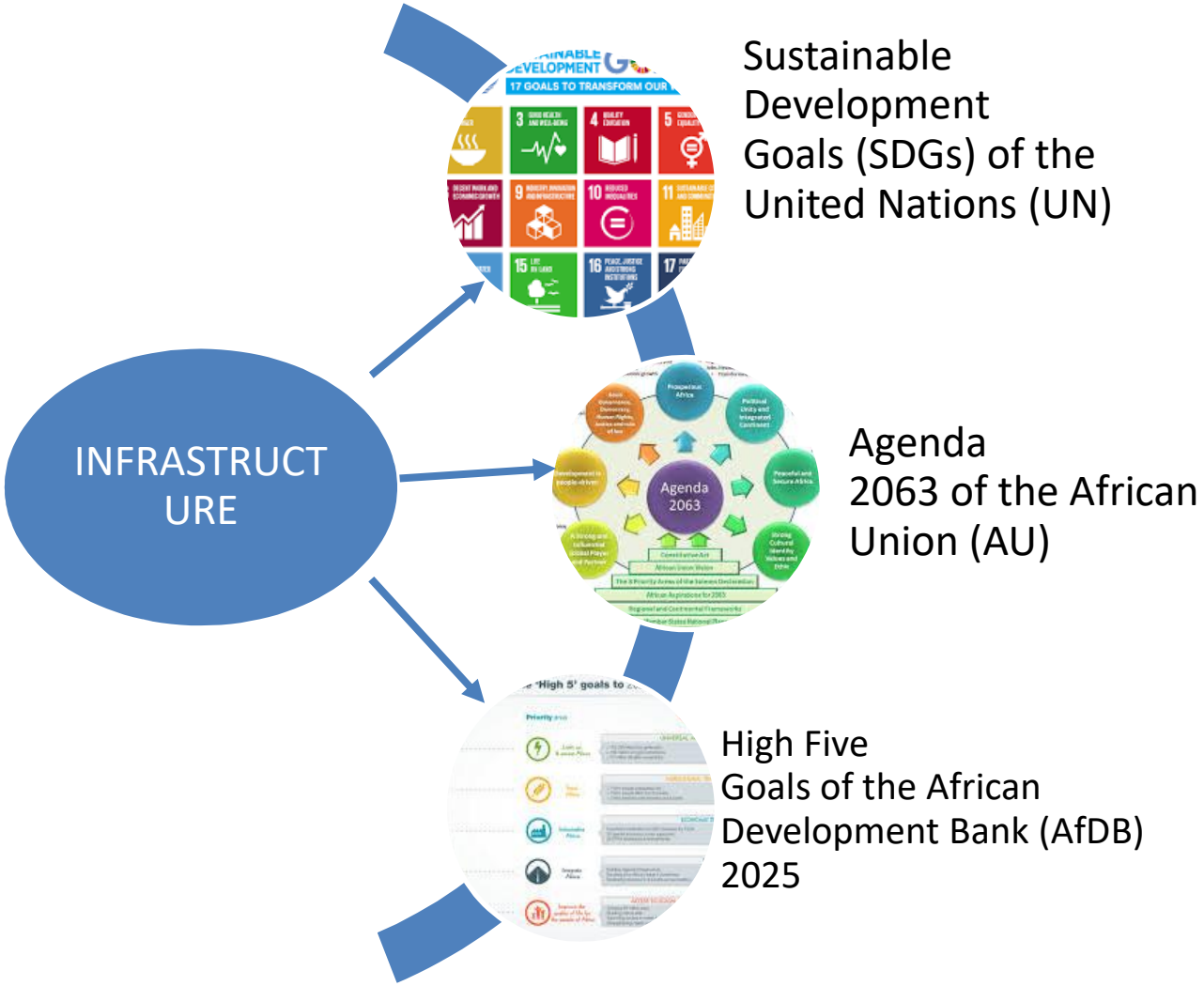
Infrastructure is key to African Growth



Sustainable Development Goals (SDGs) of the United Nations (UN)

Agenda 2063 of the African Union (AU)

High Five Goals of the African Development Bank (AfDB) 2025

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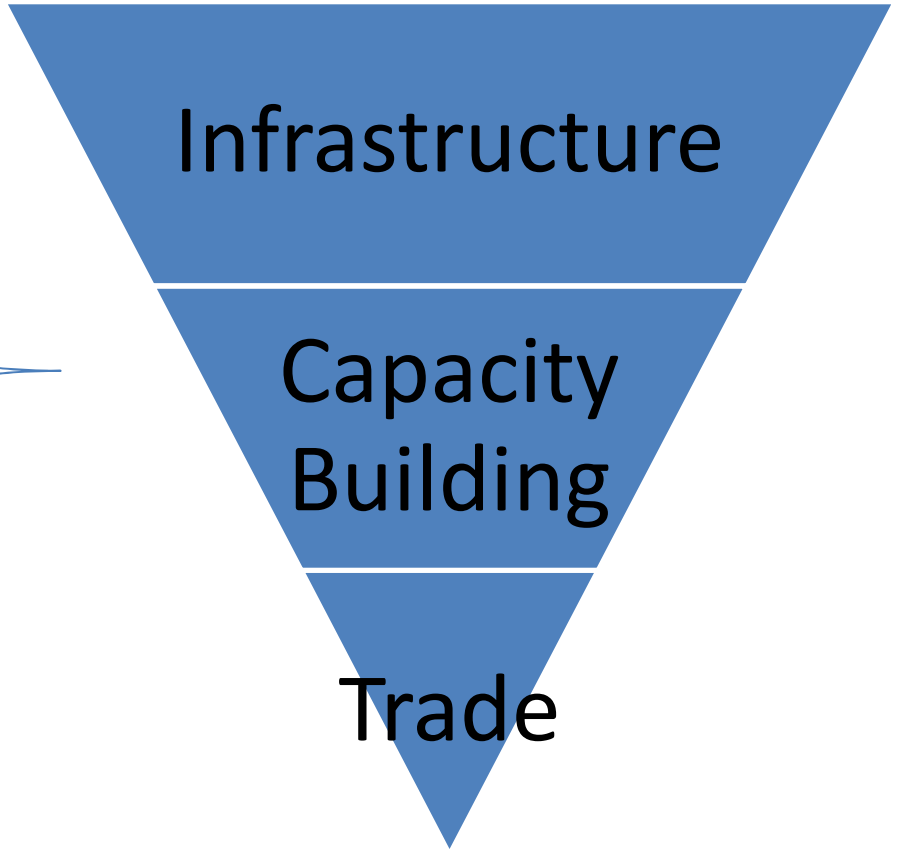
Glimpse of Infrastructure Deficit in Africa

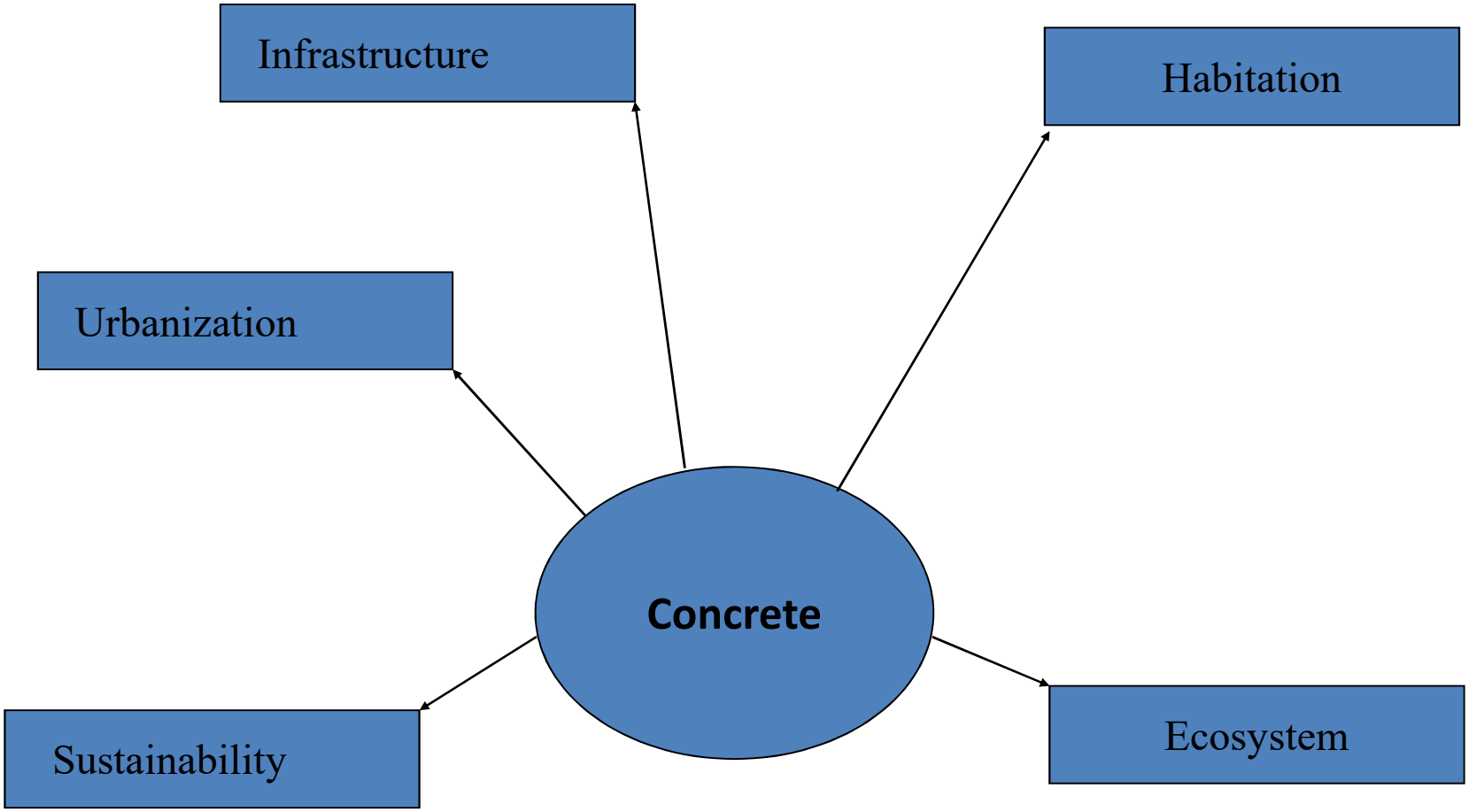
- Africa is Rebounding and Responding

Development Plans in African Countries

- Rwanda – 2040
- Nigeria – 2020
- South Africa – 2030
- Kenya – 2030
- Tanzania – 2025
- Ghana - 2020
- Cameroun – 2035



Cement is Universal

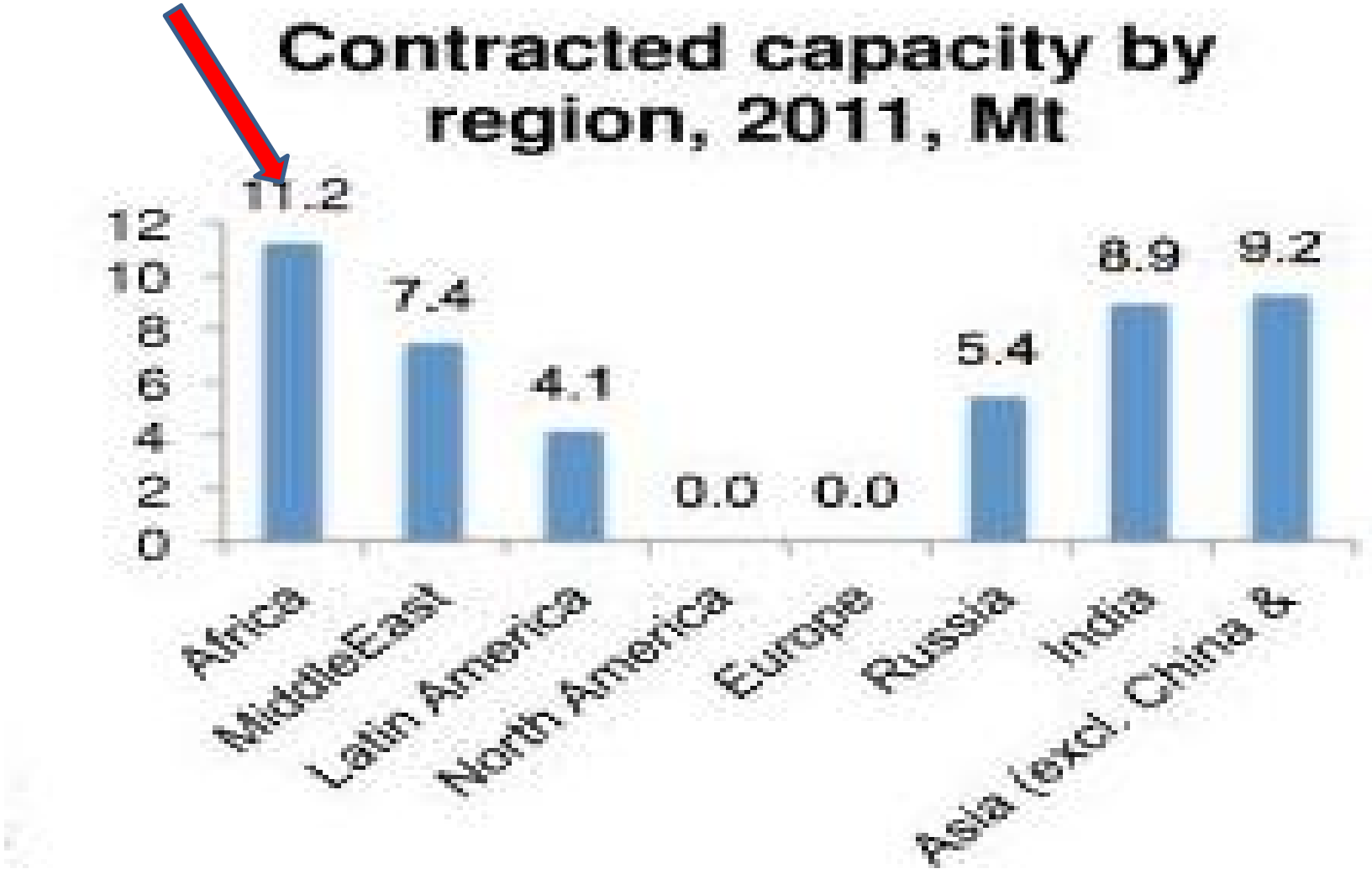


Cement is central to Africa's Infrastructure

"Africa's future growth is intrinsically linked to cement"

Dangote

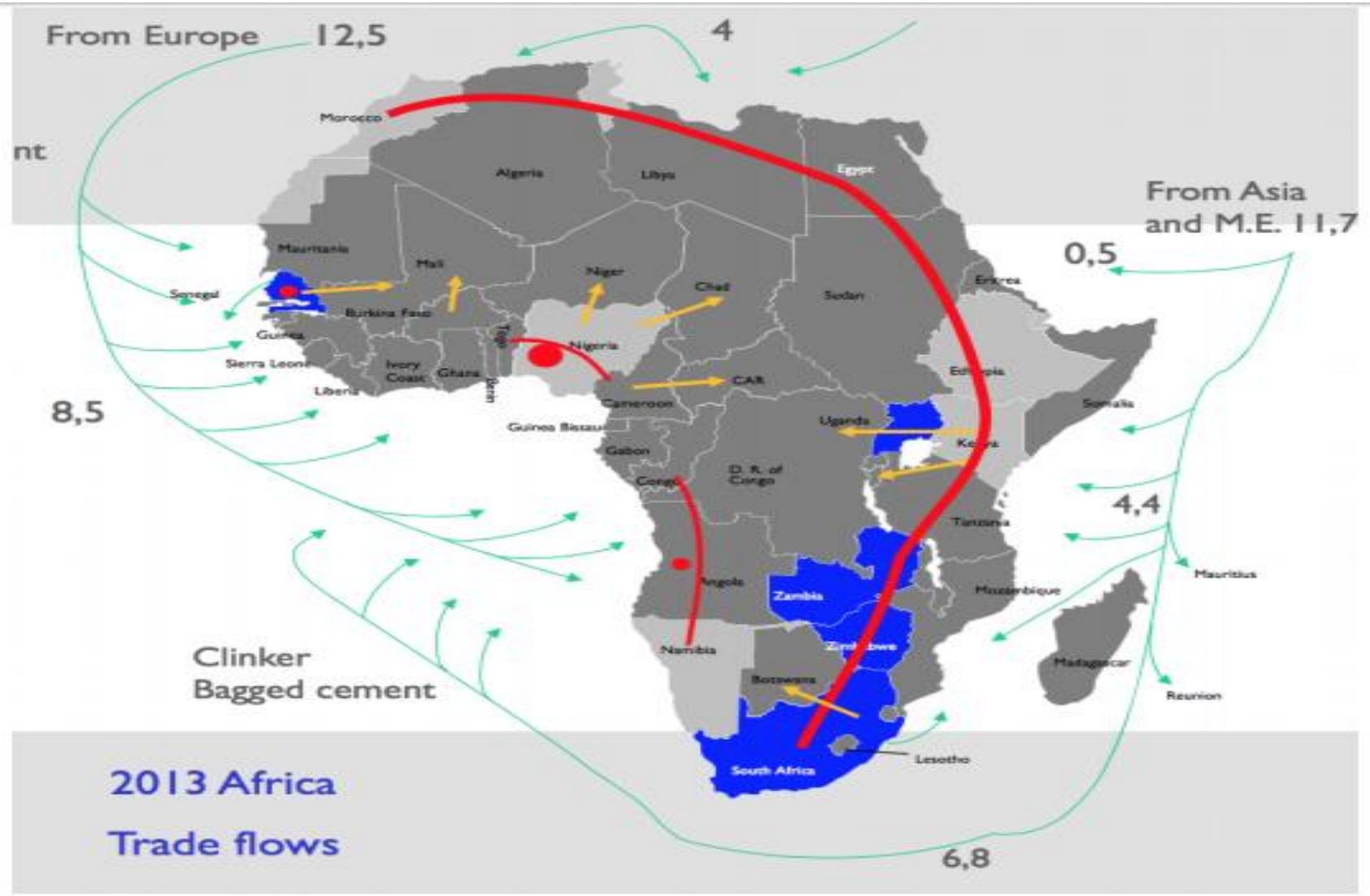
Africa is attracting investment in cement



Company	Grinding capacity (millions MT)	Countries of operation in Sub-Saharan Africa	
Dangote Cement	20.7	Nigeria, Benin, Cameroon, Zambia, Senegal, Cote d'Ivoire, Sierra Leone, Liberia, Ghana, Cameroon, Congo-Brazzaville, Ethiopia, Kenya, Tanzania, Zambia, South Africa.	
Lafarge	19.5	Nigeria, Cameroon, Benin, Kenya, Uganda, Tanzania, Malawi, Mozambique, Zambia, Zimbabwe, Botswana, South Africa.	
PPC	18.0	South Africa, Botswana, Zimbabwe.	
Heidelberg	6.7	Sierra Leone, Liberia, Ghana, Togo, Benin, Gabon, Tanzania.	
Afrisam	5.8	South Africa, Botswana, Lesotho, Swaziland, Tanzania.	
ARM Cement	5.5	Kenya, Tanzania, Rwanda, South Africa.	
Sococim	4.2	Senegal.	
Holcim	3.0	Côte d'Ivoire, Guinea, Nigeria, Tanzania, South Africa.	
Derba Midroc Cement	2.5	Ethiopia.	
WACEM	2.0	Togo, Ghana.	
Total	670		100%

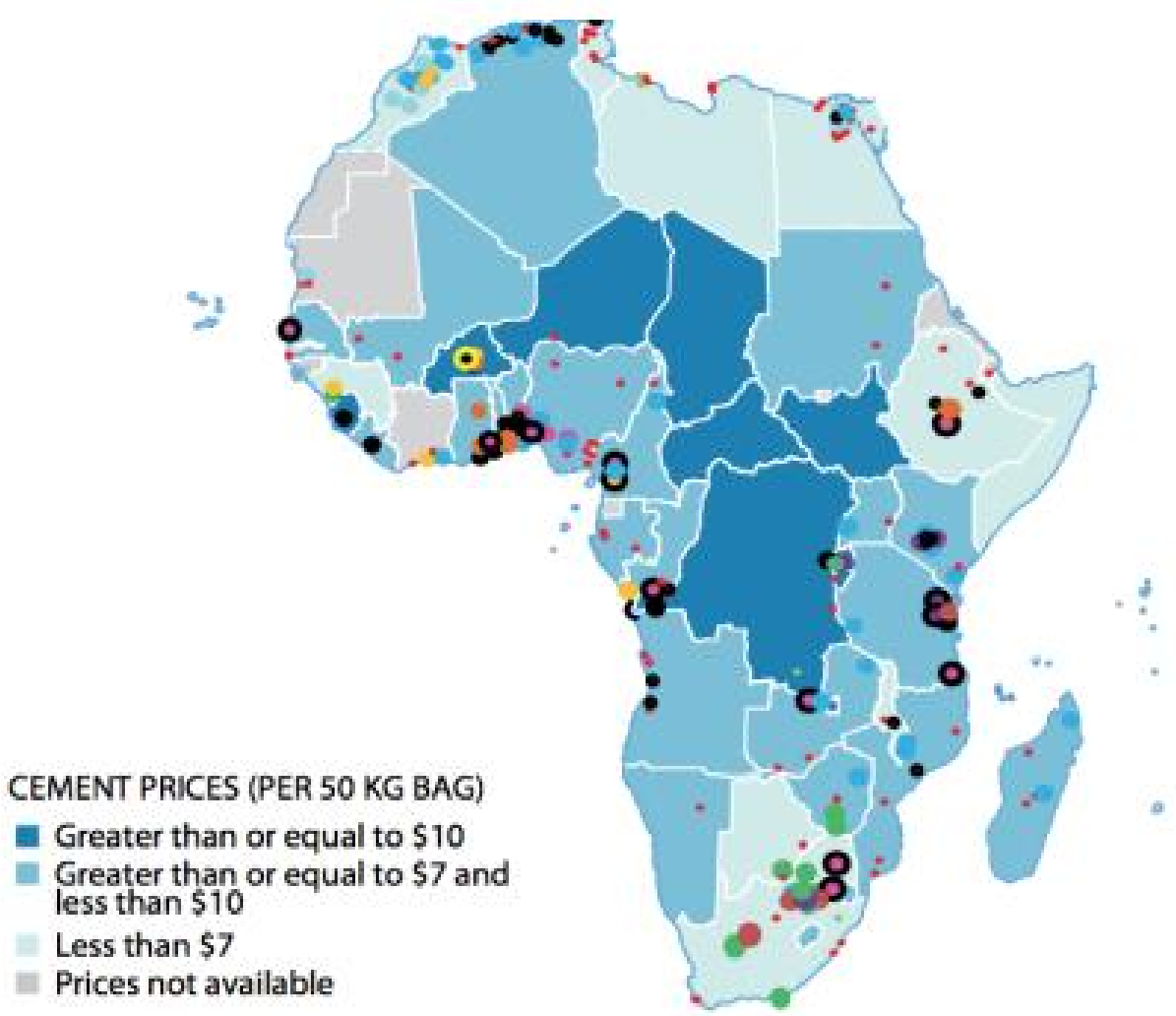
Source: Ecobank Research estimates.

Supply Chain of Cement in Africa



Source: Lightart, 2014

Price of cement is high



Source: World Bank 2016

Compare:
Europe: $3.75
Asia: $3.52

Causes:

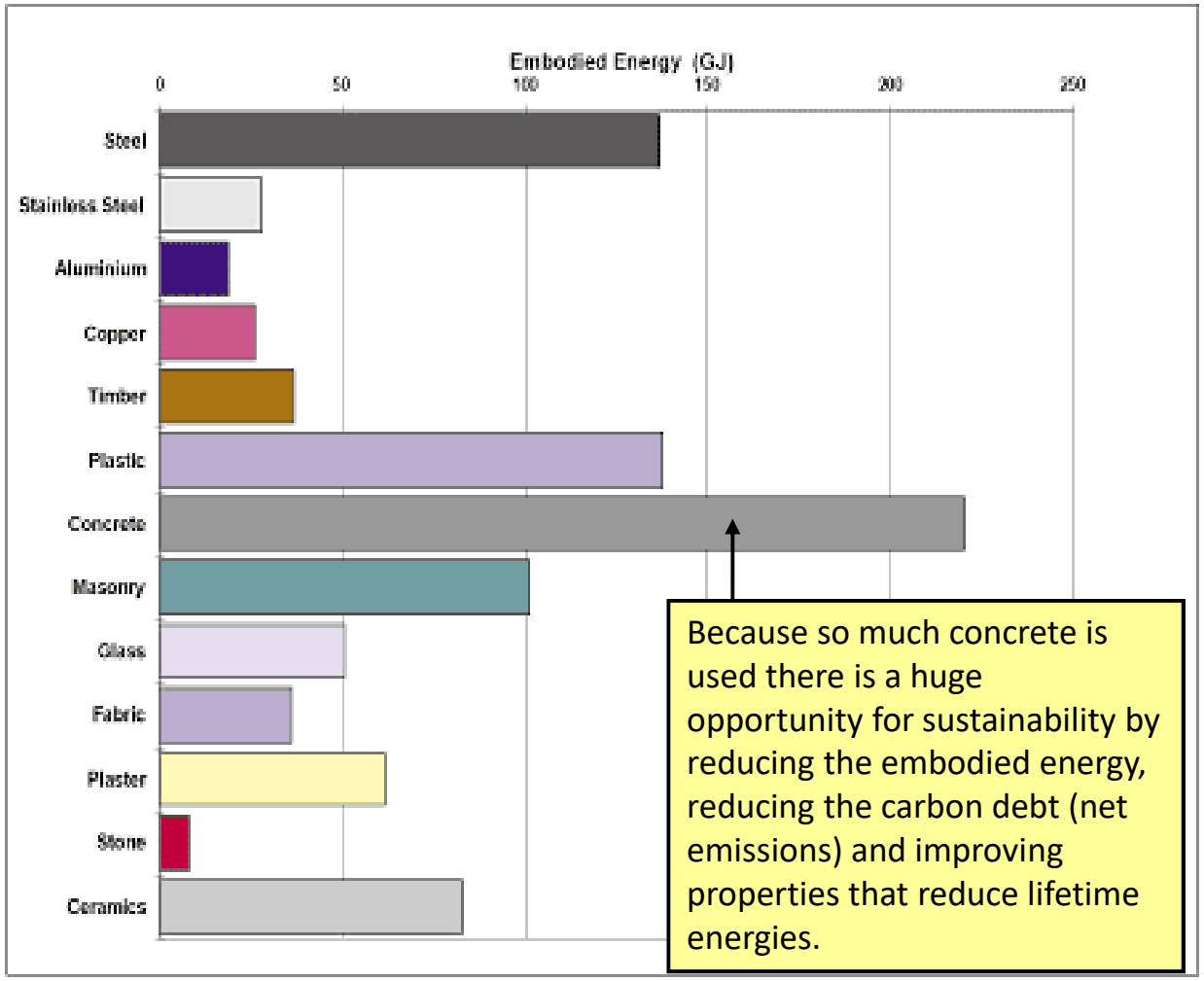
- High energy consumption
- High cost of haulage
- Importation of most parts

Consumption of CBP is a threat to our developmental plans, if nothing is done quickly

CBP is the most consumed artificial material in the world.

Cement:

- 2.1 billion tonnes per year
- 2 tonnes per capita



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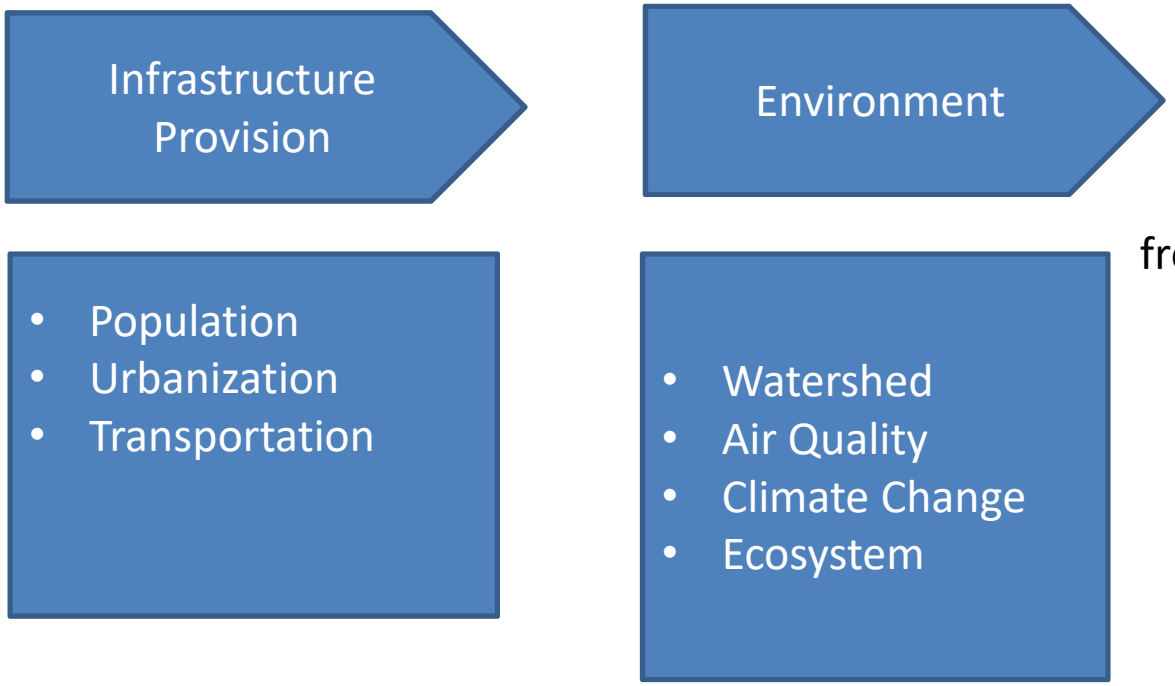
Infrastructure vs Environment



1/6 of the world's freshwater withdrawals

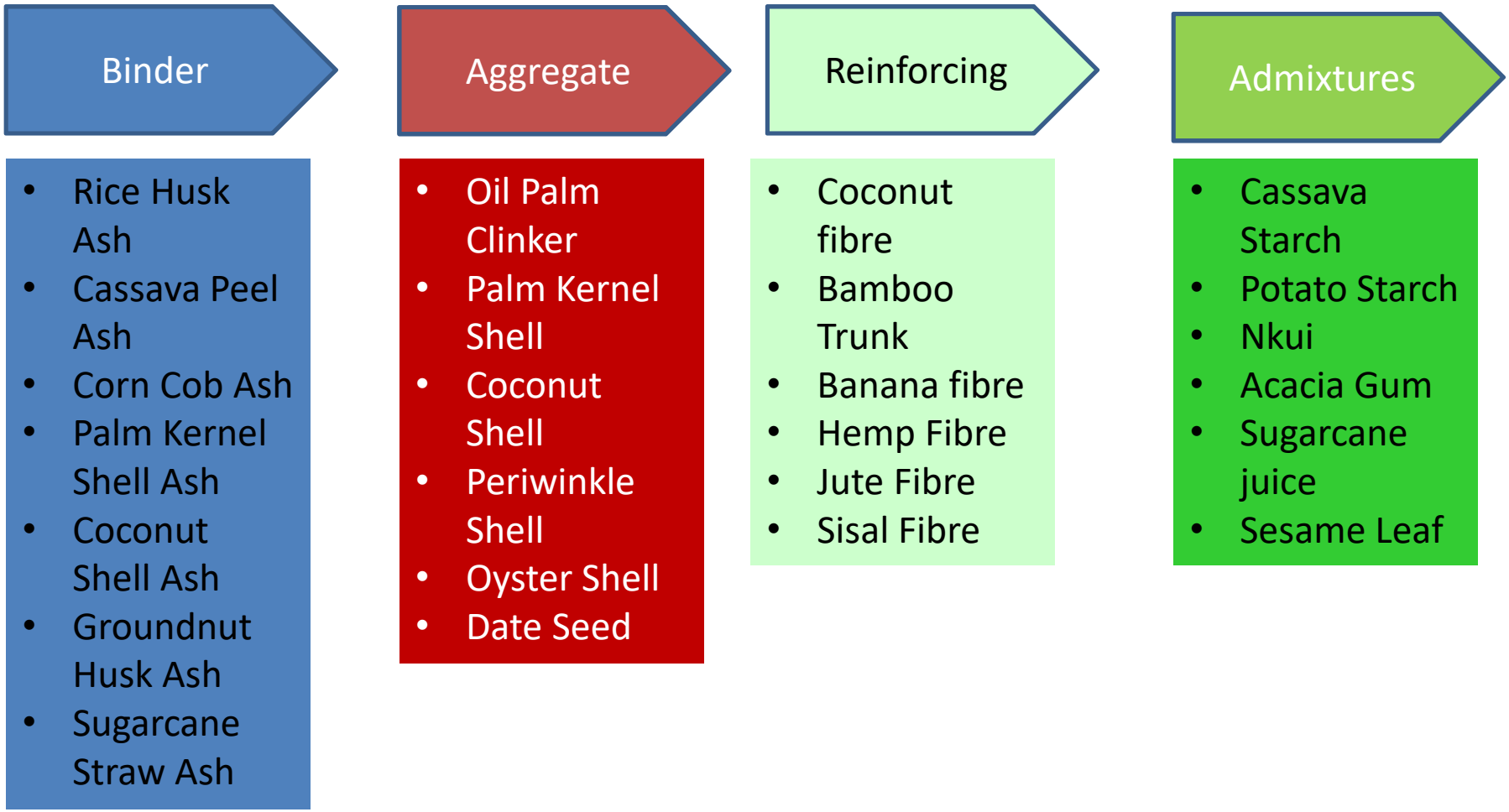
1/4 of world's wood harvest

2/5 of world's material & energy flows

Grant Neser, says. “We cannot afford to keep producing cements with conventional technologies that generate large quantities of carbon dioxide emissions, when we have the option of using more technologically advanced composite cements that offer additional advantages.”

The greener the concrete is, the better

Potentials of Bio-Wastes utilization in concrete



Bio-ashes are similar to Fly Ash, Silica fume

Table 1: The chemical composition of selected ashes of bio-based materials.

Oxides/ LOI	RHA (%) (El-Sayed *et al.* 2006; Ramezanianpour *et al.*, 2009; Bui *et al.* 2005; Zhang and Mohan, 1996; Tashima *et al.*, 2012)	CPA (%) (Salau *et al.*, 2013; Salau and Olonade, 2011; Olonade et al., 2014; Aderemi. 2017; Olutaiwo and Adanikin, 2016)	SCSA (%) (Reddy and Prasad, 2017; Cordeiro et al., 2017; Santos et al., 2015; Moise's Fri´as et al., 2007; Calligaris et al., 2015)	CCA (%) (Kamau et al., 2016; Olonade et al., 2017; Bala et al., 2016; Raheem et al., 2011; Nimityongskul and Daladar. 1995)	CSA (%) (Arum et al., 2013; Nagarajan et al., 2014; Tinga et al., 2016; Utsev and Taku, 2012, Bello, 2017)
SiO_2	65.90 - 92.9	33.2 -58.0	62.43 - 73.4	37.26 -66.38	37.97 - 58.86
Al_2O_3	0.04 - 1.78	7.21 - 12.80	0.70 - 12.53	1.09 - 7.90	9.24 - 24.12
Fe_2O_3	0.16 - 0.43	1.41 - 7.74	0.4 - 10.35	2.78 - 7.40	3.20 - 15.48
CaO	0.55 - 2.40	6.94 - 10.47	3.98 - 12.20	1.80 - 11.57	0.57 - 6.6
MgO	0.35 -3.11	1.33 - 5.02	0.96 - 2.79	2.06 - 3.15	1.03 – 16.2
SO_3	0.10 - 0.69	0.72-4.05	0.11 - 4.10	0.59 - 1.44	0.46 – 0.71
Na_2O	0.02 - 2.46	0.03 - 1.39	0.05 - 0.50	0.04 – 0.90	0.45 – 4.11
K_2O	0.72 - 3.68	4.64 - 20.58	3.05 - 6.98	4.92 - 37.09	0.52 - 3.58
LOI	5.14 - 9.71	4.18 - 16.39	1.03 - 61.60	6.49 - 16.18	9.73 – 11.94
SiO_2+ Al_2O_3+ Fe_2O_3	67.90 - 93.60	46.59 -72.23	73.79 -83.02	41.13 -78.30	71.30 -77.57
Activation (°C)	600 - 750	650 - 700	650 - 800	600 - 750	600 - 750

Olonade and Mohammed, 2019

Cement Replacement Capacity by Bio-wastes in Africa

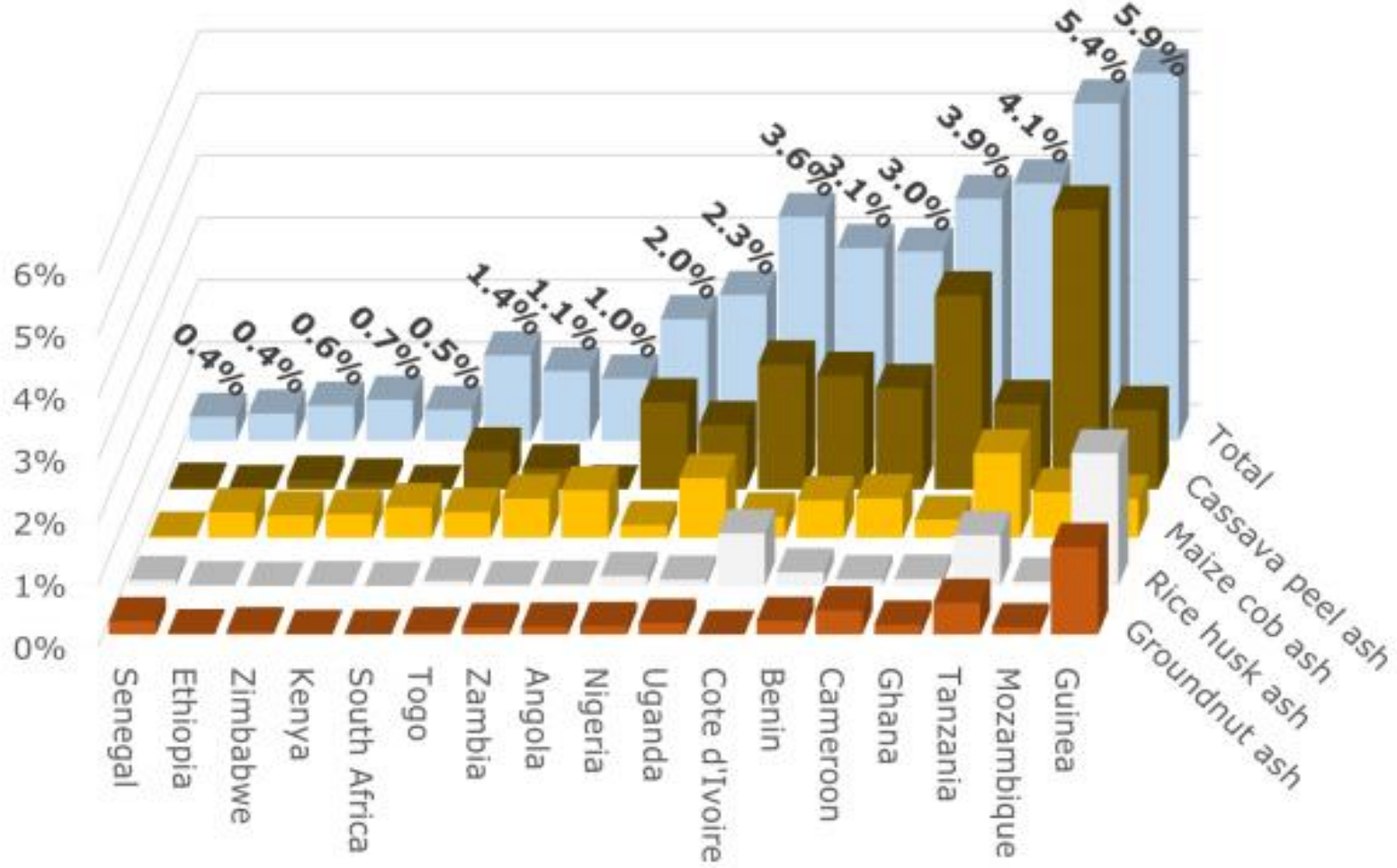


Fig. 3: Cement replacement capacity by ashes of maize cob, cassava peels, rice husks, and groundnut shells (based on total country's cement production capacity in 2015 [41]) – underlying food production data based on [42-45].

Schmidt et al

Case Study of Cassava Peel Ash

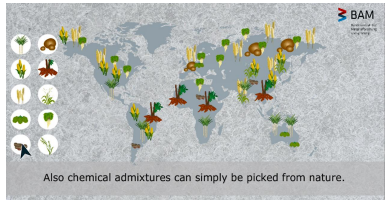
- Food for 500 million people
- Source of food for 80% of people in SSA
- Perennial crop
- Grow almost on all sand
- Global production of (60% in Africa and 35% in Nigeria)

Case study of Local-Care Project

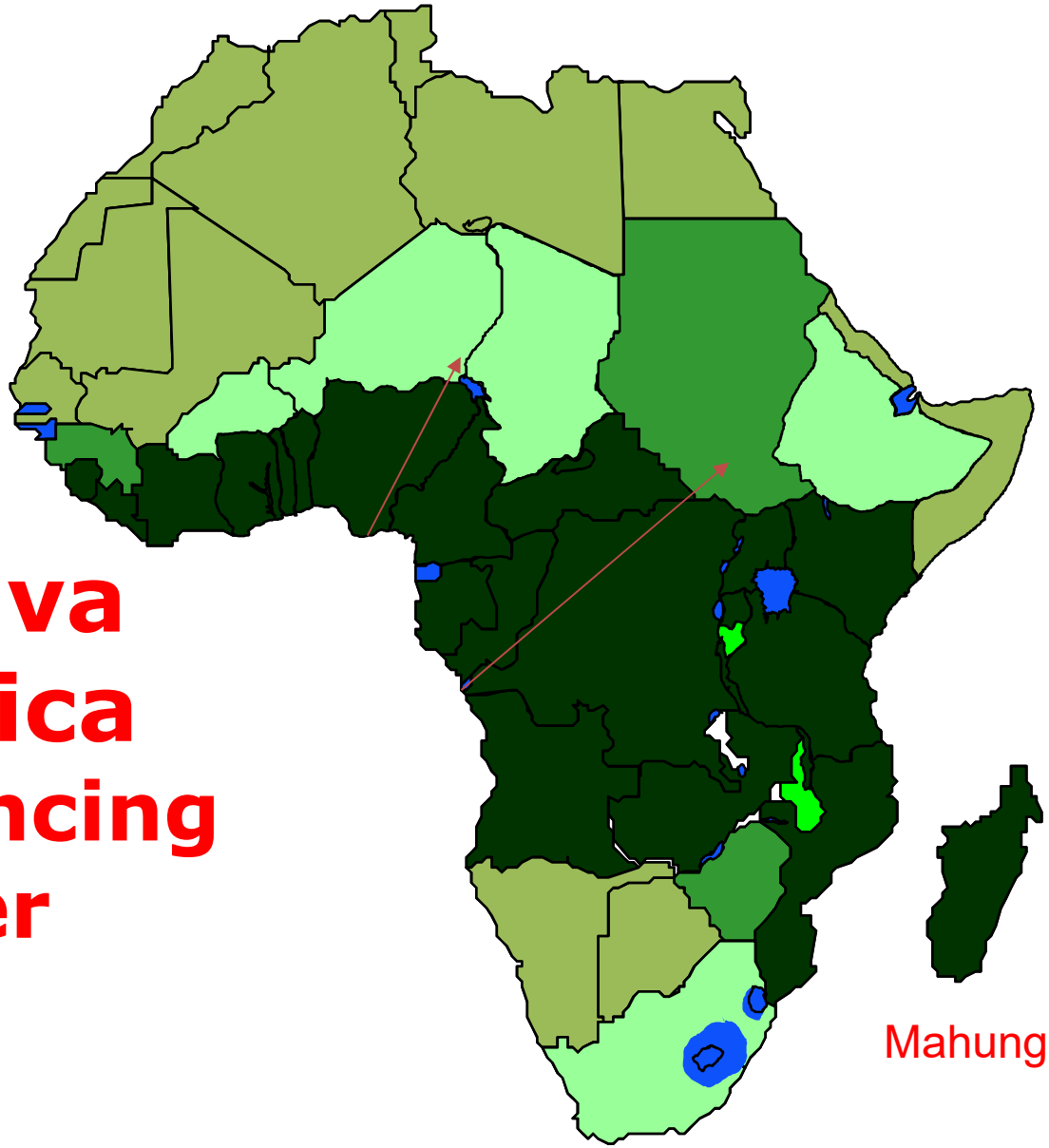
-Low-Carbon Livelihoods - Cassava residues for performance materials (Local-Care)

- German African Innovation Incentive Award (GAIIA)
- BMBF

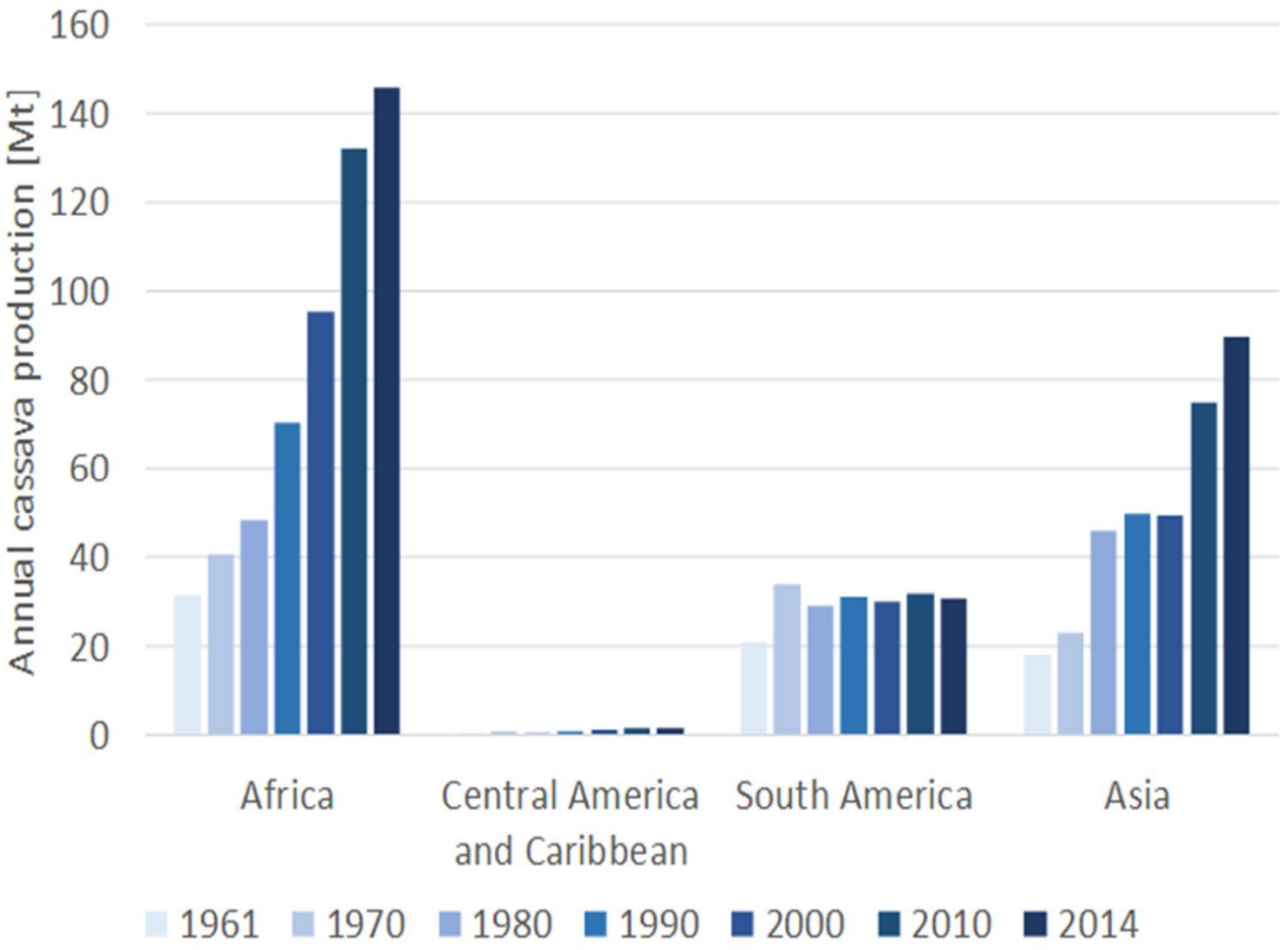
Bundesministerium für Bildung und Forschung



Cassava in Africa (advancing to drier areas)



Mahungu and Anga (2007)



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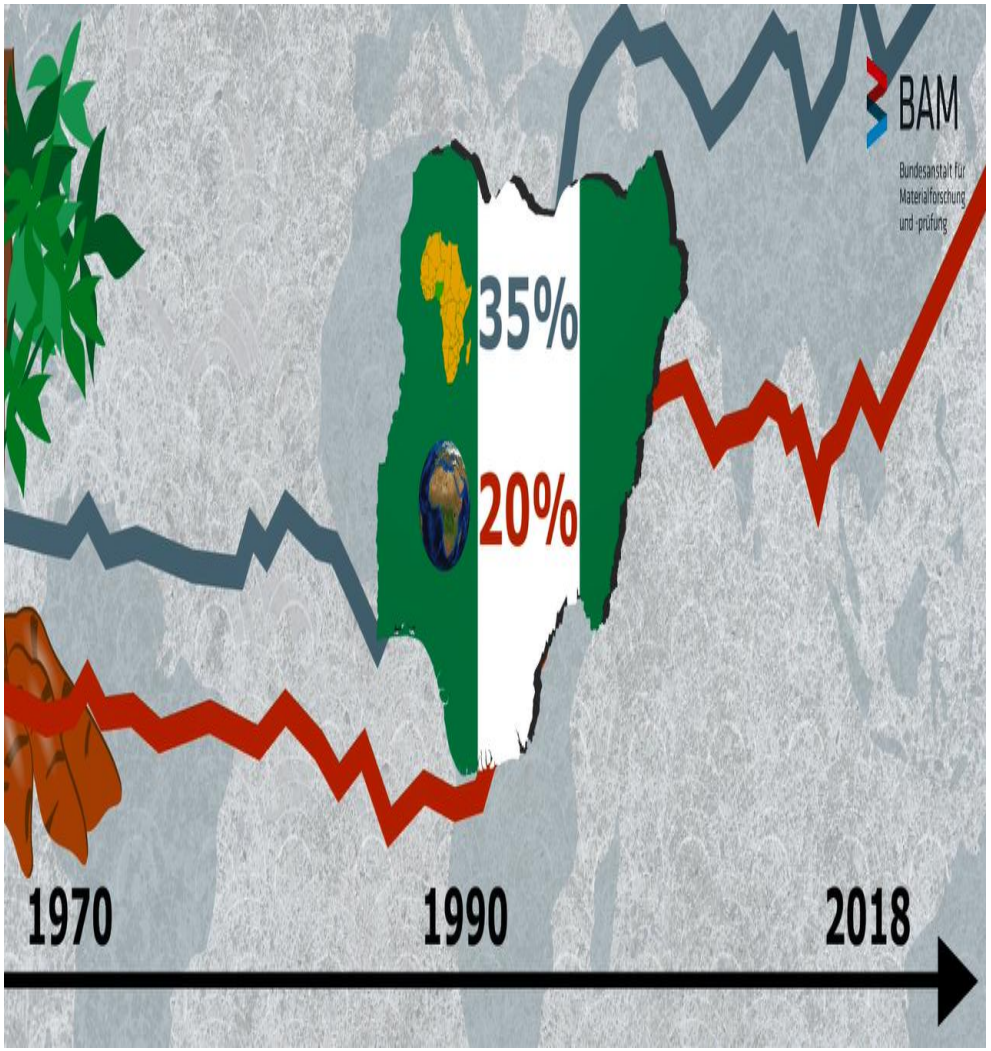

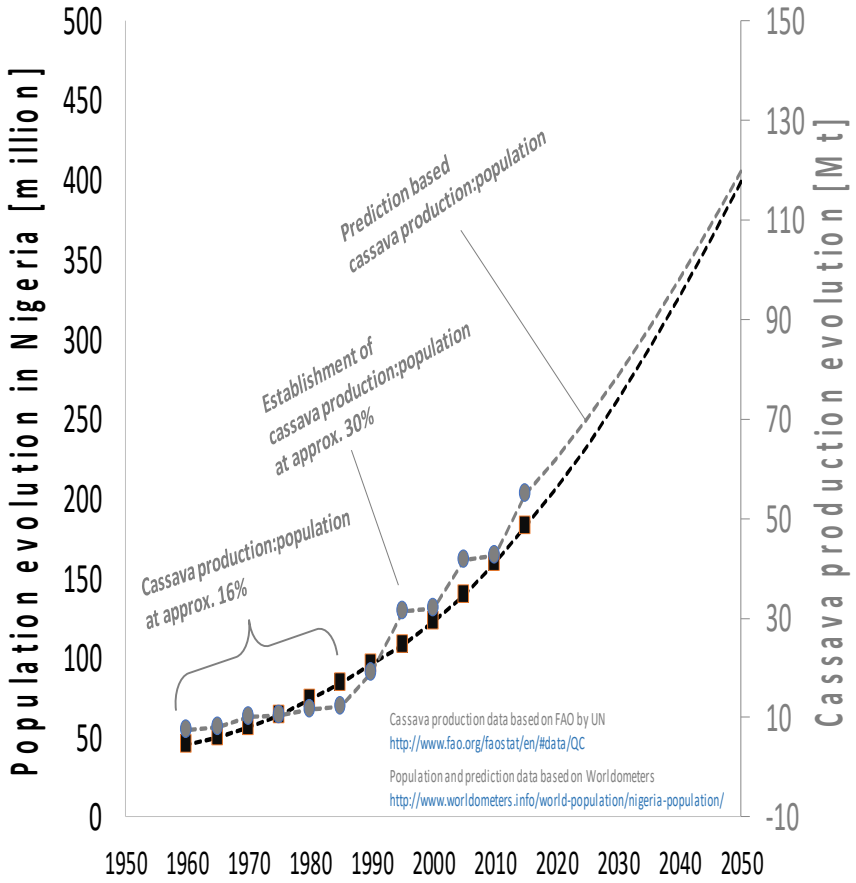

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Cooked Fufu


Cooked Gari (Eba)


Cassava Chinchin


Cassava Fries


Cassava crisps


Composite cassava-wheat bread


Cassava biscuit


Cassava meat pie


Cassava cake

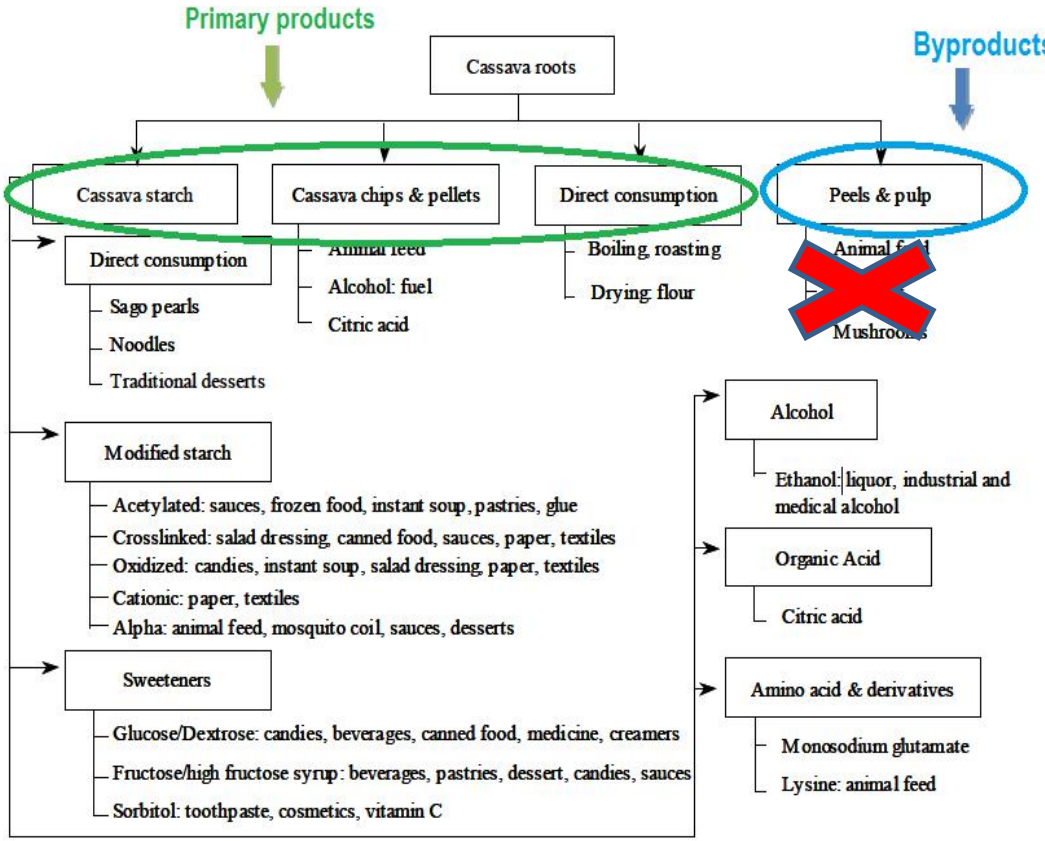

Tapioca pearls


Tapioca flakes

Low tech cassava based products traded in Nigeria

(Shittu, 2018)

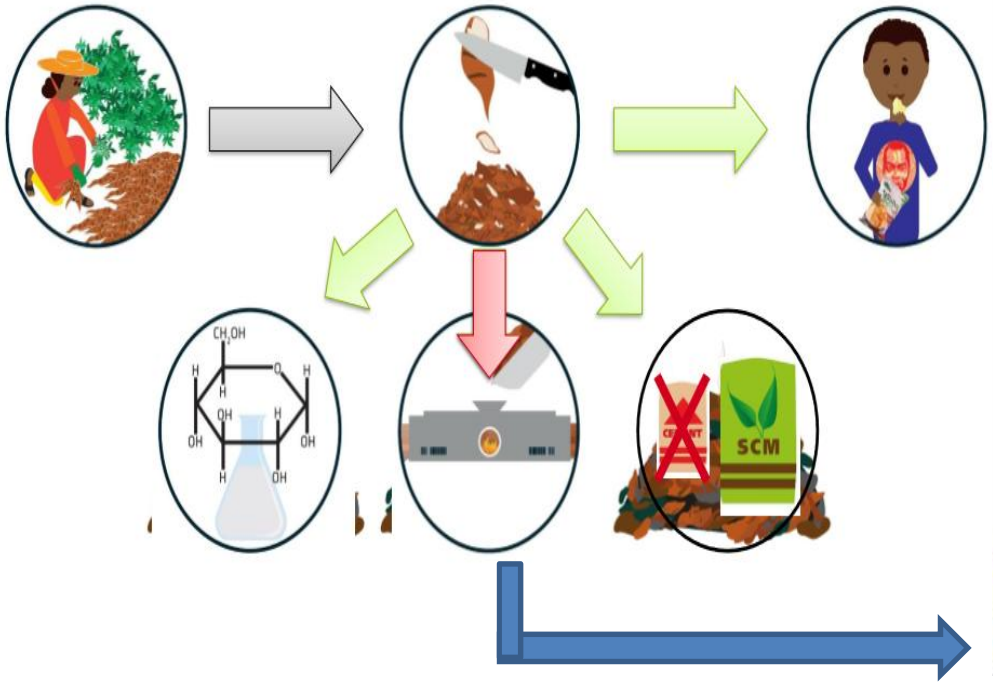
CURRENT CASSAVA VALUE CHAIN



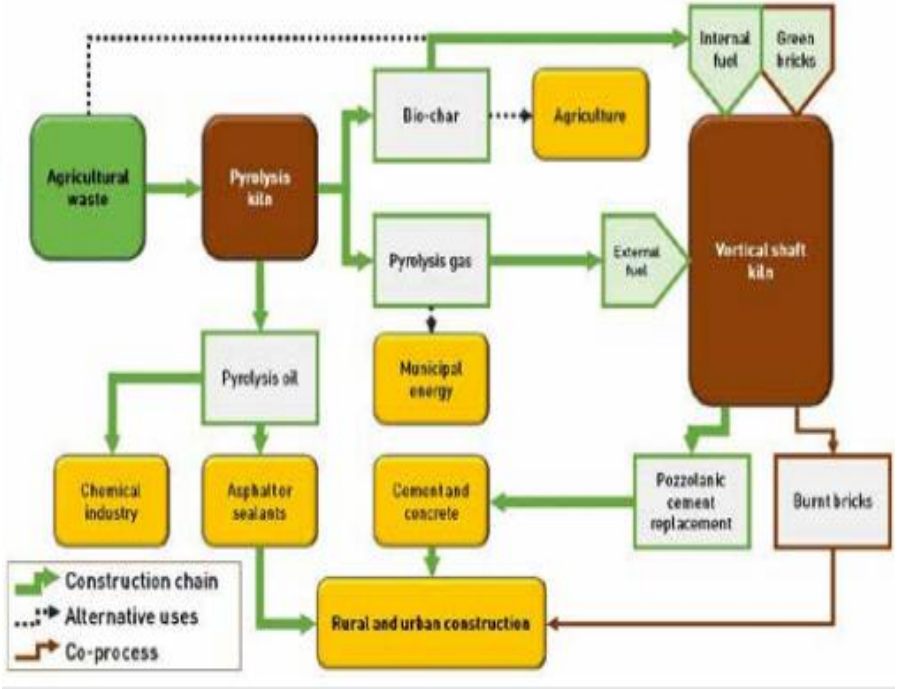
Local-Care

- German African Innovation Incentive Award (GAIIA)
- BMBF

CASSAVA PEELS –A NEW VALUE CHAIN



Low emission processing of bio-wastes



Schmidt et al (2020)

CASSAVA PEELS – Environment and Economy

- **Environment**
  - ✓ Reduced landfill
  - ✓ Reduced pollution
  - ✓ Reduced disamenity effect
- **Economy**
  - ✓ turning the youth bulge into a demographic dividend
  - ✓ Attract more participation
  - ✓ Reduce Rural-Urban migration
  - ✓ Facilitate Africa's Regional & Economic Integration

TC-AMC group 2017 at Cameroun

CASSAVA PEELS – EDUCATIONAL VALUE

- Seminar
- Undergraduate theses
- Integration in the curriculum
- Workshop on bio-concrete
- Capacity development for rural dwellers, mainly women and youth
- Concrete Structure

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Cassava Concrete Structure will be built Soon on UNILAG Campus

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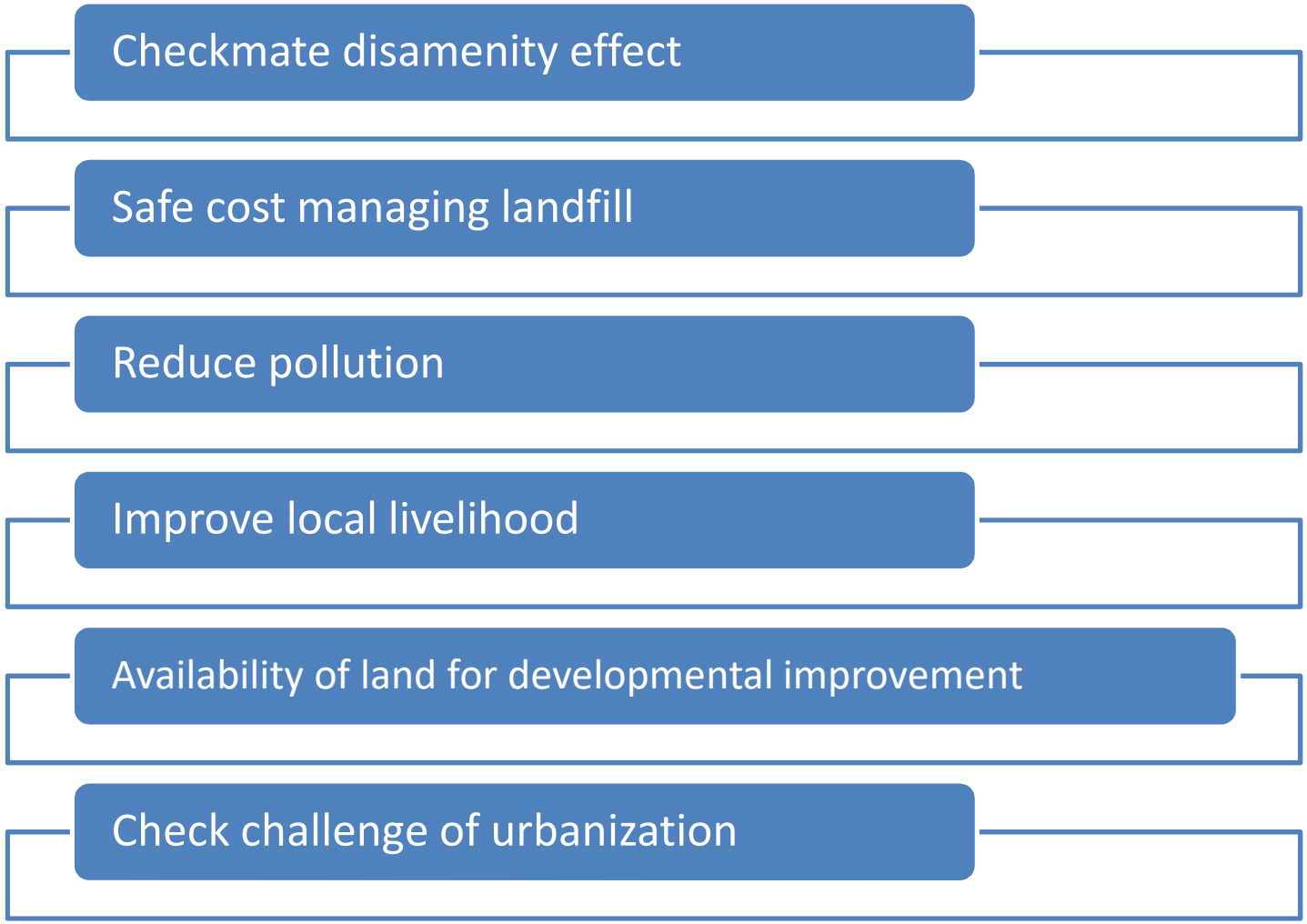
Other Agro-value Cost Saving in Concrete



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RILEM Technical Committees approved by TAC in August 2018.

RILEM TC - AMC: Use of Agro-Based Materials as Cementitious Additions in Concrete and Cement Based Materials

Chair: Prof. Said KENAI (Algeria)

Deputy Chair: Dr. Mike B. OTIENO (Kenyan)

- ✓ This TC will bring together, for the first time, many of African scholars to create a formidable team in the field of concrete;
- ✓ Create awareness on the use of agro-based materials in concrete and cement-based materials;

PACE-PT 2017 at Cameroun

Publications in this regards

Contents lists available at ScienceDirect

Developments in the Built Environment

journal homepage: www.editorialmanager.com/dibe/default.aspx

Sustainable circular value chains: From rural waste to feasible urban construction materials solutions

Wolfram Schmidt [a,*], Michael Commeh [b], Kolawole Olonade [c], Gesine Lenore Schiewer [d], David Dodoo-Arhin [e], Risikat Dauda [c], Shirin Fataei [f], Angela Tetteh Tawiah [g], Fatma Mohamed [h], Mareike Thiedeitz [i], Nonkululeko W. Radebe [j], Andreas Rogge [a]

RILEM Technical Letters (2020) 5: 63-74
https://doi.org/10.21809/rilemtechlett.2020.112

Innovation potentials for construction materials with specific focus on the challenges in Africa

Wolfram Schmidt[1], Mike Otieno[2], Kolawole Adisa Olonade[3], Nonkululeko W. Radebe[4], Henri van Damme[5], Patience Tunji-Olayeni[6], Said Kenai[7], Angela Tetteh Tawiah[8], Kuukuwa Manful[9], Akeem Akinwale[3], Rose N. Mbugua[10], Andreas Rogge[1]

Green urban development creates rural employment perspectives

By creating novel value chains from agro-waste for construction materials, rural areas can significantly benefit from urban growth. At the same time, opportunities develop for greener and more sustainable construction in Africa's expanding cities. Female farmers could especially benefit from these new value chains.

By Wolfram Schmidt, Kolawole A. Olonade, Nonkululeko W. Radebe, Vincent Ssekamatte and Faudhia Zando

ARID ZONE JOURNAL OF ENGINEERING, TECHNOLOGY & ENVIRONMENT
AZOJETE, September 2019. Vol. 15(3) 598-610
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Print ISSN: 1596-2490, Electronic ISSN: 2545-5818
www.azojete.com.ng

ORIGINAL RESEARCH ARTICLE

MECHANICAL AND MICROSTRUCTURAL CHARACTERIZATION OF ALKALI-ACTIVATED COCONUT SHELL ASH MORTAR

K. A. Olonade[1*] and T. Bello[2]

NIGERIAN JOURNAL OF TECHNOLOGICAL DEVELOPMENT, VOL. 16, NO. 3, SEPTEMBER 2019

Review of Selected Bio-Wastes as Potential Materials for Alkali-Activation for Cement-Based Products

K. A. Olonade[1*], H. Mohammed[2]

RILEM Technical Letters (2018) 3: 124-128
DOI: http://dx.doi.org/10.21809/rilemtechlett.2018.83

Plant based chemical admixtures – potentials and effects on the performance of cementitious materials

Wolfram Schmidt [a*], Ines L. Tchetgnia Ngassam [a], Kolawole A. Olonade [b], Rose Mbugua [c], Hans-Carsten Kühne [a]

Lecture delivered Online on Friday, 16th February, 2021

Where do we go from here?

- Reposition institutions to serve their mandate
- Strengthening Intra Africa Research collaboration
- Global Network for Research and Education
- Domesticate African research for development
- Strengthen Linkages between other tertiary providers, industry, and other research users. Growth and Innovation Pilots
- Promote evidence-based solutions to today's most pressing developmental challenges
- Encourage participation in international organisations

Conclusion

- Bio-wastes are available in abundance, especially in Africa
- Greater opportunities are abound in the bio-wastes
- Utilizing bio-wastes guaranteed sustainable construction
- Government policy for utilizing bio-wastes will go along way in public acceptance
- Regional and international collaboration are required for meaningful achievement

ACKNOWLEGEMENT

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BAM
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