ZECURA

Zero-Emission Concepts for Urban Resilience in selected African cities

Diagnostic Summary of Travelling University NM-AIST

29.09.2022 | Arusha

IfaS Institut für angewandtes Stoffstrommanagement

Umwelt-Campus Birkenfeld | Hochschule Trier

Federal Ministry of Education and Research

BMBF/ZECURA

*Z*ero *E*mission *C*oncepts for *U*rban *R*esilience in selected *A*frican cities

Federal Ministry of Education and Research

IfaS Institut für angewandtes Stoffstrommanagement

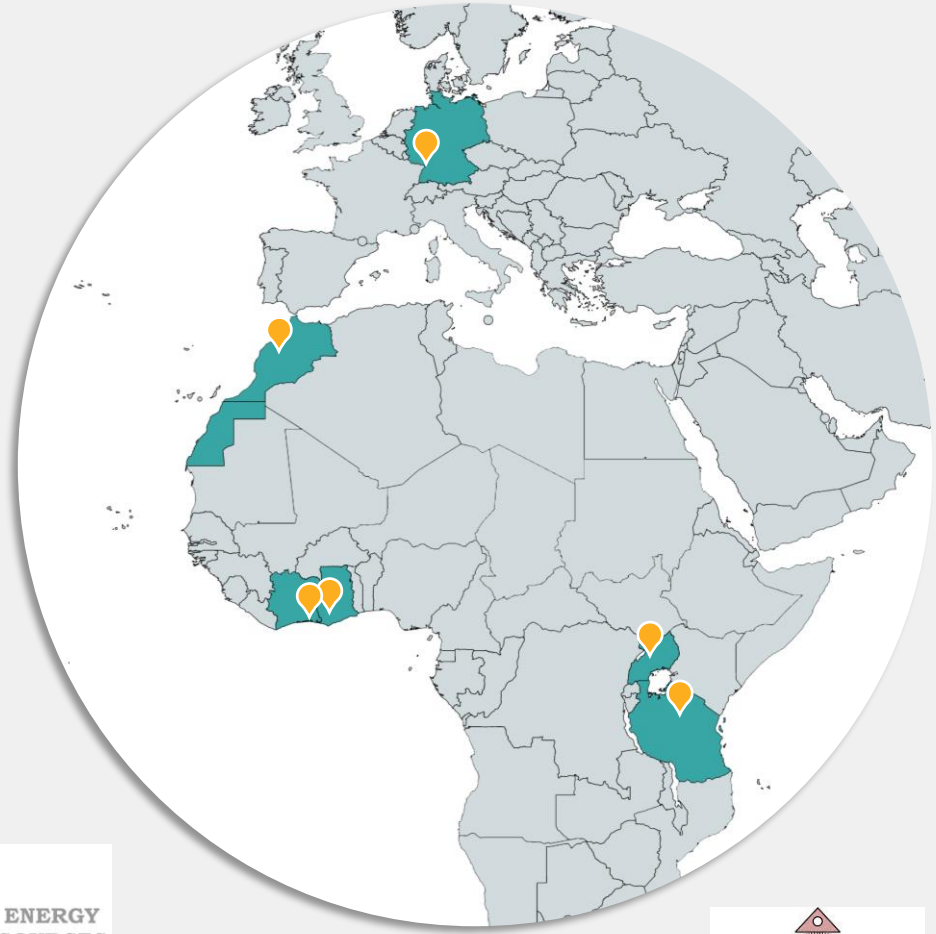
Umwelt-Campus Birkenfeld | Hochschule Trier

ZECURA

The Consortium

Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER

جامعة الأخوين
ⵜⴰⵙⴷⴰⵡⵉⵜ ⵏ ⵉⵅⴰⵡⵉⵏ
AL AKHAWAYN UNIVERSITY



INTERNATIONAL UNIVERSITY OF GRAND-BASSAM
Excellence • Accountability • Opportunity

GULU UNIVERSITY
FOR COMMUNITY TRANSFORMATION

UNIVERSITY OF ENERGY AND NATURAL RESOURCES

The Nelson Mandela African Institution of Science and Technology
Arusha
Kilimanjaro
2009
Academia for Society and Industry

ZECURA: what is this about?

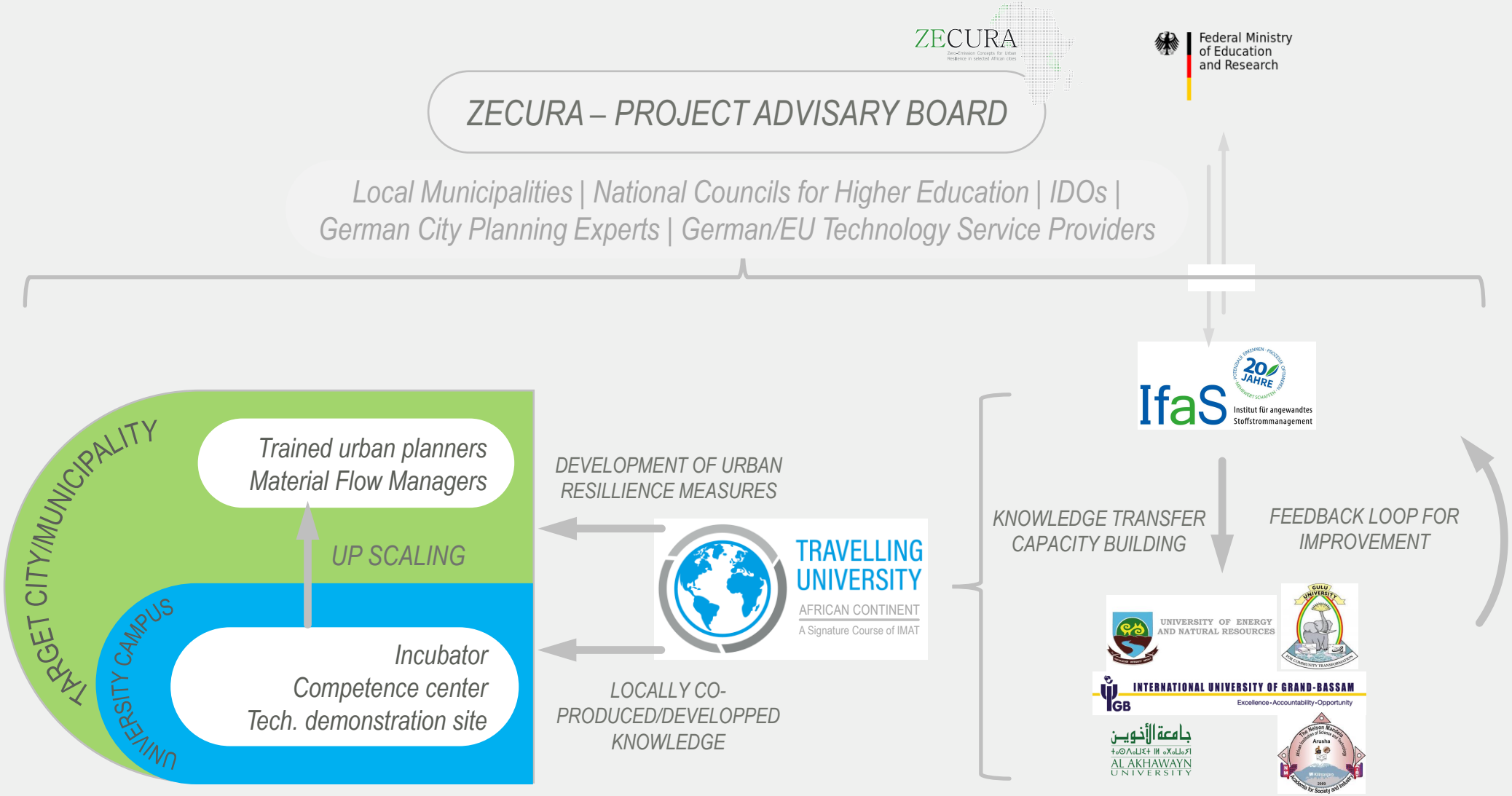
An initiative for *resilient cities*…

"[...] collaborative development and transfer of knowledge to support the transition towards resilient water, energy, food and waste management services in selected African cities enabling communities to achieve a sustainable, low-carbon future while improving the service quality"

ZECURA: technical summary

Item	*Description*
Funding Body	BMBF/Bundesministerium für Bildung und Forschung
Recipient Institution	Institute for Applied Material flow Management/Trier University of Applied Sciences, DE
Partner Countries & Institutions	AUI, MA IUGB, CI UENR, GH NM-AIST, TZ GU, UG
Project Duration	Three years (2021–2023)/144 man-months
No. of Work Packages	Three
No. of TUs	Five (SEP—2021 [AUI]; FEB [IUGB], APR [UENR], SEP [NM-AIST], OCT [GU]—2022)

Linking ZE-C to resilient cities



Visit the website…

https://zecura.info

Many sites to visit!

Preparation!

Dry Run!


Arusha's green belt
800 m of banana plants
45,000 km²
1 km
BANANA PLANTATION
ITEM | UNIT | AMOUNT
Spacing | m² | 6
Available area | km² | 36,000
Qty. banana plants (potential) | | 6.3 Billion
Yield per plant | kg/a | 40
Potential income generated | TZS | 525 Trillion
Potential jobs created | | 6,300,000
Labour costs | TZS | 1.9 Trillion
Gross Margin (only including labour cost) | TZS | 523 Trillion
| USD | 237,777,273
Mt Kilimanjaro
2009
Academia for Society and Industry
NM-AIST
The Nelson Mandela African Institution of Science and Technology
Arusha

Keep life interesting all the time!

Impressions

ASANTENI SANA!

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ZECURA Grand Finale

Traveling University as a catalyst for resilient city development

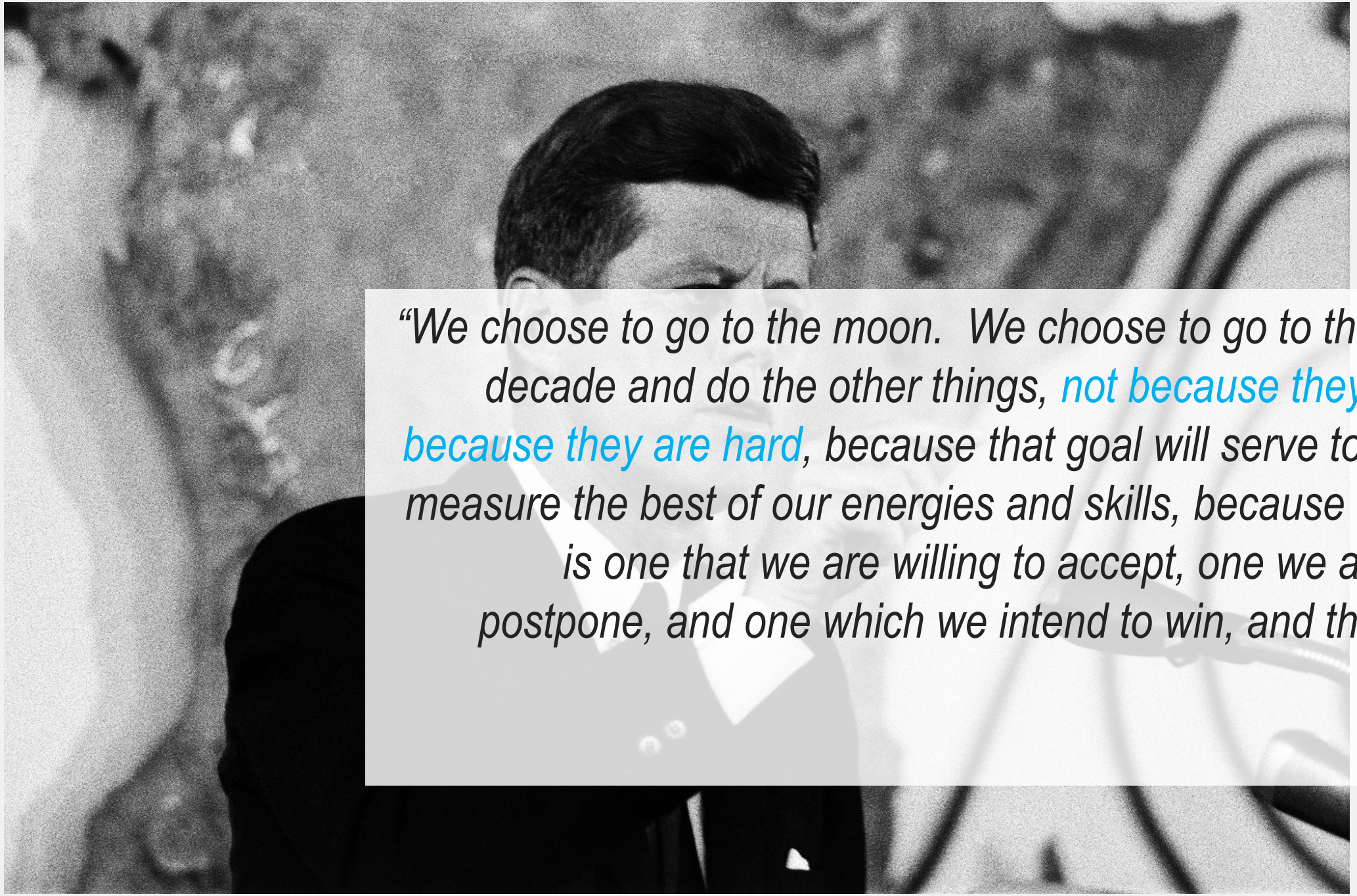
29.SEPTEMBER.2022 | RANAHANSA **DASANAYAKE** | ARUSHA, TANZANIA

Federal Ministry of Education and Research

IfaS Institut für angewandtes Stoffstrommanagement

Umwelt-Campus Birkenfeld | HOCHSCHULE TRIER

ZECURA



"We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too."

JFK,
RICE UNIVERSITY,
SEP. 1962

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The Endeavor

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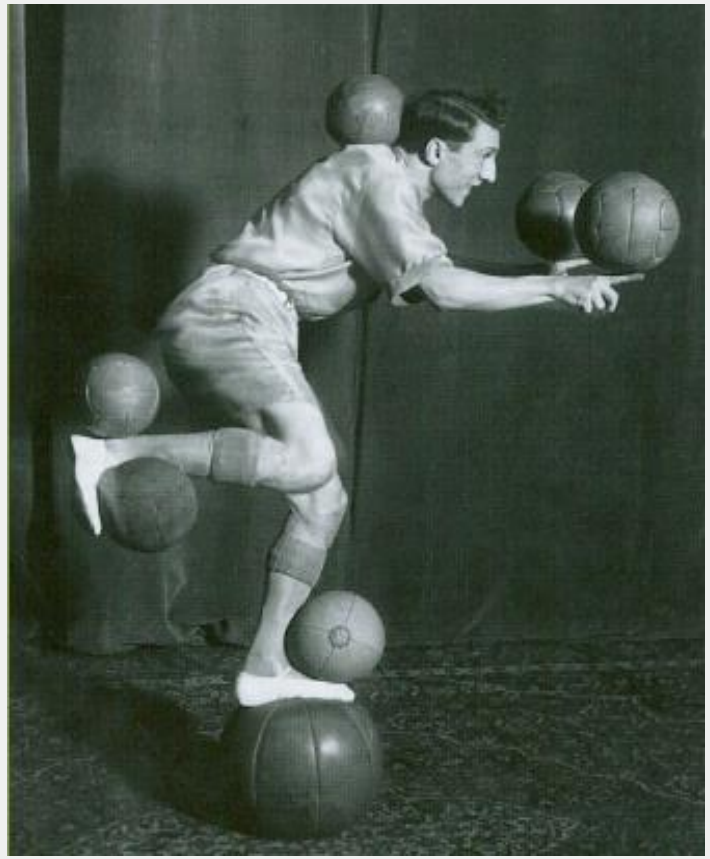
TU Challenges:
get to know…

- Understanding clients' needs
- Understanding the system
- Get to know the stakeholder

IMAGE SOURCE: Google Imagery, (2019)

TU Challenges: work-work-balance



- Time, tasks, teams
- Contingency planning
- Concentrate on results not on being busy

IMAGE SOURCE: Google Imagery, (2019)

TU Challenges: importance of partnership

- Get together as a team
- Faith and trust
- Maintain the team spirit

IMAGE SOURCE: Google Imagery, (2019)

TU Challenges: get your bearing

- Navigation is the key
- No map, no chance
- What is the red line?

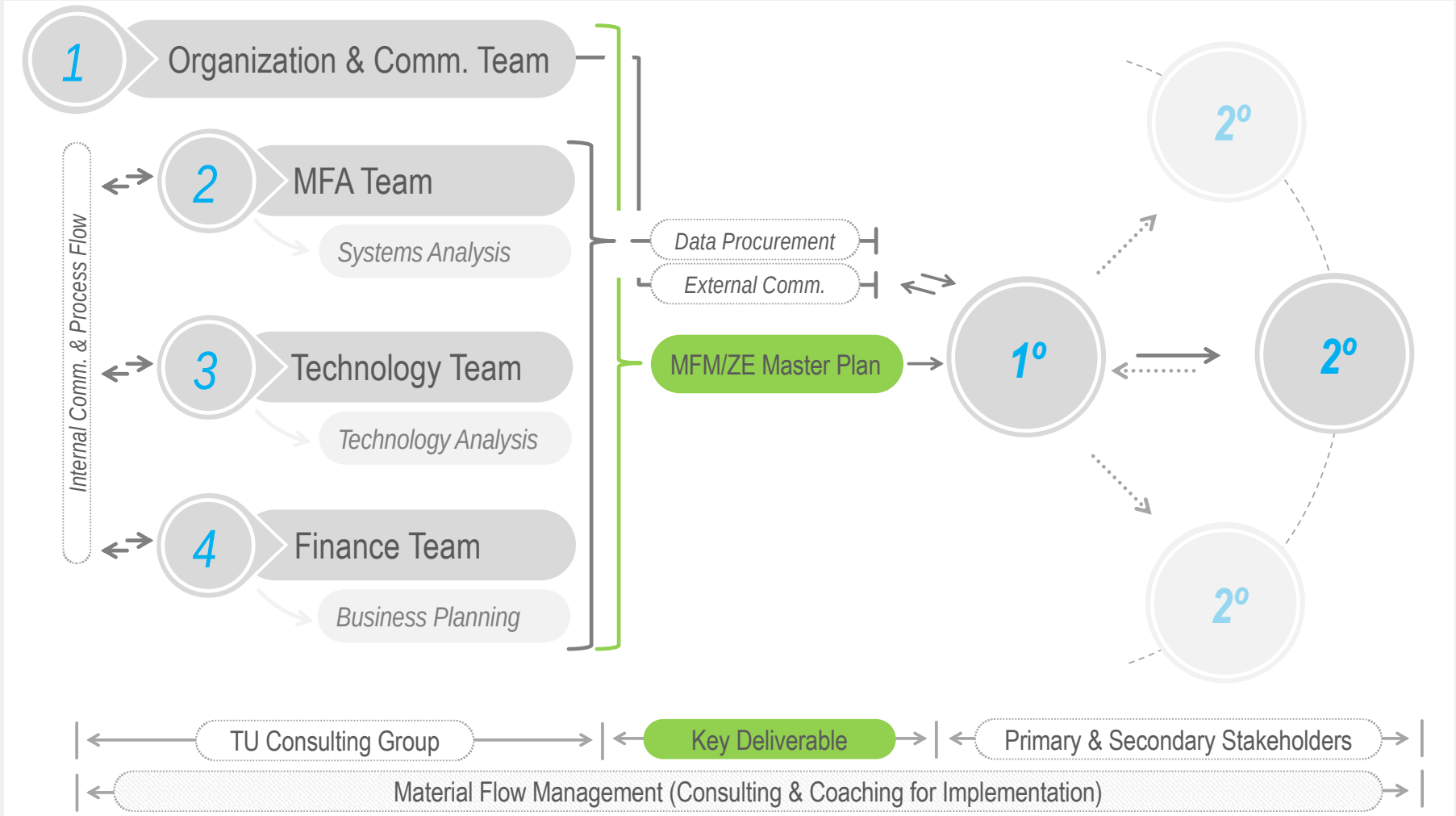
IMAGE SOURCE: Google Imagery, (2019)

TU Challenges: take a deeper look

- Curiosity
- Practical
- Hands-on

IMAGE SOURCE: Google Imagery, (2019)

Travelling University: mechanism of delivery



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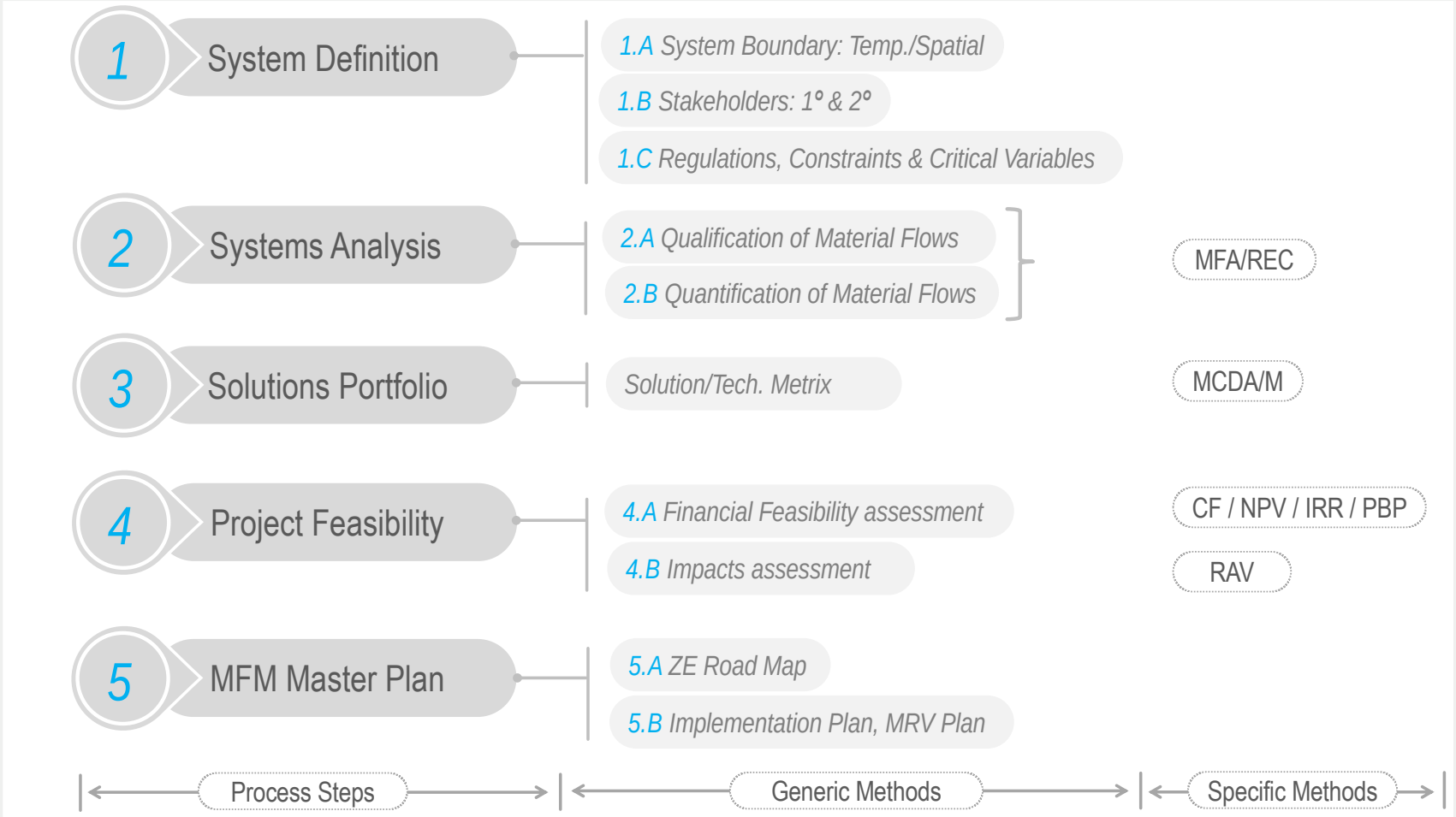
Travelling University: mechanism of delivery



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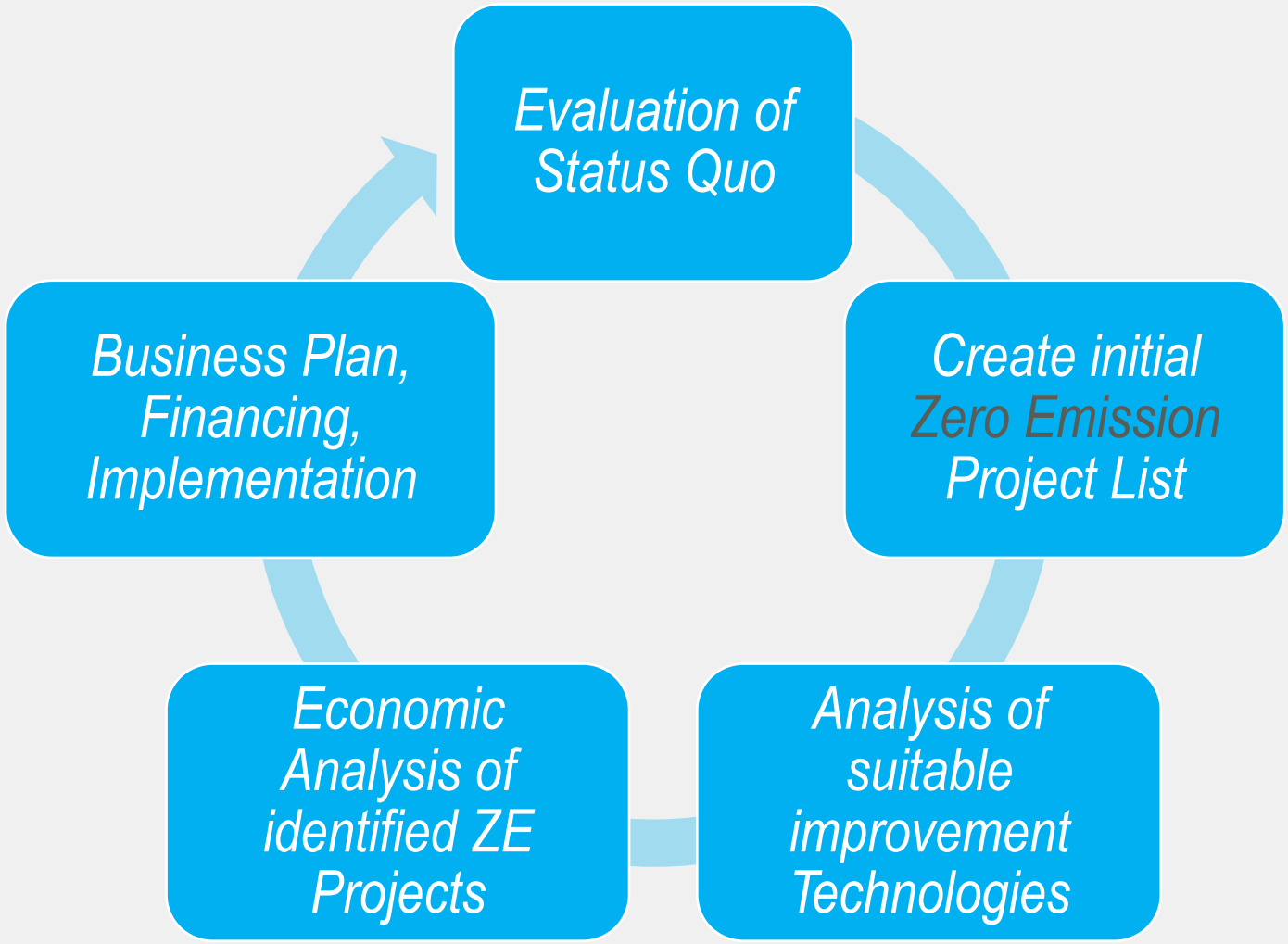
MFA: systemic method



We've been around the world

ZECURA: what is this about?

An initiative for *resilient cities*…

"[...] collaborative development and transfer of knowledge to support the transition towards resilient water, energy, food and waste management services in selected African cities enabling communities to achieve a sustainable, low-carbon future while improving the service quality"

What SDGs we target?

SOURCE: https://sustainabledevelopment.un.org/sdgs

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Transition to climate neutrality

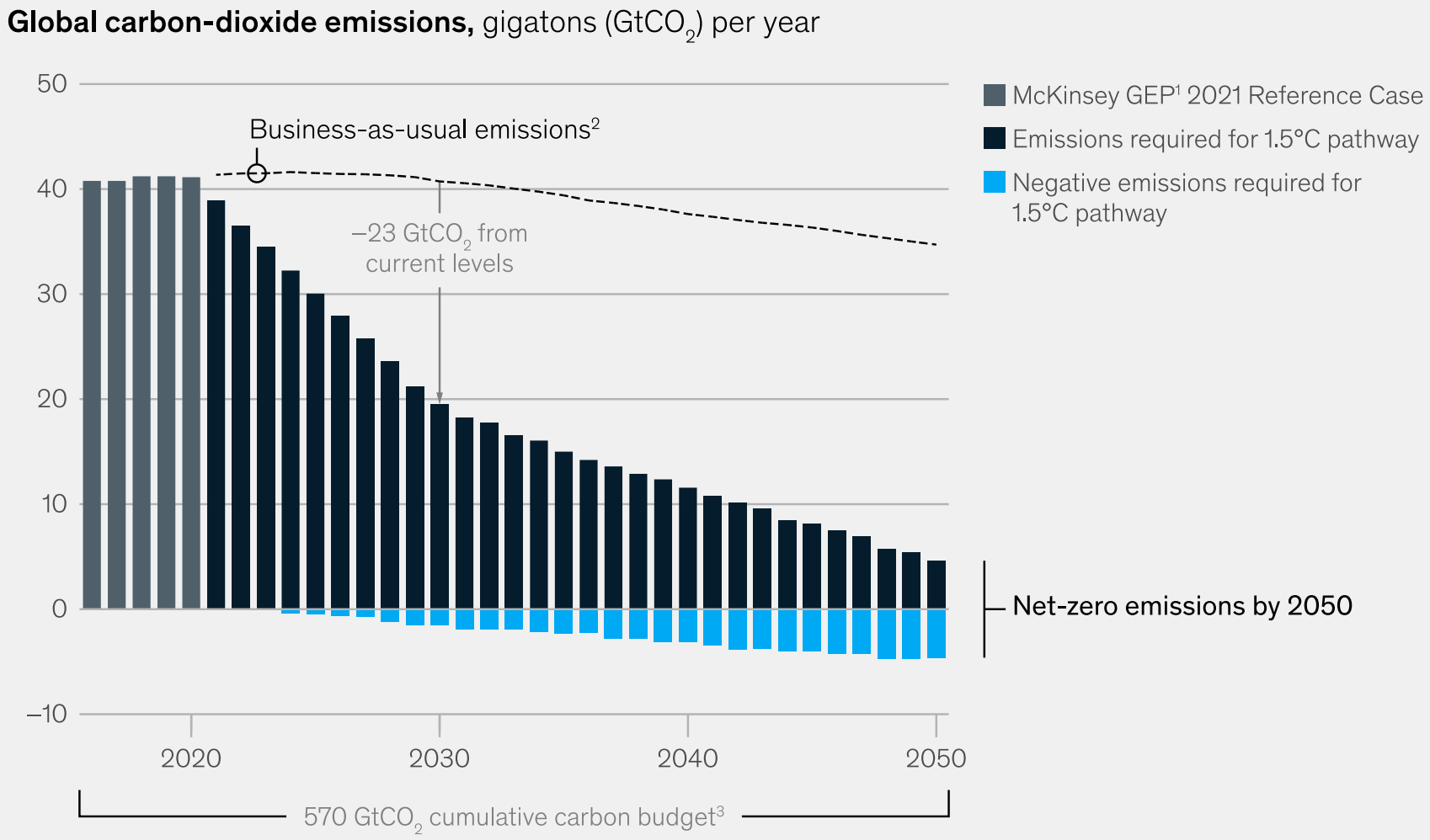

IMAGE SOURCE:
https://www.mckinsey.com/capabilities/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge, (2022)

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Transition to climate neutrality

In Scenario 1.5ºC *strict emission reductions and carbon removals* are required!

Need for 100% renewable (electricity, heat, mobility)

Massive investments in RE and Circular Economy and new business concepts necessary

Africa is a prime spot to leapfrog green development

Carbon certificate could leverage investments

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SDG value creation by climate actions (e.g. clean cooking stove Uganda)

Gold Standard
improved cookstoves

INVESTMENT MADE	SDG 8 Decent work	SDG 1 No poverty	SDG 3 Good health	SDG 13 Climate action	VALUE CREATED
$5,000	$1,500	$46,500	$27,500	500 tCO_2	$75,500
500 VERs at $10/VER	Manufacturing + distribution of efficient cookstoves	Financial savings from reduced fuel use	Reduced respiratory illnesses and death	Tonnes of Greenhouse Gases mitigated	

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IMAGE SOURCE: Gold Standard

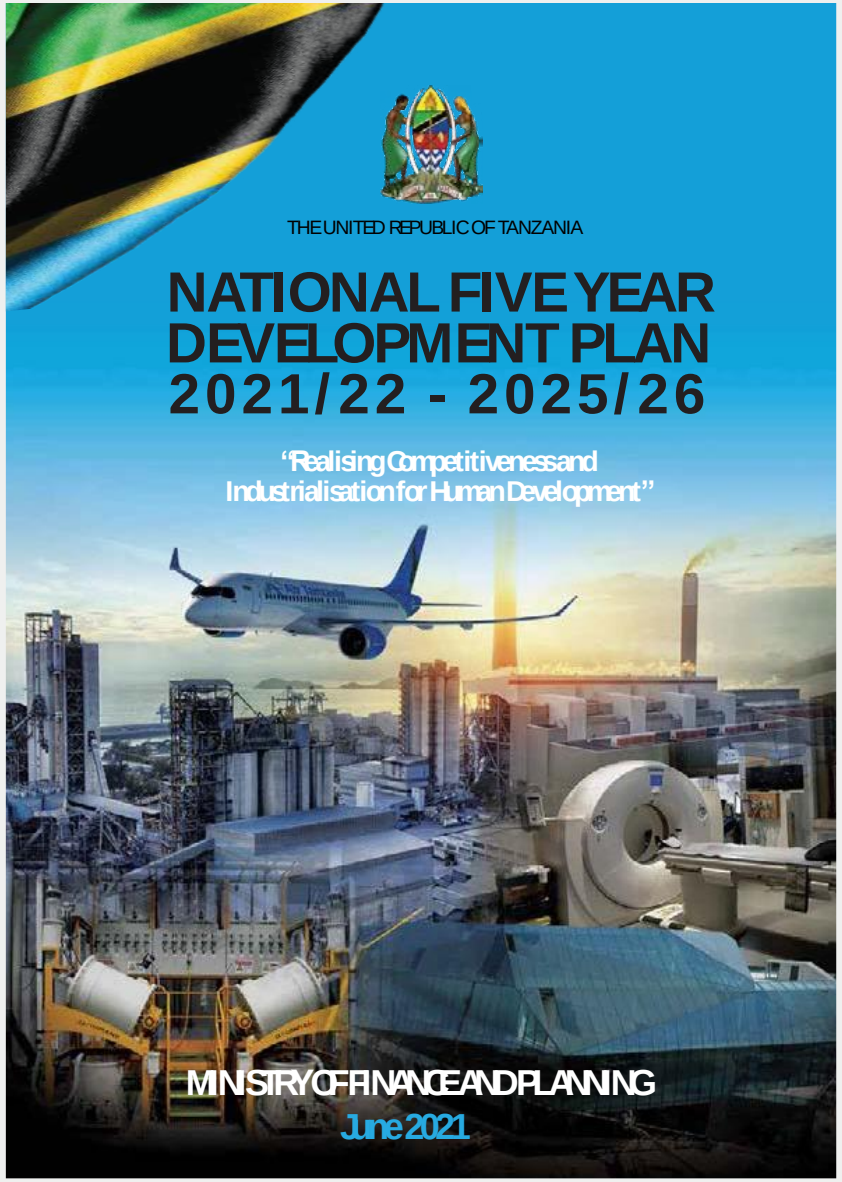
Supporting the vision(s)

"The three principal objectives of the Vision 2025:

a.) *achieving quality & good life for all*; b.) good governance & the rule of law; c.) *building a strong & resilient economy* that can effectively withstand global competition"

IMAGE SOURCE: Google Imagery, (2022)

Supporting the vision(s)



"To strengthen *capacity building* in the areas of *science, technology and innovation* to enhance competitiveness and productivity in all sectors especially the productive, manufacturing and services sectors to enable Tanzanians to *benefit from the opportunities available within the country*"

2nd specific objective of the FYDP III

IMAGE SOURCE: Google Imagery, (2022)

#1 Greenest university campus

ECB is a living laboratory

100% renewable heat supply based on waste wood, biogas (co-generation) and solar thermal

ECB is a living laboratory

100% renewable electricity supply based on cogeneration (heat and electricity) & photovoltaic

ECB is a living laboratory

100% renewable cooling system based on geothermal, biomass and solar adsorption chilling

ECB is a living
laboratory

EE/RE

State-of-the art energy and resource efficiency technologies and strategies in place

ECB & industrial symbiosis

- 100% Private company investments (30 million EUR CAPEX) in Public-Private-Partnership [PPP]
- 100% Regional Added Value [RAV] (35 new jobs, GHG abatement, long-term energy security)

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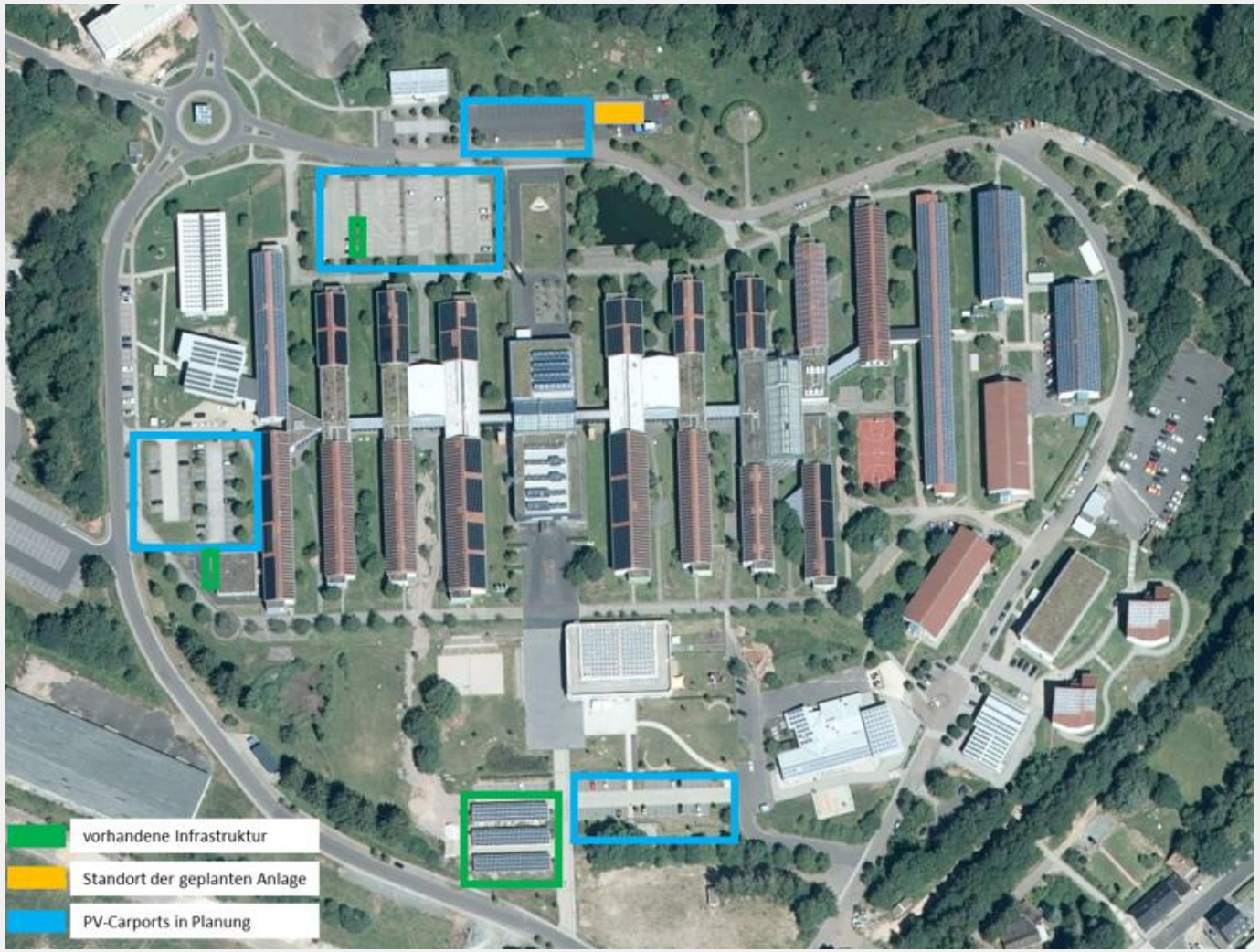
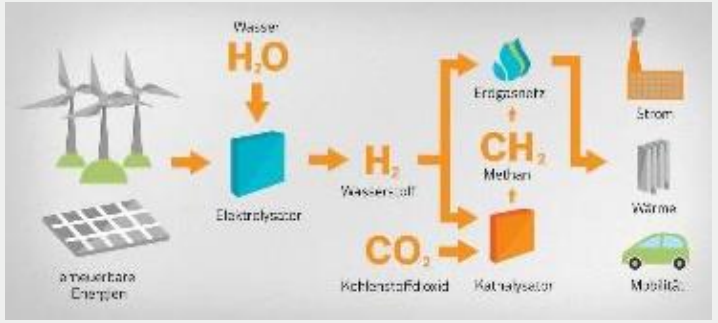
Zero Emission Building

Powered by the sun

Green hydrogen





ZECURA

An institute for change…

Our areas of expertise

International Project Management

Study and Qualification

Fundraising

Biomass and Cultural Landscape Development

Energy Effciency & Renewable Energies

E-mobility

Material Flow Management and Zero Emission

PR – Communication and Participation

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IMAT masters

IMAT
INTERNATIONAL
MATERIAL FLOW MANAGEMENT

Joint education, research &
technology transfer for Circular Economy

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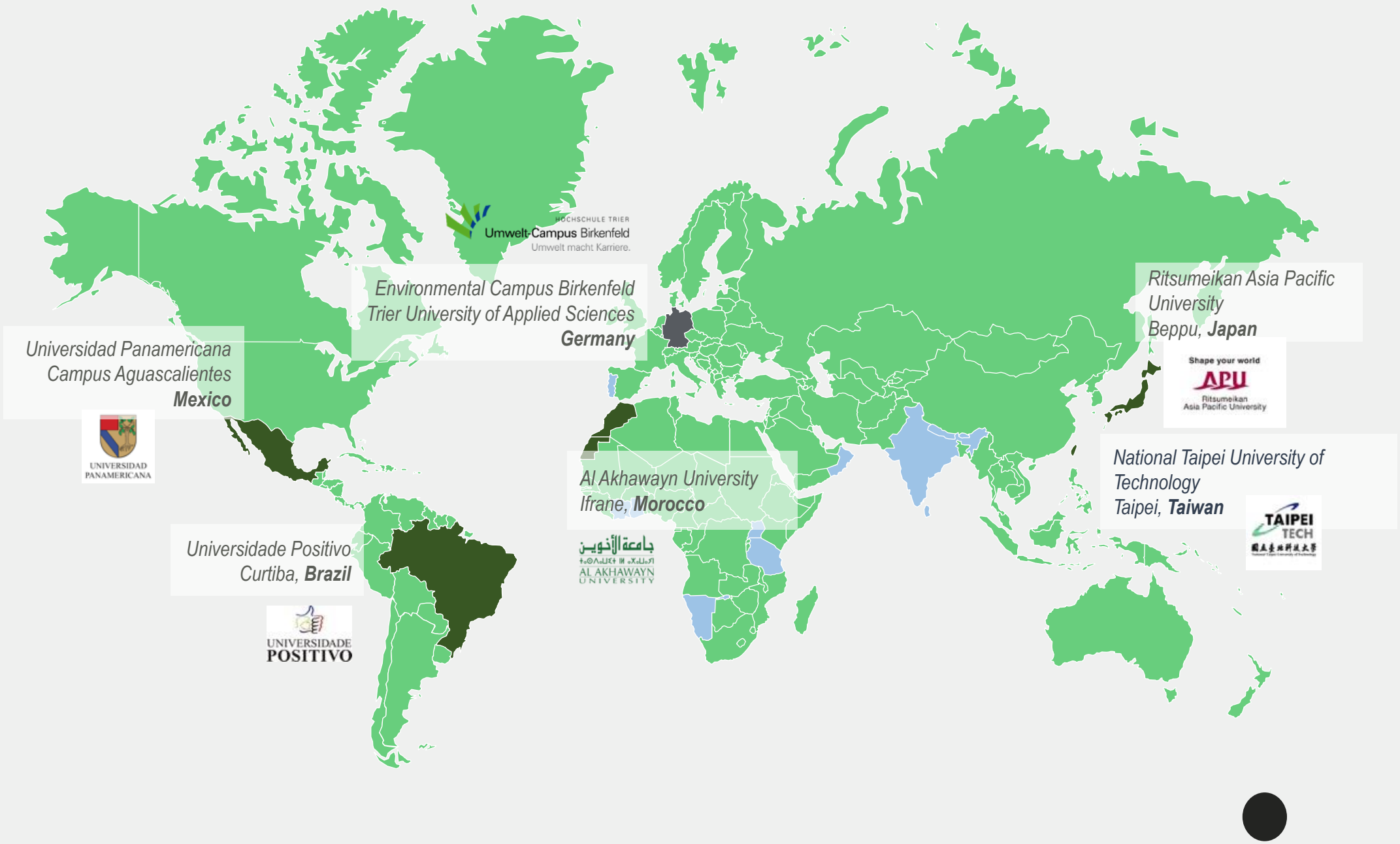
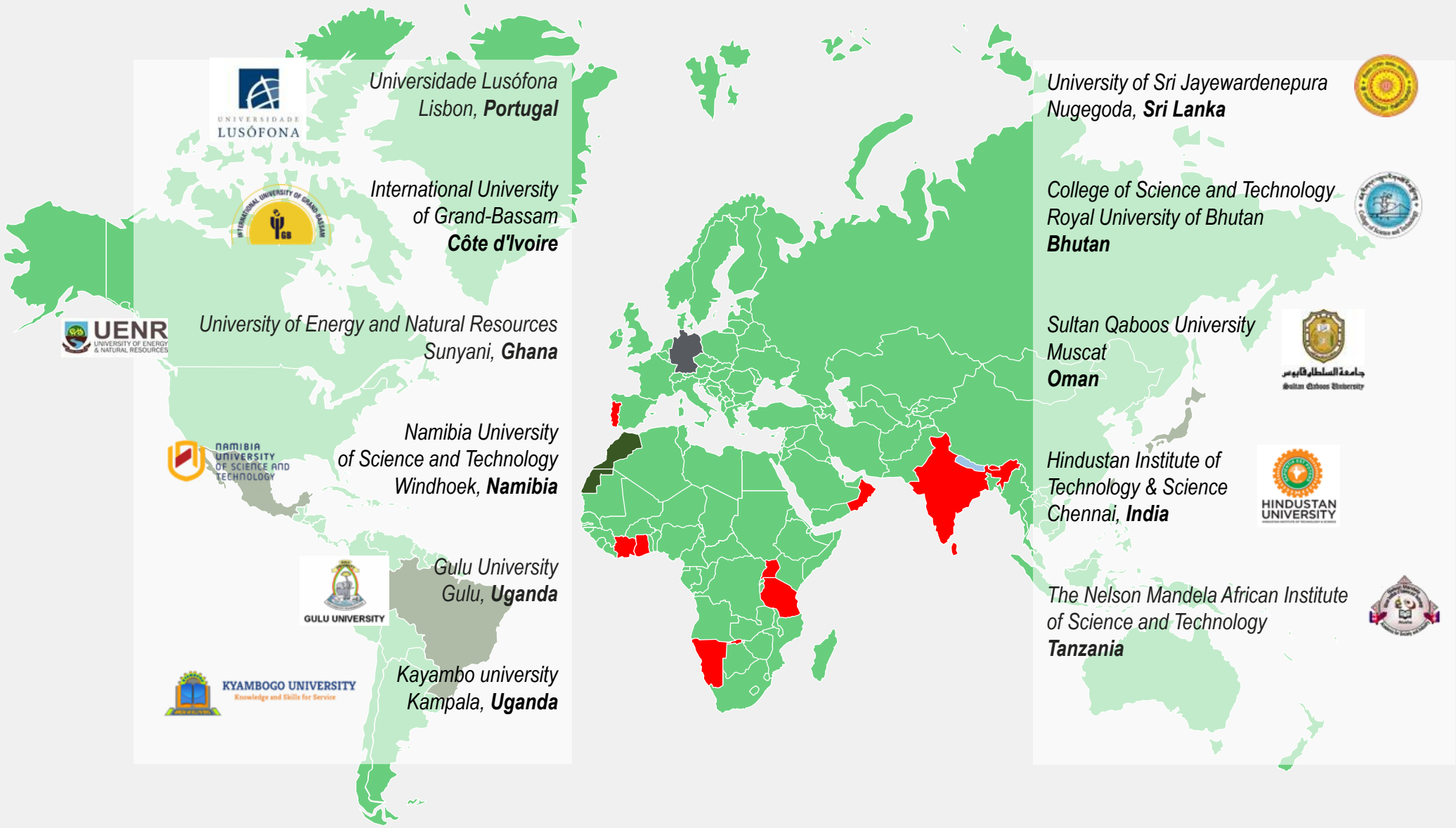
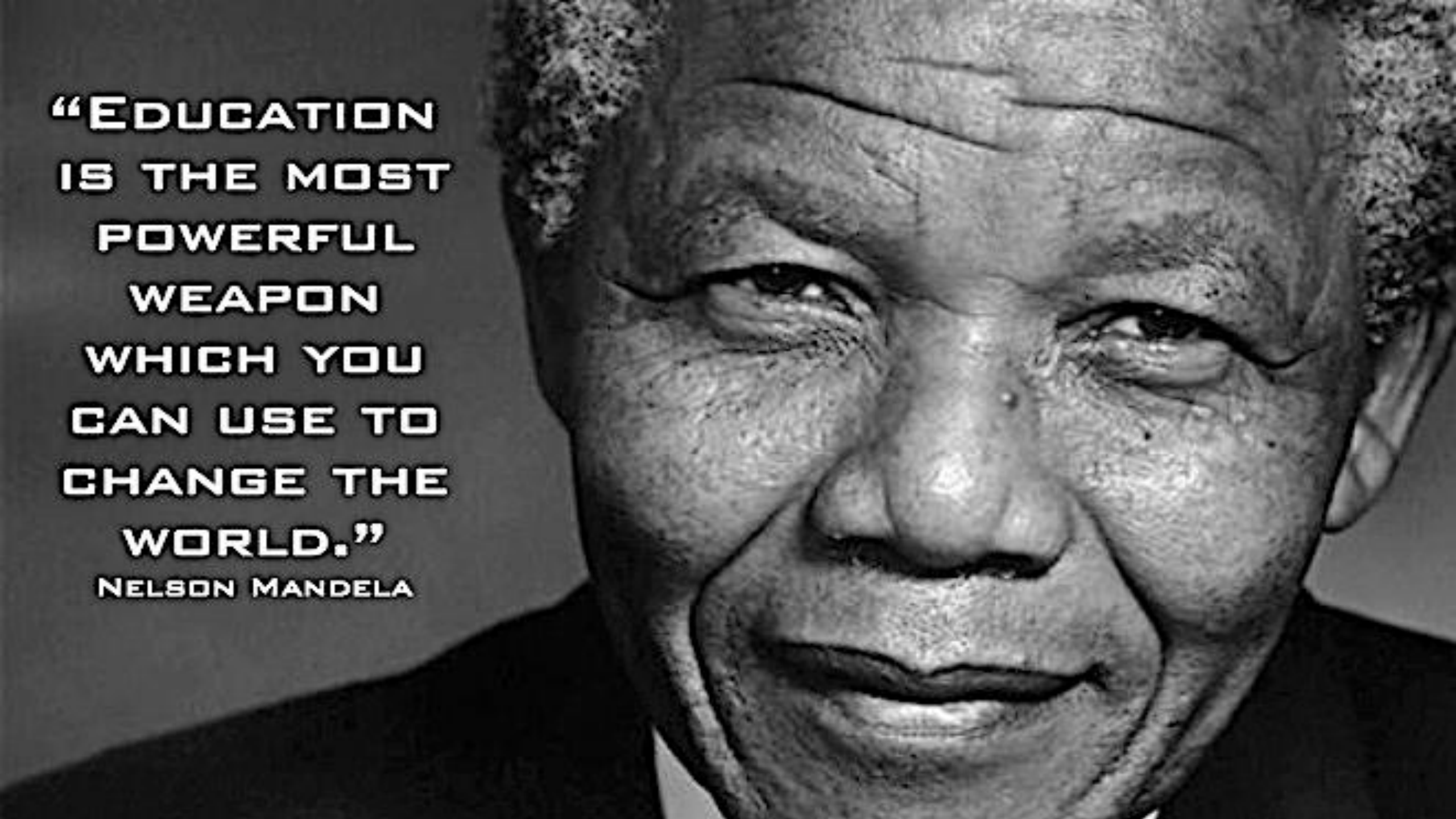
IMAT-network university



IMAT-NU: the road ahead…




"Education is the most powerful weapon which you can use to change the world."
Nelson Mandela

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Outline

1. Introduction: *team, vision, mission*
2. Status Quo
3. Ideas & Strategies
4. Evaluation of Technologies
5. Economic Analysis
6. Impacts
7. Conclusion

Our Vision

Our vision is to create innovative resilience strategies for fast growing cities to successfully overcome current and future sustainability challenges.

Our Mission

Our mission is to make Arusha a ***resilient city***; a city that withstands socio political and environmental stressors and demographic change whilst accelerating its economic growth.

NM-AIST will be the sustainability, technology and transport hub of East Africa through a secure, independent and sustainable economy, whilst sharing its knowledge with surrounding communities.

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Zero-Emission Concepts for Urban Resilience in selected African cities

Research Team

Visiting Team

Host Team

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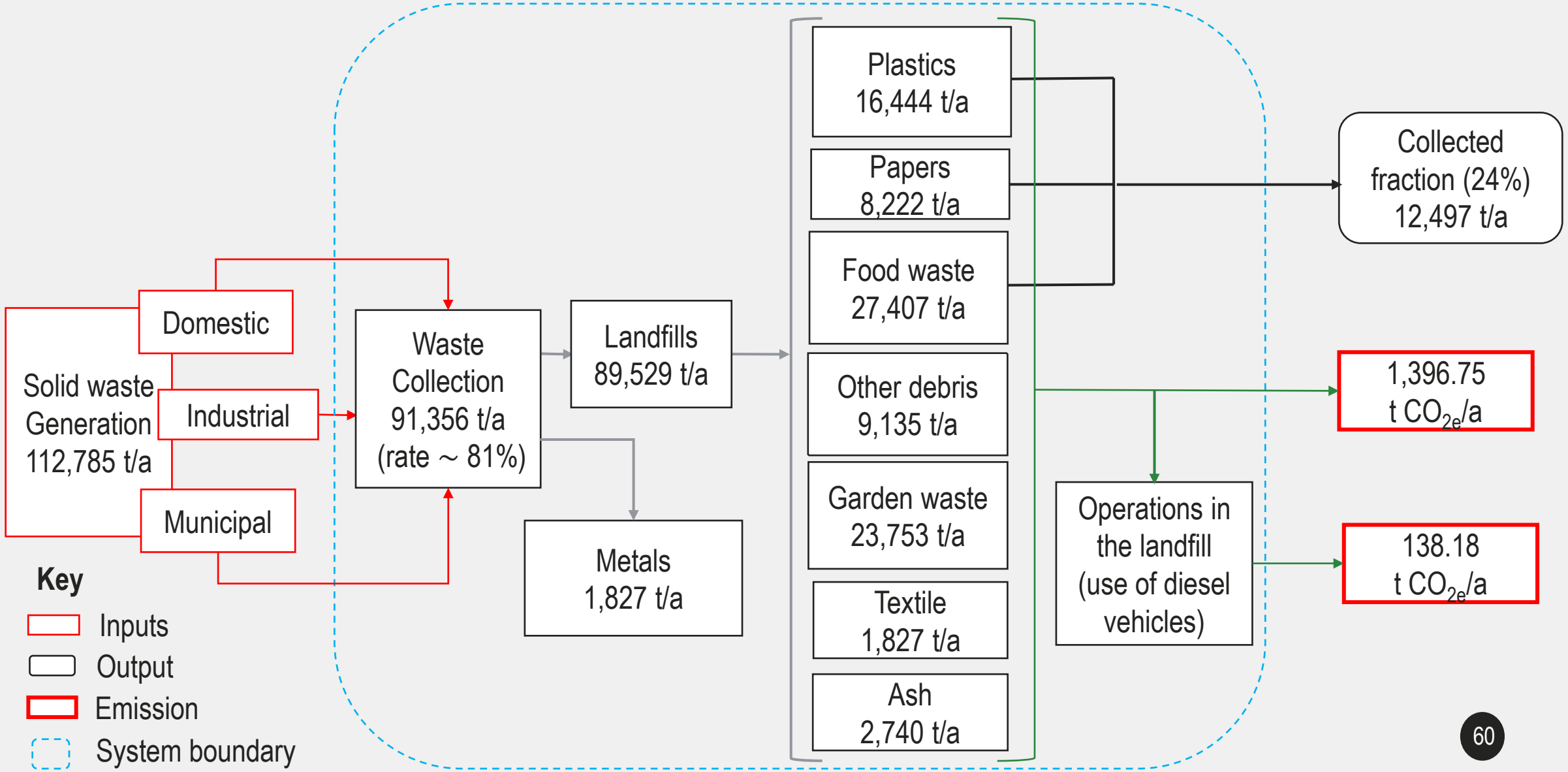
Zero-Emission Concepts for Urban Resilience in selected African cities

Municipal Solid Waste

Status quo: MSW Arusha



Status quo: MSW composition

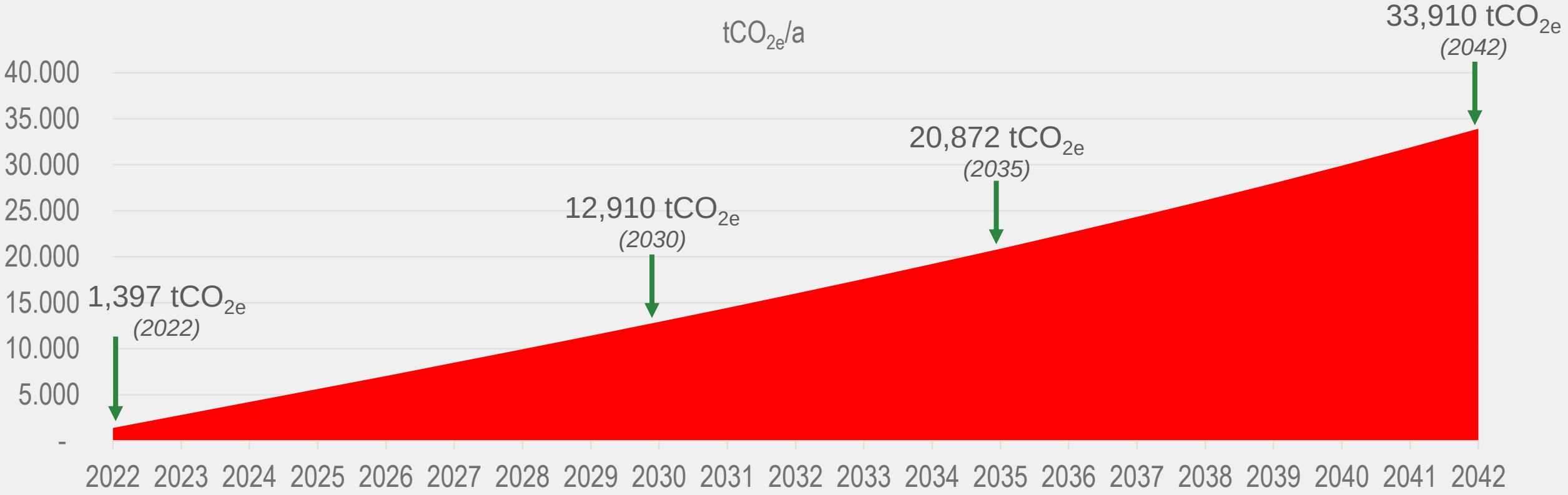
Waste Composition in Muriet Landfill, Arusha

Composition	Fraction	Amount (t/a)
Food waste	30%	27,407
Garden waste	26%	23,753
Plastic	18%	16,444
Metal	2%	1,827
Other debris	10%	9,135
Paper	9%	8,222
Textiles	2%	1,827
Ash	3%	2,740

SOURCE: Arusha City Council: The Current Status of Solid Waste Management (Recycling, W-to-E & Biomass Disposal Options)

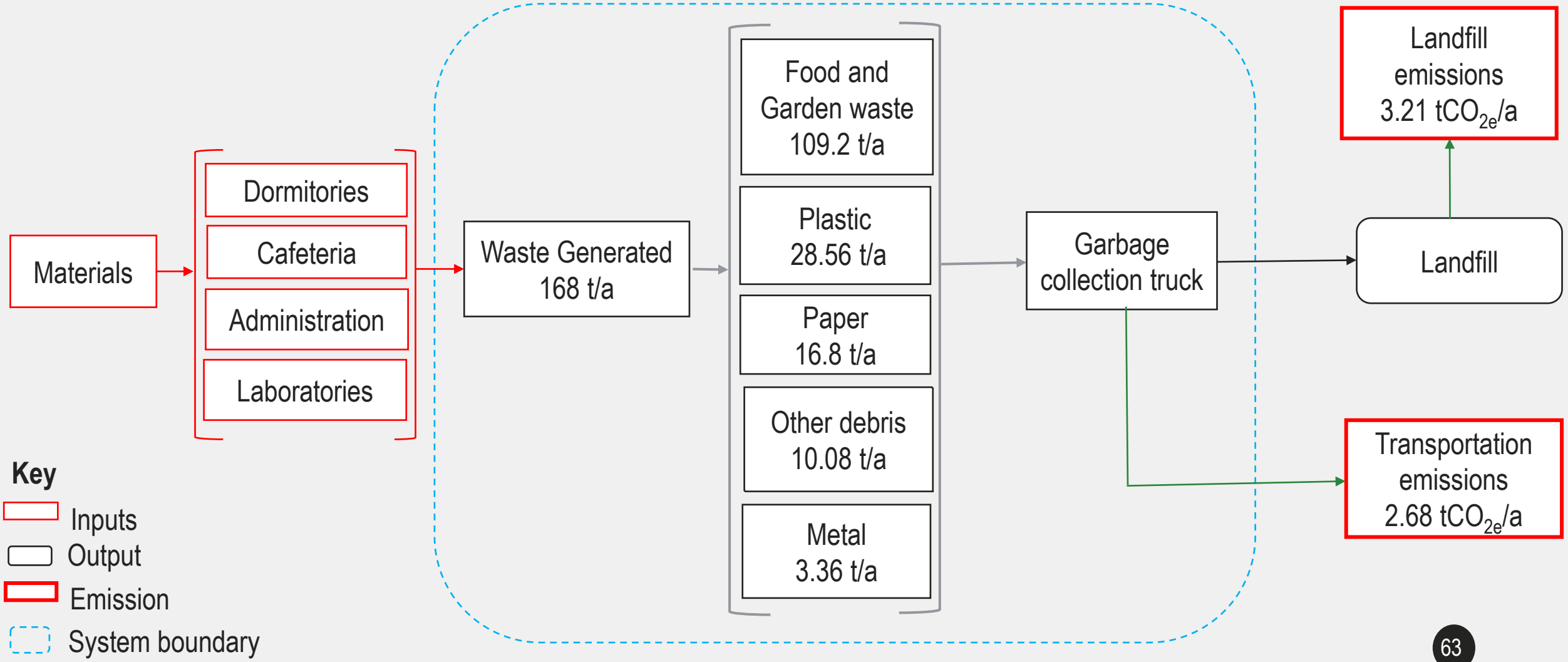
Projected CO_{2e} emissions

***CO_{2e} emissions** in Muriet landfill in the next 20 years (Baseline: 2022)*



SOURCE: Calculated by using Methodological tool: Emissions from solid waste disposal sites, Tool 4, V8, UNFCCC,

Status quo: Solid waste (NM-AIST)



Status quo: Solid waste (NM-AIST)

Waste composition in NM-AIST

Composition	Fraction	Amount (t/a)
Food and garden waste	65%	109.2
Plastic	17%	28.56
Paper	10%	16.8
Other debris	6%	10.08
Metal	2%	3.36

Total CO_2 equivalent emissions = 3.21 tCO_{2e}/a

Unsorted waste (bin)

Garden waste generation

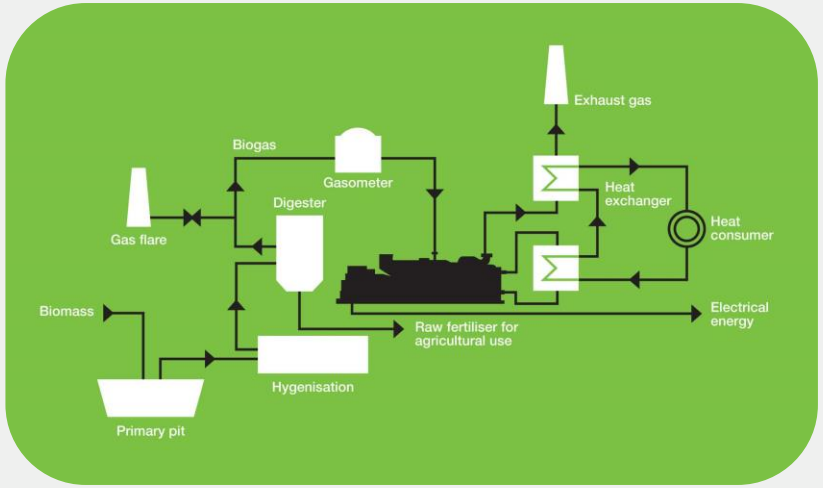
Mixed/unsorted waste (at the collection point)

Waste collection point

SOURCE: Observation and interview with students

Ideas & Strategies: Solid waste to energy/biogas

Appropriate waste collection and sorting



Energy generation

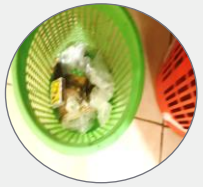
Biogas for cooking (reduce deforestation)

SOURCE: https://www.nytimes.com/wirecutter/blog/dont-need-ditch-your-gas-stove-yet/ (2022); http://biblioteca.olade.org/opac-tmpl/Documentos/cg00530.pdf (2022); http://biblioteca.olade.org/opac-tmpl/Documentos/cg00530.pdf (2022); Google Images (n.d.), www.irena.org, https://www.clarke-energy.com/applications/biogas/

Ideas & Strategies: Waste management

Status quo

Status quo waste management method. (hostels)



Mixed/unsorted waste (collection point)

Garden waste generation

Hazardous waste management (incineration)

Proposed strategies

Separate containers in residences

Separate containers (external)

Research line to obtain essential oils, waxes, plant extracts and fodder.

Used cooking oil (potential business)

Education and awareness

Ideas & Strategies: Waste resource center

1 Source segregation program within the university

The center will be managed by students (the aim: learn about the types of waste and administration of a center)

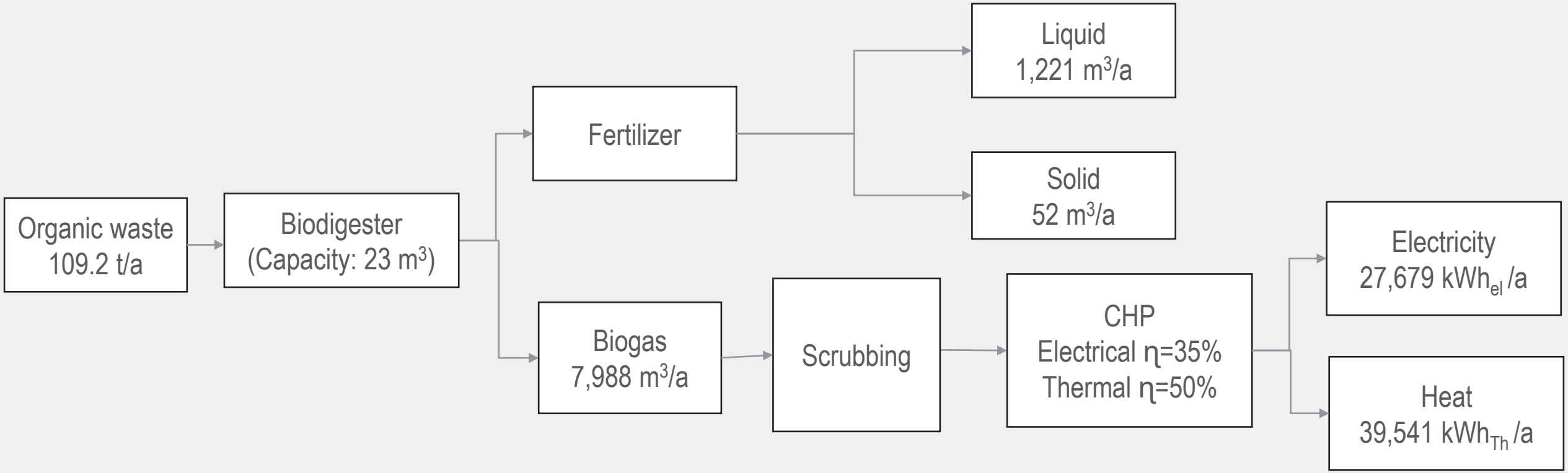
2 Main WRC
Collection points

3 Sell secondary resources (revenue for NM-AIST)

ITEM	UNIT	PAPER	METALS	PLASTICS	CARDBOARD
Price	TZS/kg	200	800	500	100
Generation	kg/year	15,120	3,360	28,560	1,680
Income	TZS/a	3,024,000	2,688,000	14,280,000	168,000
Total income	TZS/a			***20,160,000***	

SOURCE: https://www.tandfonline.com/doi/pdf/10.1080/27658511.2021.1935532

Ideas & Strategies: Proposed biogas production at NM-AIST



SOURCE: Computed values

Ideas & Strategies: Waste-to-value potential

Business opportunity: small-scale biogas digestors (replacing LPG)

University *CECC* as a "business unit" to transfer technology knowledge and competence to schools, community etc.

ITEM	UNIT	AMOUNT
Estimated bio-methane production	m^3/a	7,988
Total heat generation potential	kWh/a	79,082
CHP unit's electrical efficiency	$\eta_{elec.}$	35%
CHP unit's thermal efficiency	$\eta_{thermal}$	50%
Electricity output	$kWh_{elec.}/a$	27,679
Heat output	$kWh_{thermal}/a$	39,541
Electrical power	$kW_{elec.}$	6
Thermal power	$kW_{thermal}$	9
HRT of the biogas digester	days	*18*
Total digestor volume	m^3	23

LPG equivalent

2,966 kg/a

GHG abatement potential

18 tCO_{2e}/a

Ideas & Strategies: Waste-to-value potential

ITEM	UNIT	AMOUNT
Estimated investment	TZS	53,904,000
Total cost saving potential	TZS/a	19,239,205
Maintenance (5% CAPEX)	TZS/a	2,695,200
Simple payback	years	4.5

Levelized cost of Electricity (CHP biogas) 374.6 TZS/kWh *(higher than grid)*

Levelized cost of Heat (CHP biogas) 262 TZS/kWh_{Heat} *(same as LPG)*

Fertilizer production potential of the digestate

ITEM	UNIT	AMOUNT
Digestate output (4-5% TS)	m^3/a	1,744
Liquid fertilizer output (70% (TS - 2%)	m^3/a	1,221
Dried fertilizer output (3% (TS -85%)	t/a	52
Discharge liquid (7%, TS<0.1%)	m^3/a	122
Recirculated Liquid (20% TS-2%)	m^3/a	349

TS = total solids

Ideas & Strategies: Waste-to-value potential

Biowaste is a resource!

From waste to resource management

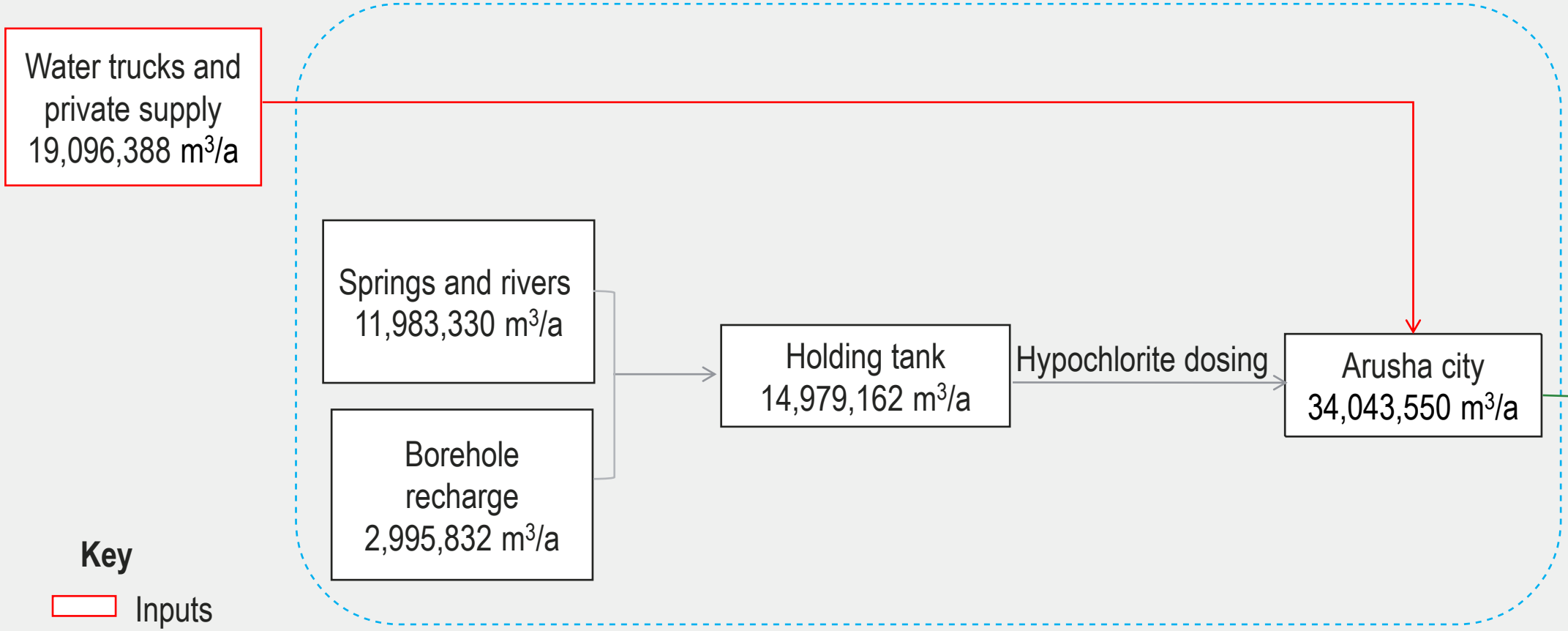
No disposal in the future

SOURCE: Google Images (2022), Waste resource center & biogas plants in Germany, https://www.euractiv.com/section/energy-environment/opinion/biogas-in-germany-maintaining-momentum/

ZECURA
Zero-Emission Concepts for Urban Resilience in selected African cities

Fresh Water

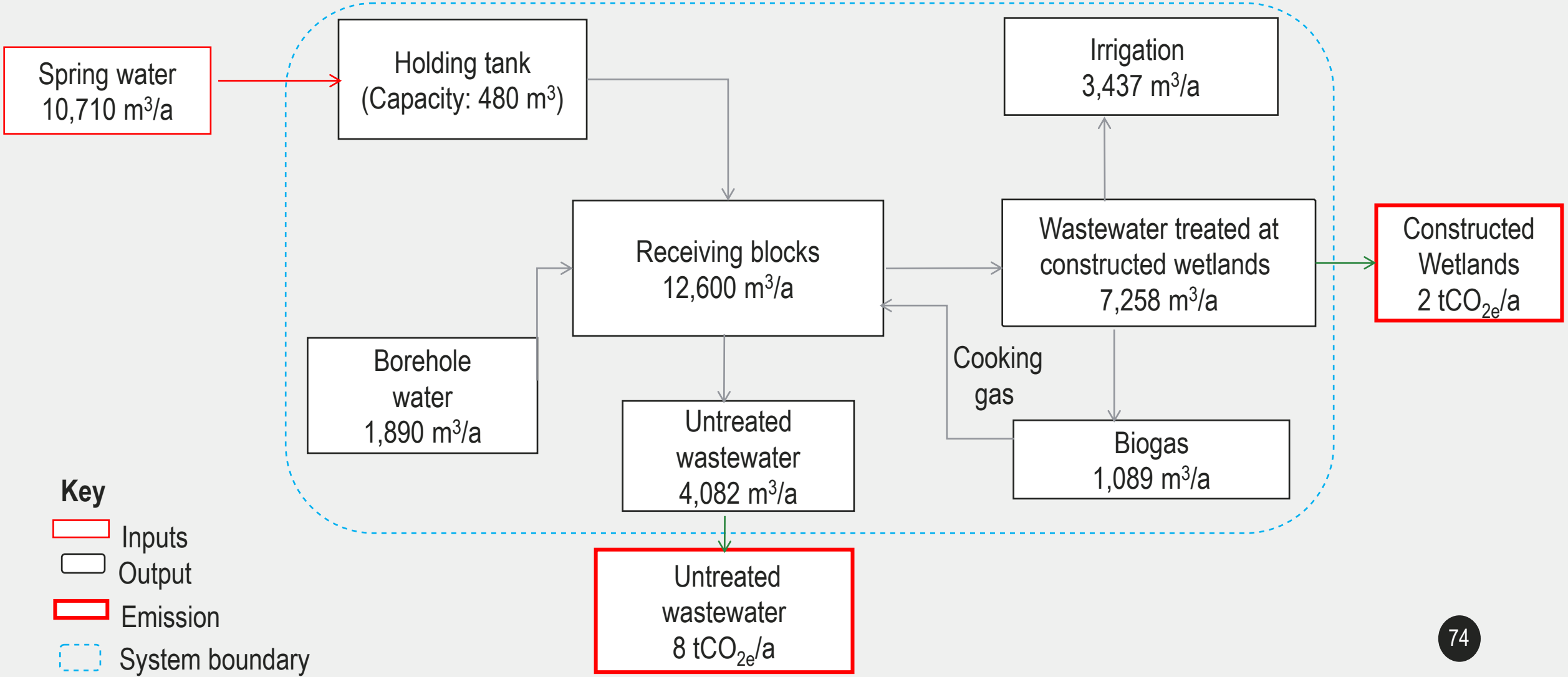
Status quo: Water treatment (Arusha)



Water demand = 34,043,550 m³/a
Water supplied by AUWSA = 14,979,162 m³/a

SOURCE: AUWSA

Status quo: Fresh water (NM-AIST)



Status quo: Fresh water (NM-AIST)

ITEM	UNIT	AMOUNT
Fresh water consumption	m^3/day	42
Total population in the campus		600
Water consumption rate	L/ca/day	70
Energy coumsumption (0.2 kWh/m^3)*	kWh/a	2,520
Total water costs	TZS/a	16,380,000
GHG emissions (energy related)	tCO_{2e}/a	0.85

**Regional value, computed*
(300 days/a are considered as full operating days)

***SOURCE*:** Google images (2022)

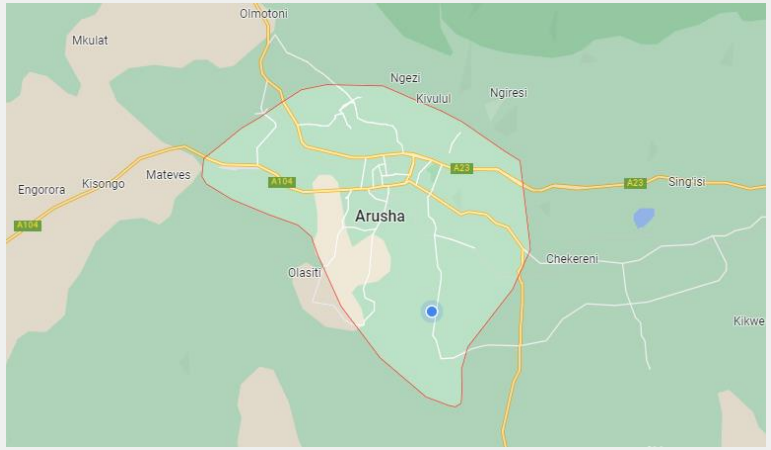
Status quo: Fresh water (Arusha)

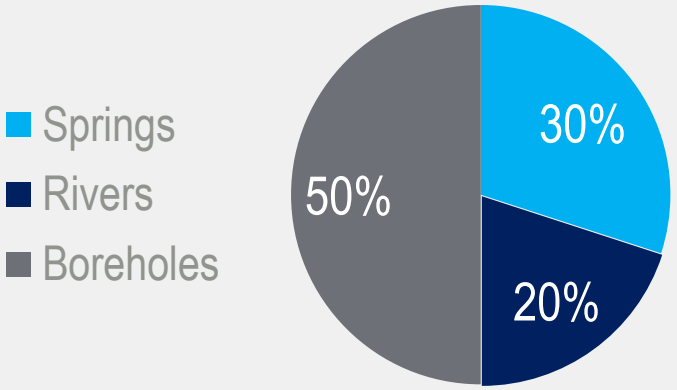
ITEM	UNIT	AMOUNT
Population		616,616
Supply from the municipality (AWUSA)	m^3/day	41,039
Supplied by private distributors	m^3/day	52,231
Fresh water consumption	m^3/day	93,270
Water consumption rate	L/ca/day	151
Estimated energy use (energy related)	kWh/a	6,808,710
GHG emissions (energy related)	tCO_{2e}/a	2,288

25 L/ca/day
if water is drawn from a public kiosk in rural and urban

In urban areas,
70 L/ca/day
if there is a water connection in the backyard

120 – 150 l/ca/day
if there is supply into the house





SOURCE: Images - Google maps, AWUSA, Water resource group, TANZANIA: hydro-economic overview–an initial analysis

Ideas & Strategies: Water efficient faucets

Simulation for administration building

ITEM	UNIT	OLD	NEW
Water output	L/min	6	2
Unit		120	120
Usage per day	min	20	20
Water demand annual	m^3/a	5,256	1,752
Water savings annual	m^3/a		3,504
Saving potential	%		67
Estimated CAPEX	TZS		14,070,000
Monetary savings	TZS/a		4,555,200
Payback	years		3.1

SOURCE: https://www.enware.com.au/products/general-commercial-tapware/enware-delabie-tempostop-time-flow-basin-pillar-tap-push-button/ (2022).

Ideas & Strategies: Water efficient cisterns

Simulation for administration building

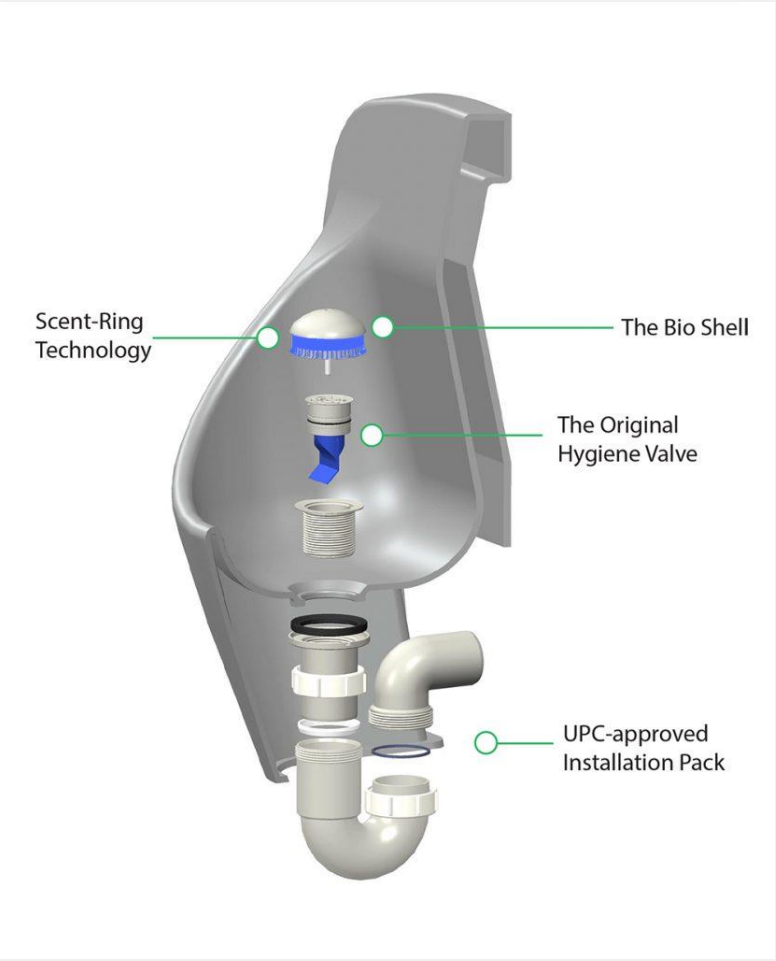
ITEM	UNIT	OLD	NEW
Water amount single use	L	10	4
Units	x	80	80
Usage per day	users/day	5	5
Water demand annual	m^3/a	1,460	584
Water savings annual	m^3/a		876
Saving potential	%		60
Estimated CAPEX	TZS		5,266,000
Monetary Savings	TZS/a		1,138,800
Payback	years		5.1

SOURCE: https://jlplumbing.com/product/ce-watermark-toilet-water-tank-pneumatic-concealed-cistern/ (2022), https://toilet-guru.com/pressure.html (2022).

Ideas & Strategies: Waterless urinals

Simulation for administration building

ITEM	UNIT	OLD	NEW
Water output	L/flush	4	0
Units	X	60	60
Usage per day	X	10	10
Water demand annual	m^3/a	876	0
Water savings annual	m^3/a		876
Saving potential	%		100
Odor trap cost	TZS/a		43,926
Monetary Savings	TZS/a		1,138,800
Estimated CAPEX	TZS		11,256,000
Payback	years		9.9



SOURCE: https://waterless.solutions/how-waterless-urinals-work

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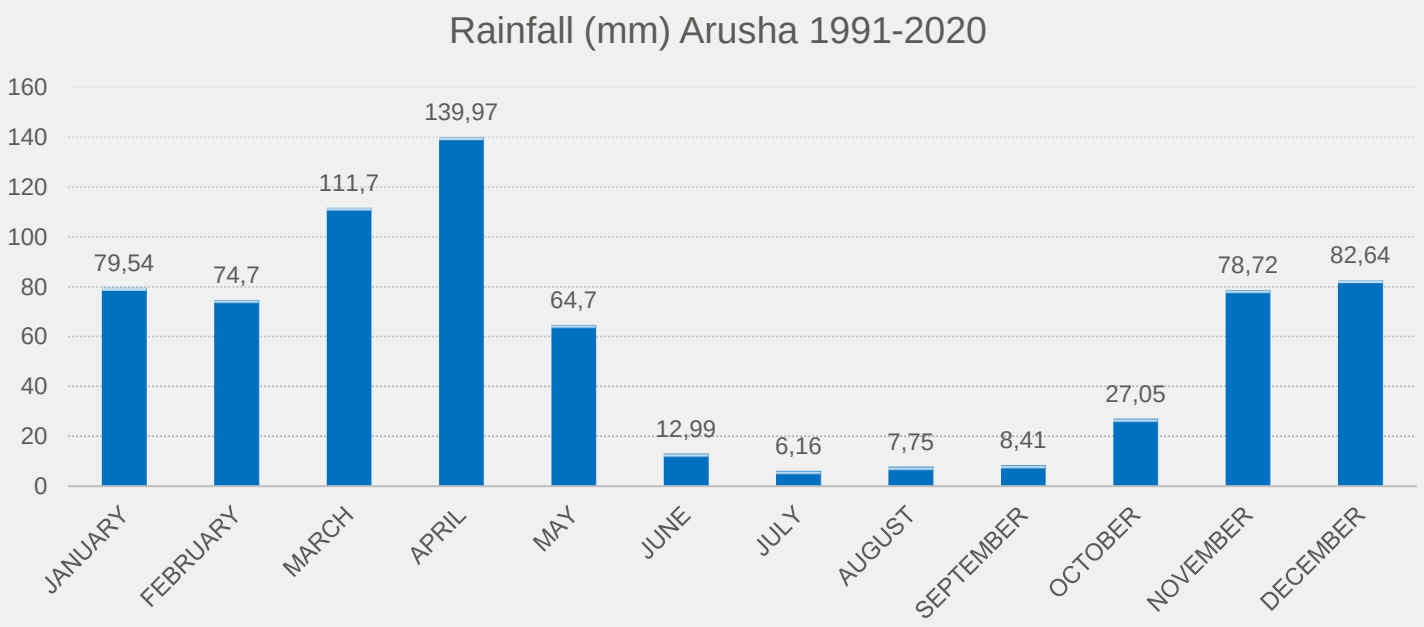
Rain Water

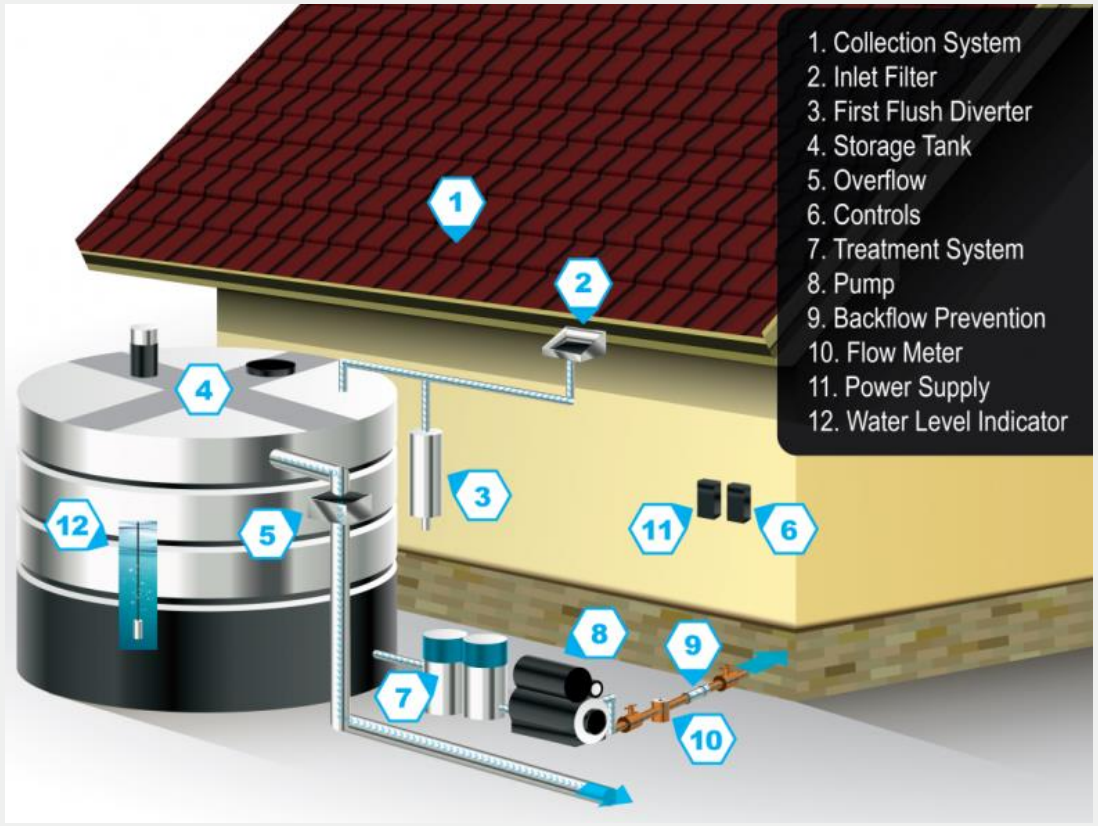
Ideas & Strategy: Rain water harvesting

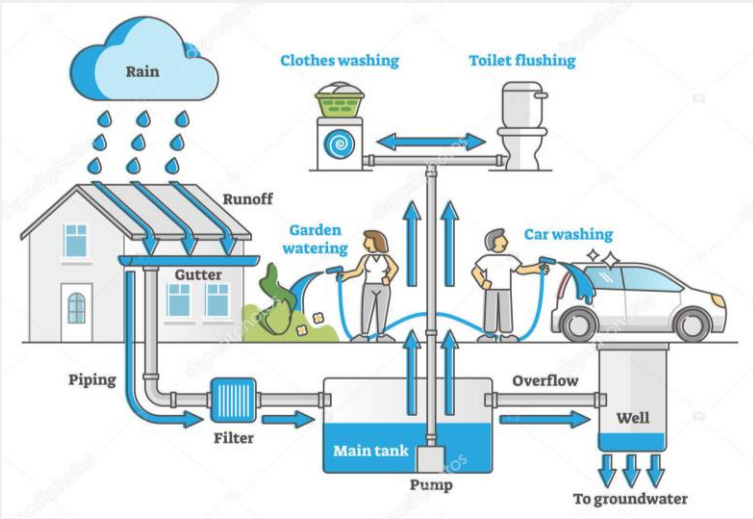


ITEM	UNIT	AMOUNT
Catchment/roof area	m^2	12,100
Selected roof area (50%)	m^2	6,050
Annual rainfall	mm	1,282
Annual available water	m^3/a	5,817

SOURCE: data information https://climateknowledgeportal.worldbank.org

Ideas & Strategy: Rain water harvesting





Reservoir for 1,940 m^3 of rainwater

(Approx. 4 months of rainwater)

ITEM	UNIT	AMOUNT
Total construction cost	TZS	54,292,700
Operating cost	TZS/a	1,085,854
Monetary saving	TZS/a	7,562,198
Payback period	years	11.6
Levelized cost of service unit (LCoS)	TZS/m^3	1,307

SOURCE: https://www.energy.gov/eere/femp/water-efficient-technology-opportunity-rainwater-harvesting-systems (2022).

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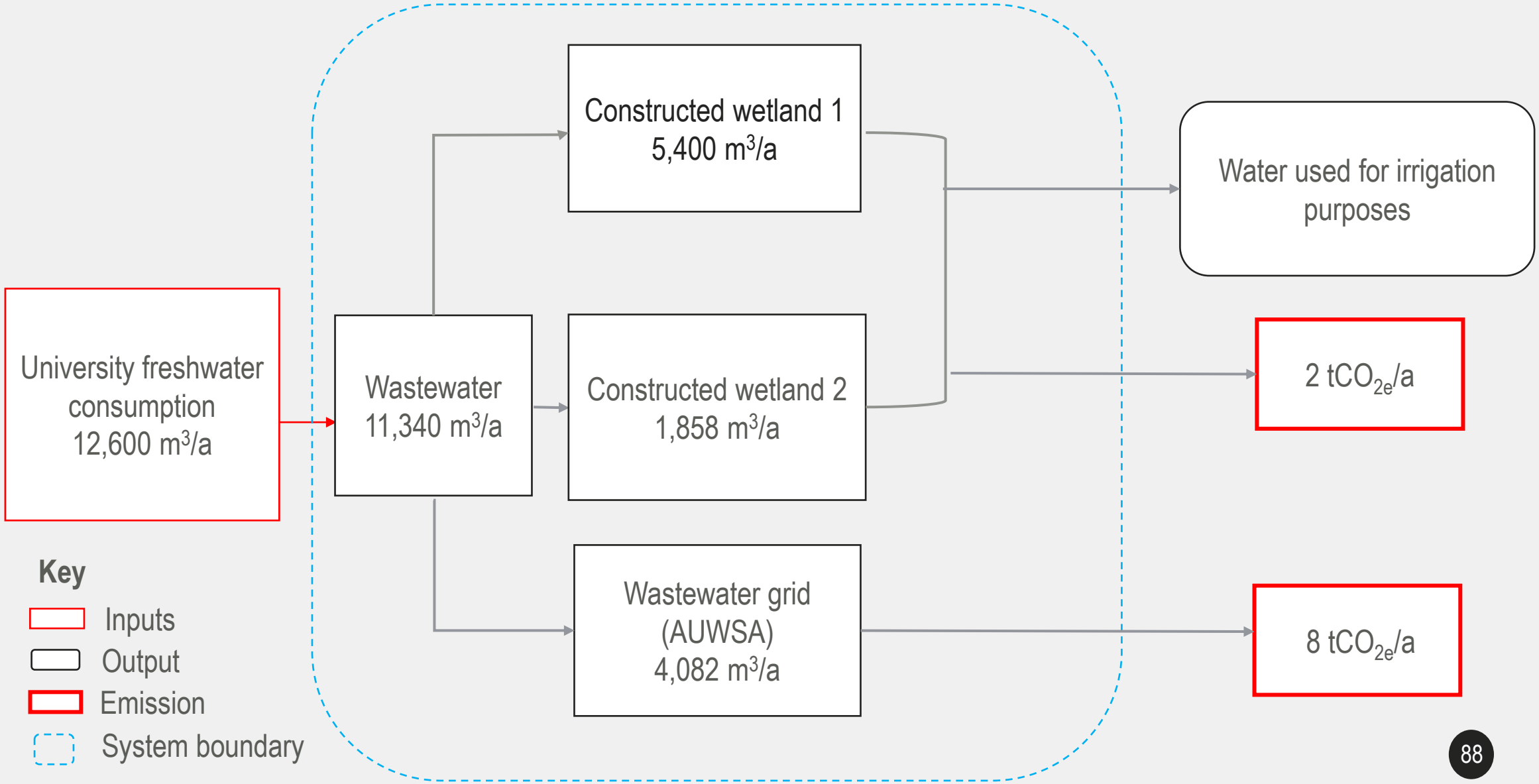
Wastewater

Status quo: Wastewater (NM-AIST)



Status quo: Wastewater (Arusha)

ITEM	UNIT	AMOUNT
Total water consumption	m^3/a	34,043,550
Wastewater generation	m^3/a	30,639,195
Treated wastewater	m^3/a	3,650,000
GHG emissions for treated wastewater	tCO_{2e}/a	6,796
GHG emissions of total wastewater (lagoon)	tCO_{2e}/a	18,368

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Reed Bed Filter

Ideas & Strategy: RBF expansion (NM-AIST)

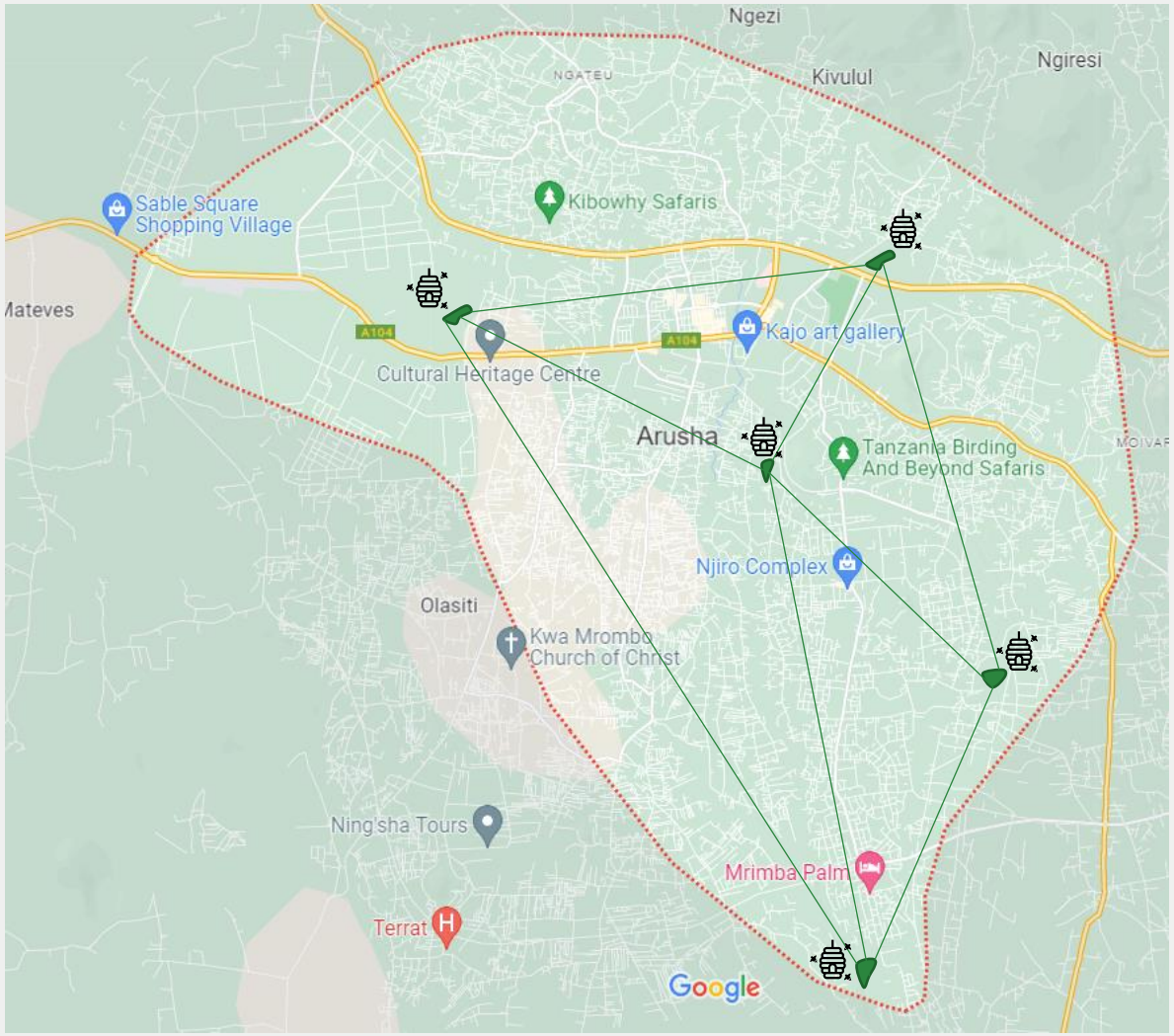
ITEM	UNIT	AMOUNT
Volume	m^3/a	4,082
Area requirement	m^2	91
GHG abatement potential	tCO_{2e}/a	7

SOURCE: https://earth.google.com/

Ideas & Strategy: RBF (Arusha)

ITEM	UNIT	AMOUNT
Number of people	x	616,616
Estimated occupancy days	days/a	365
Water consumption	m^3/a	34,043,550
Wastewater (untreated)	m^3/a	30,639,95
Inflow area ratio	$L/m^2.d$	200
Area demand	**ha**	**41.9**
COD removal efficiency	%	53%
Weighted average water price	TZS/m^3	1,300
Daily wastewater generation per capita	L/d	120
Annual wastewater generation per capita	m^3/a	43.8

RBF system of Arusha city



RBF (42 ha total)

Apiary

tCO_{2e} reduction potential

6,796 tCO_{2e} → 1,265 tCO_{2e}

SOURCE: https://www.google.com/maps/place/Arusha/@-3.3777155,36.65386,12.49z/data=!4m5!3m4!1s0x18371c88f2387383:0xbc1907f7ec497152!8m2!3d-3.3869254!4d36.6829927

RBF – Cropping options

7 ha Reed Bed Filter		
	Input volume (m^3/a)	Output volume (m^3/a)
Total	5,110,000	4,599,000

SOURCE: Google Images

Crop selection for treated sewage effluent

ITEM	UNIT	BANANA	GUAVA	MAIZE
Spacing	meter	2.4 x 2.4	3 x 3	0.75 x 0.75
Crop water requirement	mm/month	240	16	150
Yield	kg/plant/a	40	35	0.4

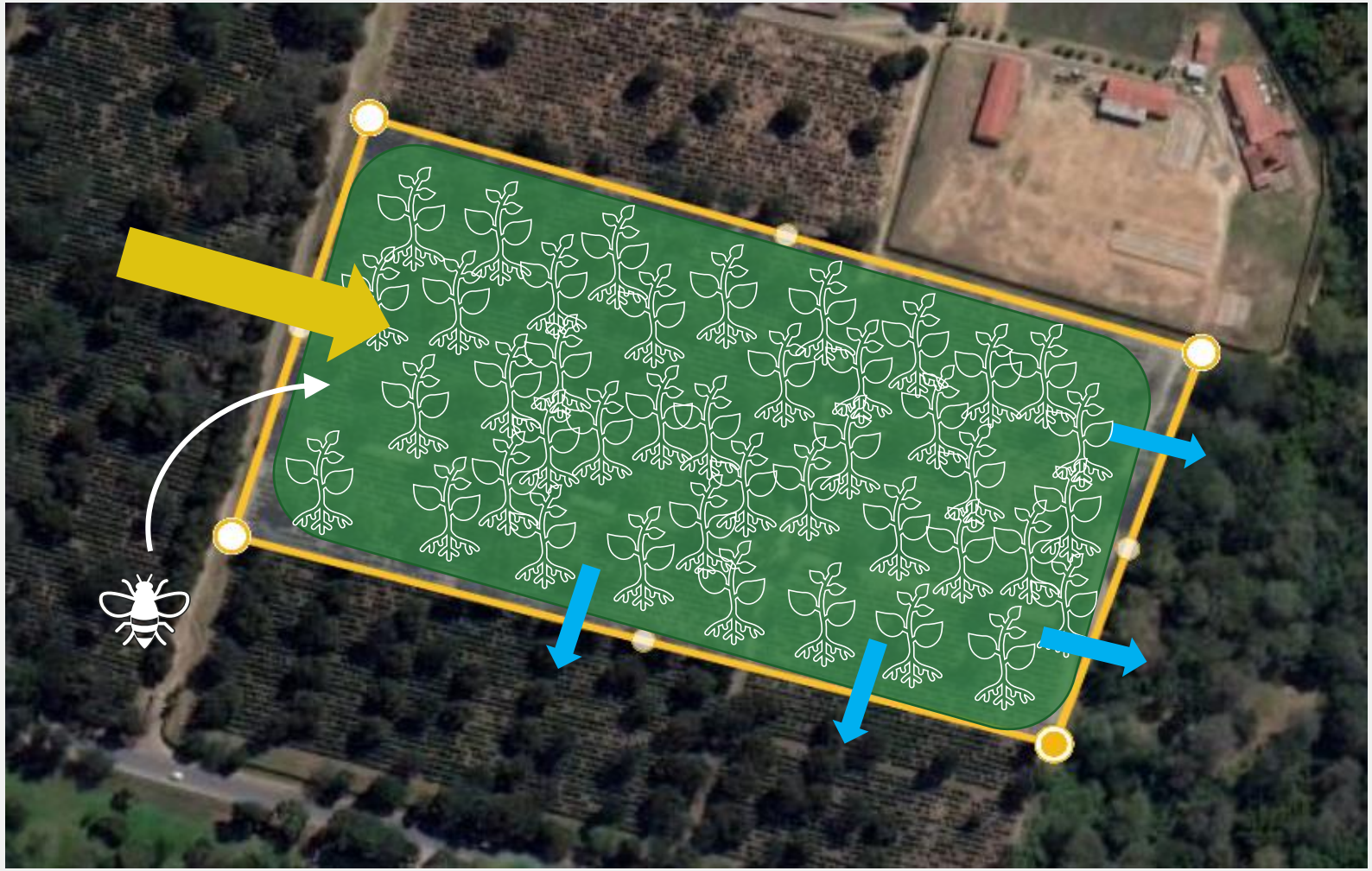
Exemplary RBF system

Potential benefits from banana crops

ITEM	UNIT	AMOUNT
Spacing per banana plant	m^2	6
Available area	ha	7
Number of plants		12,153
Yield	kg/plant/a	40
Potential of banana crop produced annually	**kg**	**486,111**
Market value	TZS/kg	2,100
Potential income generated	TZS	1,020,833,333
Post harvest losses	%	20%
Estimated income generated	**TZS**	**816,666,667**

Water used:	2,917	m^3/month
Water available:	380,333	m^3/month

Exemplery RBF system

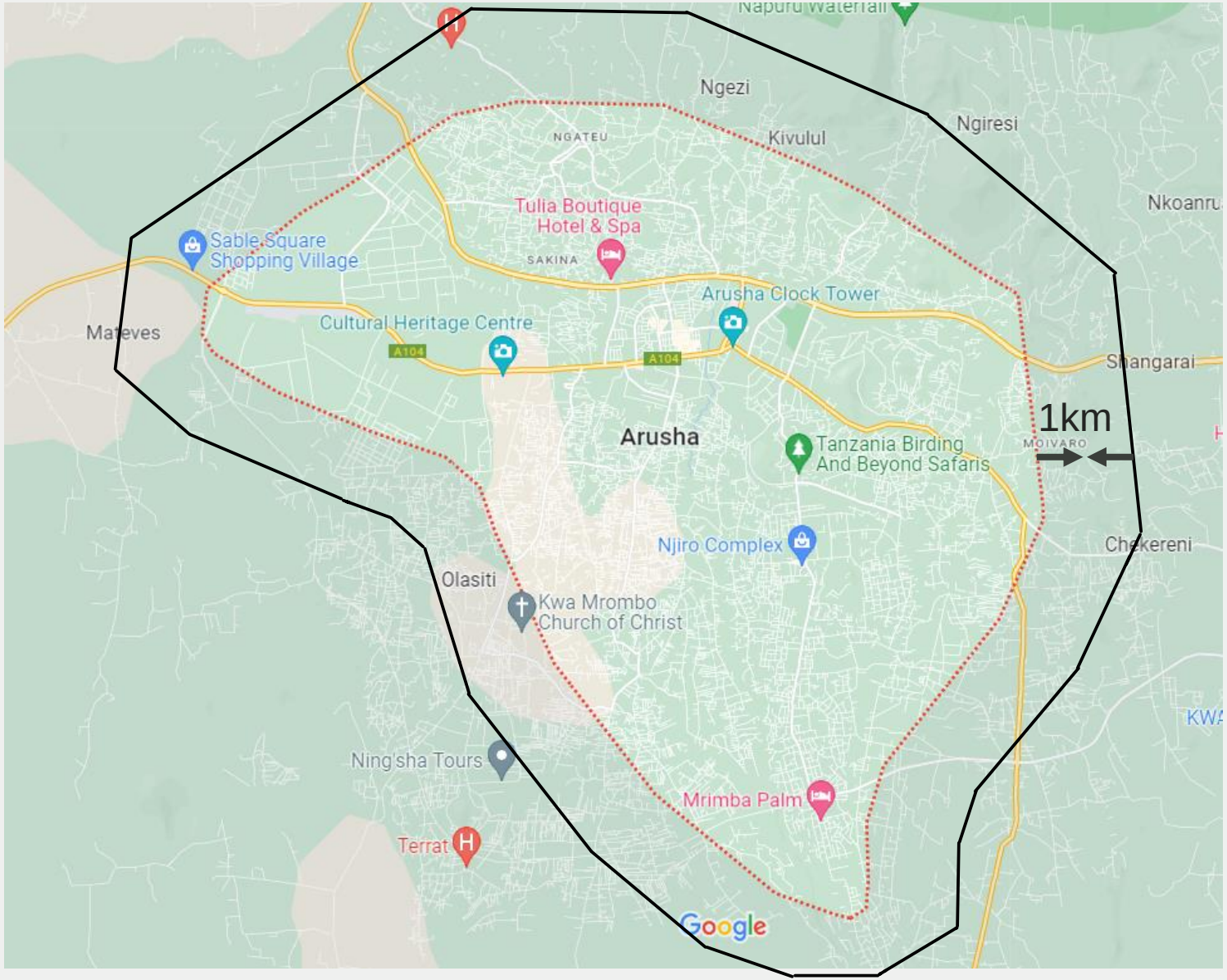


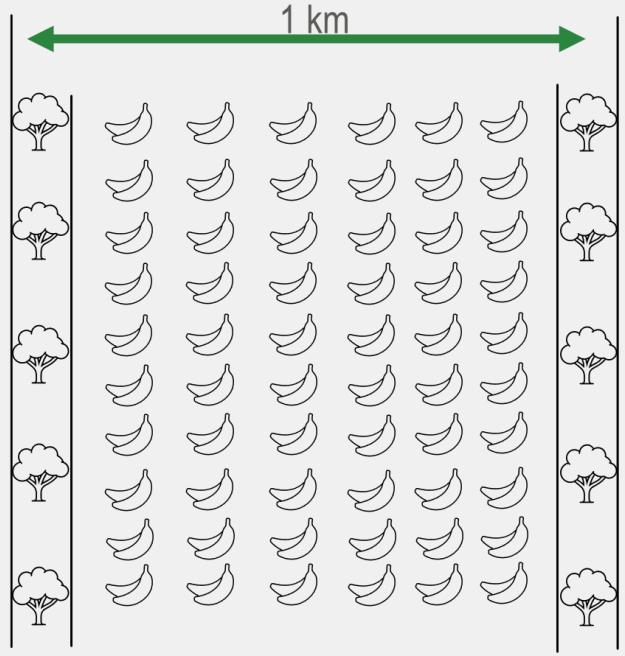
Potential income from 7 ha, depending on the kind of crop

	816,666,667	TZS/a
	223,513,195	TZS/a
	35,828,053	TZS/a

SOURCE: https://earth.google.com/web/search/Cultural+Heritage+Centre,+Dodoma+St,+Arusha/@-3.37414017,36.65032973,1377.26651405a,968.96531473d,35y,0.00860025h,0t,0r/data=CigiJgokCXMgsmHvvwrAEauyjMj7BQvAGZDoH0ZtWEJAIUYveJmpUUJA, Google Images (2022).

Arusha's green belt



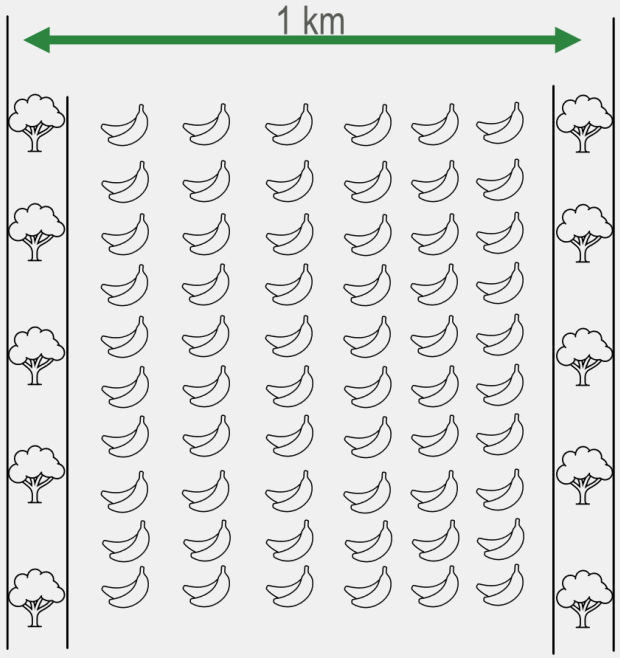


SOURCE: https://www.google.com/maps/place/Arusha/@-3.3979698,36.6070005,12z/data=!3m1!4b1!4m5!3m4!1s0x18371c88f2387383:0xbc1907f7ec497152!8m2!3d-3.3869254!4d36.6829927

Arusha's green belt

2 x 100 m of timber

45,000 km^2

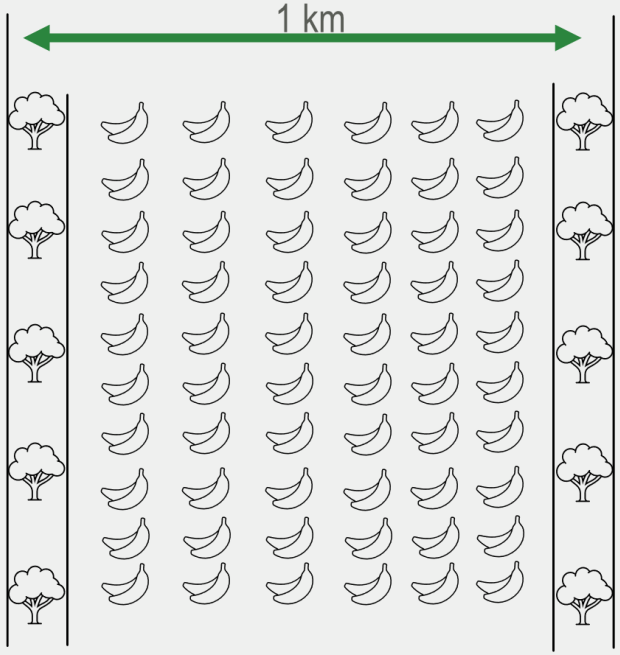


TEAK PLANTATION		
ITEM	UNIT	AMOUNT
Spacing	m^2	9
Available area	km^2	9,000
Potential trees planted	x	1 Billion
Market price	TZS/m^3	72,202
Annual water requirement	mm/tree	1,600
Carbon stored in standing tree (26y)	kgC/tree	60
Potential carbon stored at 26y	**tC**	**60,415,809**
Potential income from carbon offsetting by 2050	**TZS**	**6,6 Trillion**
	USD	**3,020,790,464**

Arusha's green belt

800 m of banana plants

45,000 km²



BANANA PLANTATION		
ITEM	UNIT	AMOUNT
Spacing	m^2	6
Available area	km^2	36,000
Qty. banana plants (potential)		6.3 Billion
Yield per plant	kg/a	40
Potential income generated	TZS	525 Trillion
Potential jobs created		6,300,000
Labour costs	TZS	1.9 Trillion
Gross Margin (only including labour cost)	**TZS**	**523 Trillion**
	USD	**237,777,273**

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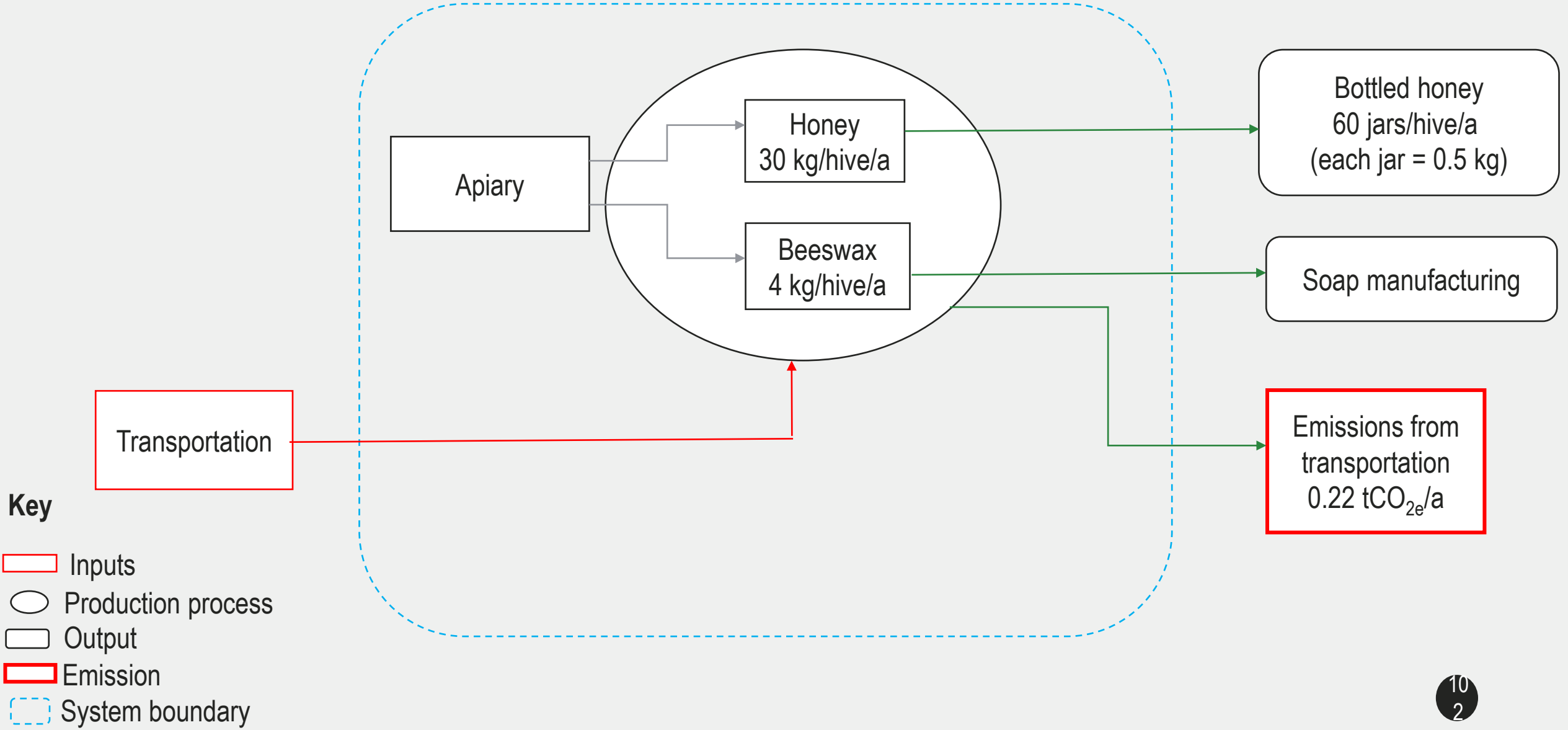
Honey Production

Honey production



Honey production

ITEM	UNIT	AMOUNT
Vegetative area	ha	27
Hive density	hives/ha	15
Price of honey	TZS/kg	15,000.00
Price of beeswax	TZS/kg	9,600.00
Honey produced	kg/hive/a	30
Beeswax produced	kg/hive/a	4

SOURCE: https://swahilihoney.co.tz/,https://doi.org/10.1007/s10457-019-00478-1, Google Images (2022).

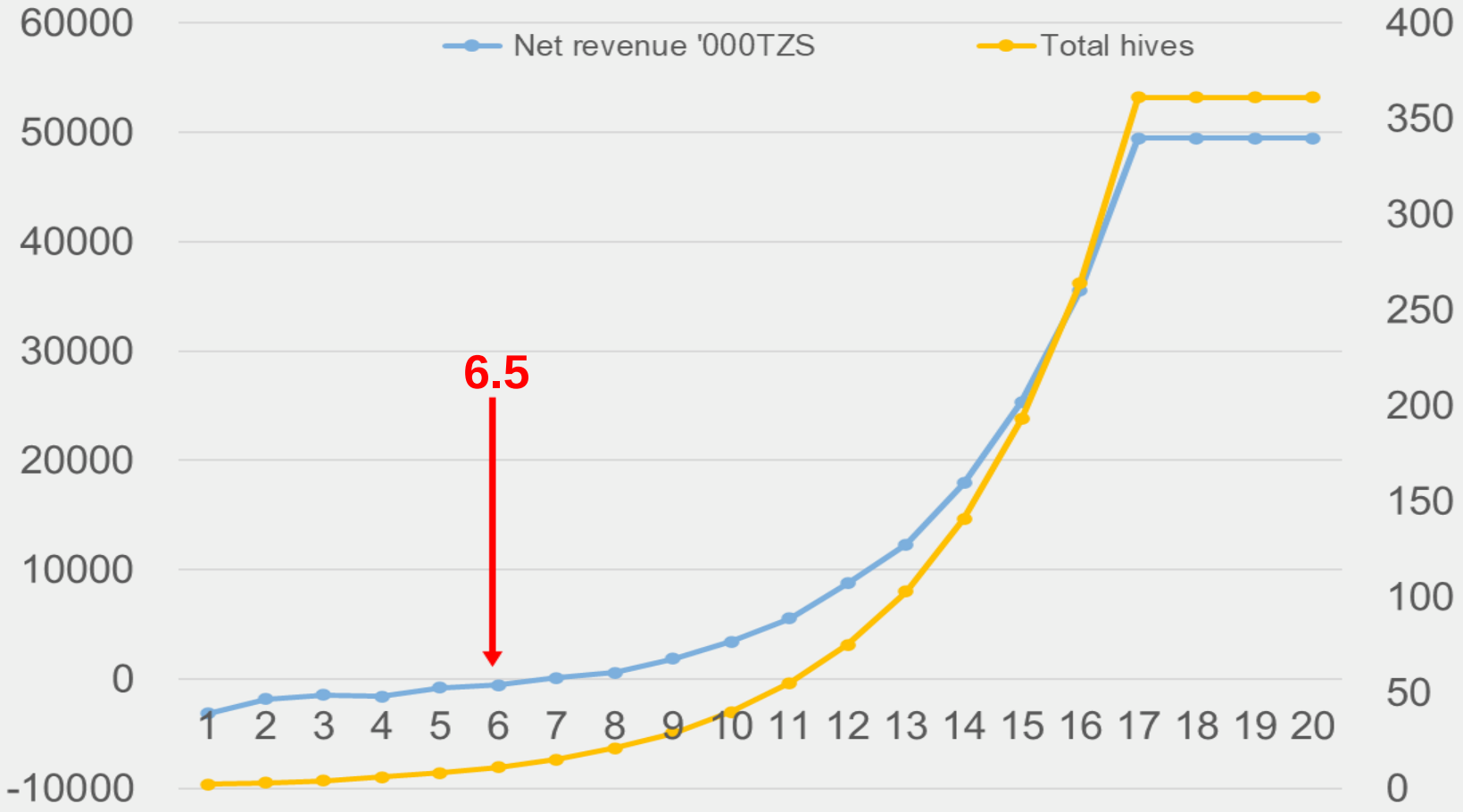
Honey production

ITEM	UNIT	AMOUNT
Area Available	ha	27
Cost of hive installation	TZS	930,320
Transportation emissions	tCO_{2e}/a	0.22
Labour	persons/a	1-5
Payback period	years	6.5

SOURCE: https://www.ilo.org/global/docs

Honey production

Revenue projections for honey production



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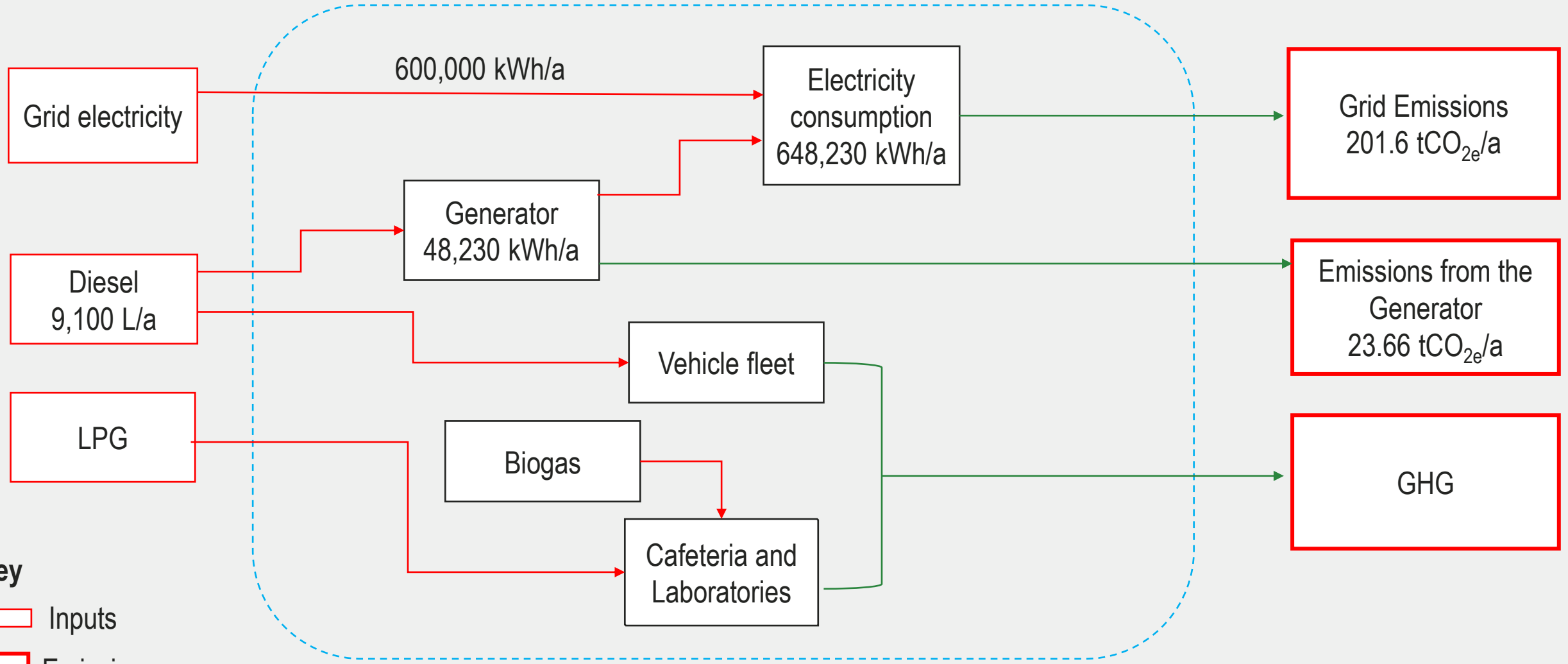
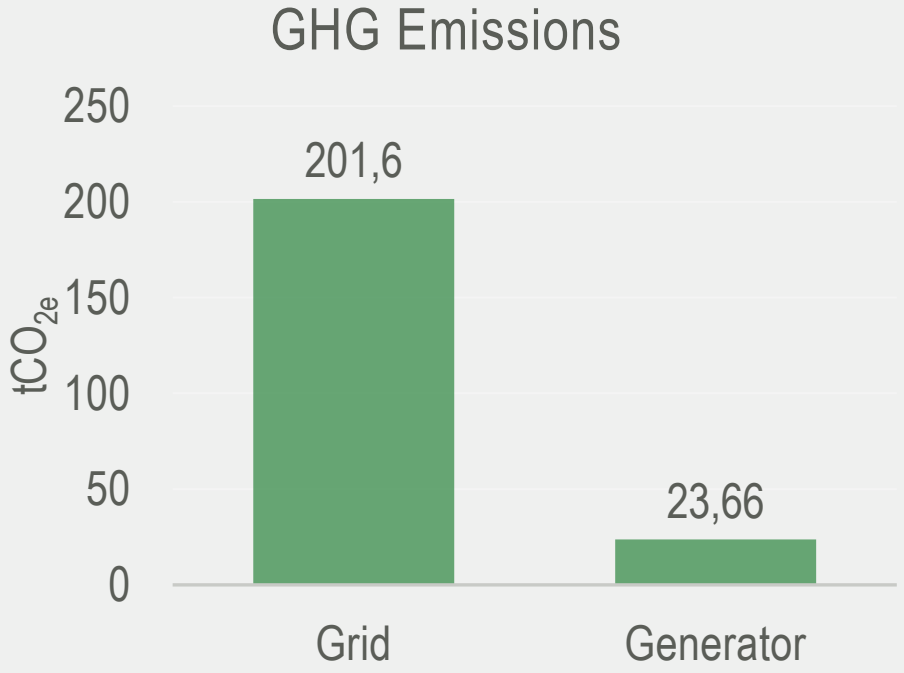
Energy System

Status quo: Energy NM-AIST



Status quo: NM-AIST energy

ITEM	UNIT	AMOUNT
Electricity consumption from the grid	kWh/a	600,000
Fuel input	L/a	9,100
Energy from generators	kWh/a	48,230
Total GHG emissions	tCO_{2e}/a	225.26



Total energy supply	kWh/a	648,230
Electricity costs	TZS/a	222,195,256
Total emissions	tCO_{2e}/a	225.26

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Lighting

Ideas & Strategy: Light replacement analysis

Example for replacing T8 FTL in Administration building

ITEM	UNIT	CURRENT (T8-36W)	LED (17W)
Number of light points (T8-36W)		428	428
Wattage of the light	W	36	17
Total energy consumption (Incl. ballast)	kWh/a	28,954	12,005
Energy savings	kWh/a		16,949
CO_{2e} savings	tCO_{2e}/a		6
Energy costs	TZS/a	9,265,344	3,841,728
Annual energy cost savings	TZS/a		5,423,616
Estimated investment cost	TZS		26,172,200
Simple payback	a		4.8

Estimated Average operating hours – **5.5** h/day

SOURCE: https://lanzmanufaktur.net/, https://www.energy.gov/energysaver/led-lighting (2022), https://www.lighting.philips.co.uk/consumer/ultra-efficient (2022)

Ideas & Strategy: Light replacement analysis

ITEM	UNIT	FTL	LED - Low Tech	LED - High Tech
Approximate cost per bulb	TZS	19,568	36,690	61,150
Average lifespan	h	5,000	20,000	50,000
Watts used	W	36	18	17
No. of bulbs needed for 50,000 hours of use	x	10	3	1
Average Operating hours	h/day	5	5	5
Operating hours of the year	h/a	1,225	1,225	1,225
Total purchase price of bulbs over 50000 hrs	TZS	360,000	216,000	144,000
Total cost of electricity used (50,000 hours at 320 TZS/kWh)	TZS	576,000	288,000	272,000
Total cost over 50,000 hours	TZS	936,000	504,000	416,000
GHG Emissions	tCO_{2e}/a	15	7.4	7.0
Cost per operational year	TZS/a	22,932	12,348	10,192

SOURCE: https://lanzmanufaktur.net/, https://www.energy.gov/energysaver/led-lighting (2022), https://www.lighting.philips.co.uk/consumer/ultra-efficient (2022)

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Pump System

Ideas & Strategy: Pump replacement

ITEM	UNIT	AMOUNT
Operating hours	h/a	3,650
Total dynamic head	m	20
Flow rate	m^3/s	0.003
Nominal installed capacity	kW	4
Calculated efficiency rate (η)	%	19%
Energy consumption	kWh/a	8,687
Annual costs	TZS/a	2,779,840
New power absorption	kW	1
New efficiency rate (η)	%	66%

SOURCE: https://www.ksb.com/en-global (2022)

SOURCE: https://depositphotos.com

$$\eta = \frac{Q\left(\frac{m^3}{s}\right) * H(m) * \left(\frac{kg}{m^3}\right) * 9.81(\frac{m}{s^{2)}}}{EC_p(w)}$$

ITEM	UNIT	AMOUNT
Equipment cost	TZS/a	6,421,909
Energy savings	kWh/a	6,520
Cost savings	TZS/a	2,291,427
CO_{2e} savings	t/a	1.8
Payback time	a	2.8

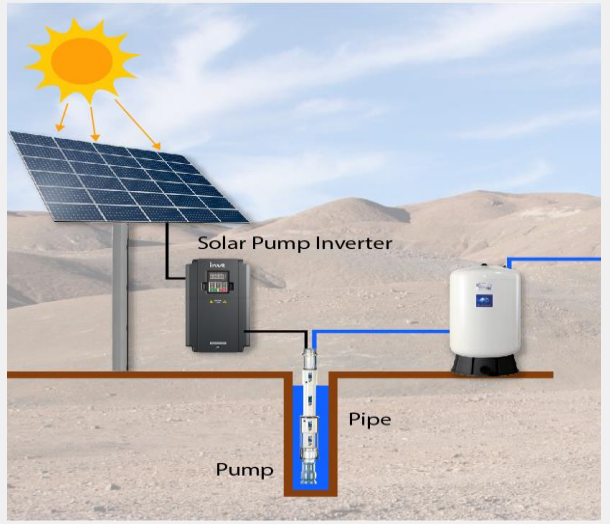
Ideas & Strategy: Pump replacement

Energy from photovoltaic

Automated pumps which are working when there is surplus of PV energy

Ideal for irrigation purposes at the farmlands

PV-powered water level metering device



SOURCE: https://www.worldpumps.com/content, https://www.purityfire.com/solar-pump/ycqb-series-surface-solar-pump-for-irrigation.html

Ideas & Strategy: Airconditioning

ITEM	UNIT	OLD	NEW
Model		Toshiba APO241H	Panasonic - CS-Z20VKEW
Nominal cool output	kW	8	9
Seasonal Energy Efficiency Ratio (Product data)		4.29	8.5
Estimated operating time (Full load hours)	h/a	1,600	1,600
Power input - Electrical (Outdoor unit)	kW	1.9	1.06
Annual energy consumption (Cooling)	kWh/a/unit	12,800	14,400
Annual energy consumption (Electrical)	kWh/a/unit	2,984	1,600
Number of units		12	11
Total energy savings (Electricity)	kWh/a	35,804	17,067
GHG abatement potential	tCO_{2e}/a	12	6
Energy costs	TZS/a	11,457,343	5,461,333
Annual energy cost savings	TZS/a		5,996,009
Estimated investment cost	TZS		35,018,667
Simple payback	a		6

SOURCE: https://www.topten.eu/private/product/view/Panasonic-CU5Z90TBE-5-CSZ20VKEW , https://www.olimpiasplendid.com/seer-scop

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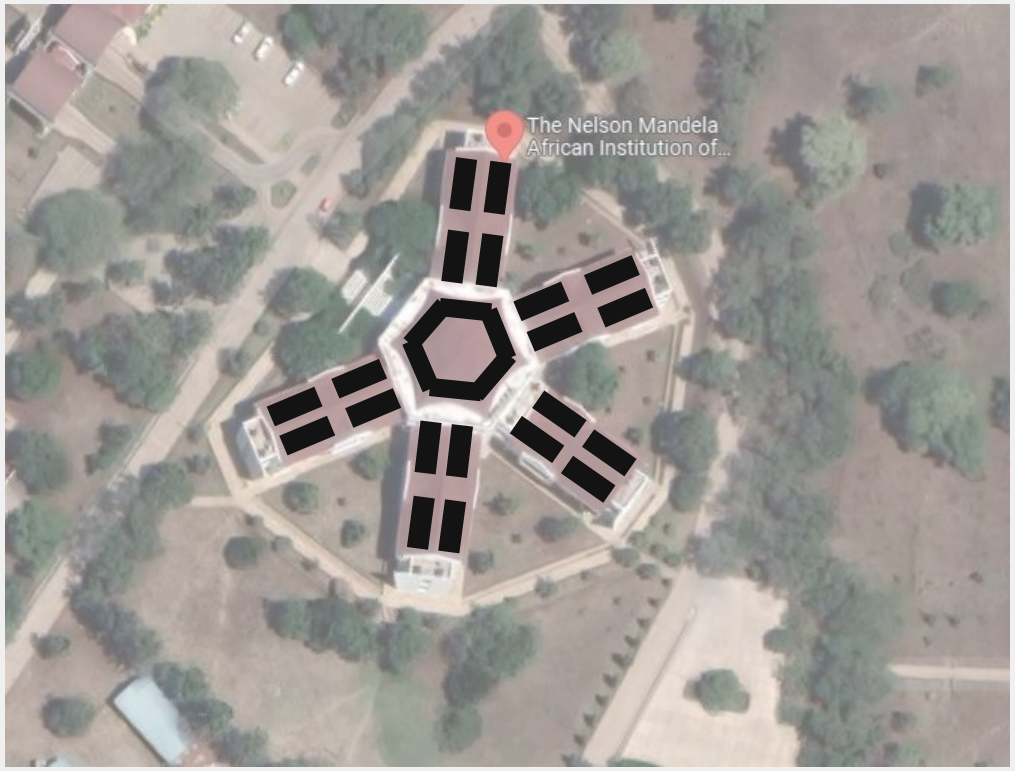
Zero-Emission Concepts for Urban Resilience in selected African cities

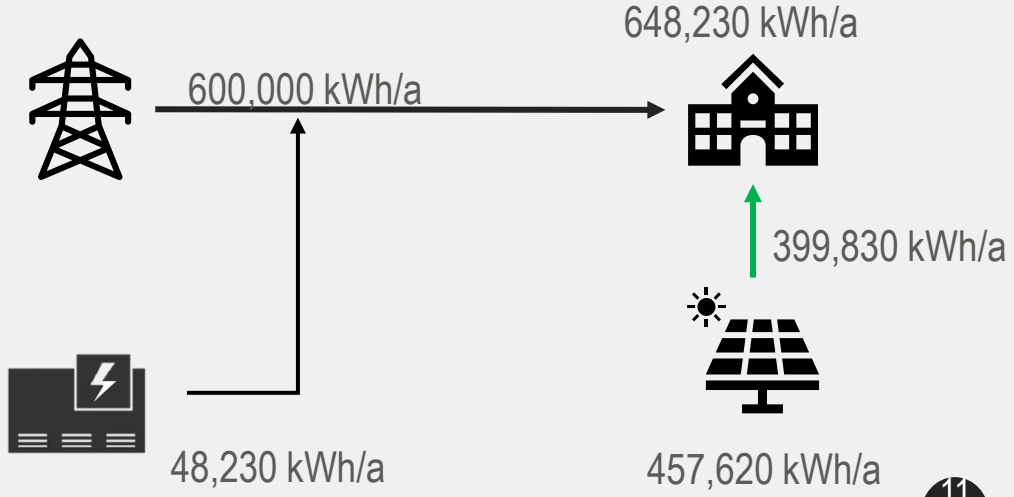
Photovoltaic

Ideas & Strategy: Photovoltaic system for NM-AIST



ITEM	UNIT	AMOUNT
Simulated installed capacity	kWp	235
Generation	kWh/a	457,620
Specific annual yield	kWh/kWp	1,947
Solar fraction	%	58.6%

Estimated electricity consumption (total)	600,000	kWh/a
Reported kVA (bill 04/03/2019)	248	kVA
Simulated peak load	226	kW
Required rooftop space (admin)	1,008	m^2



SOURCE: Simulated using PVSoL.

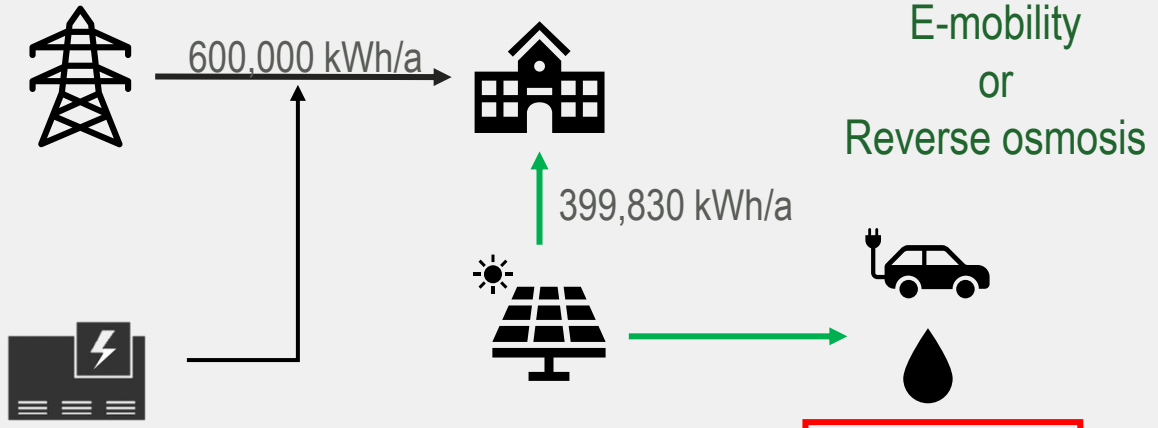
Ideas & Strategy: Photovoltaic system for NM-AIST

ADMINISTRATION BUILDING		
ITEM	UNIT	VALUE
Consumption by grid (Estimated)	kWh/a	600,000
Installed capacity	kWp	235
Specific annual yield	kWh/kWp	1,947
Annual generation	kWh/a	457,620
Self consumption	%	76.8%
Solar fraction (annual)	%	58.6%
LCoE	TZS/kWh	101
LCoE (with loan)	TZS/kWh	138
GHG savings (Grid)	tCO_{2e}/a	118

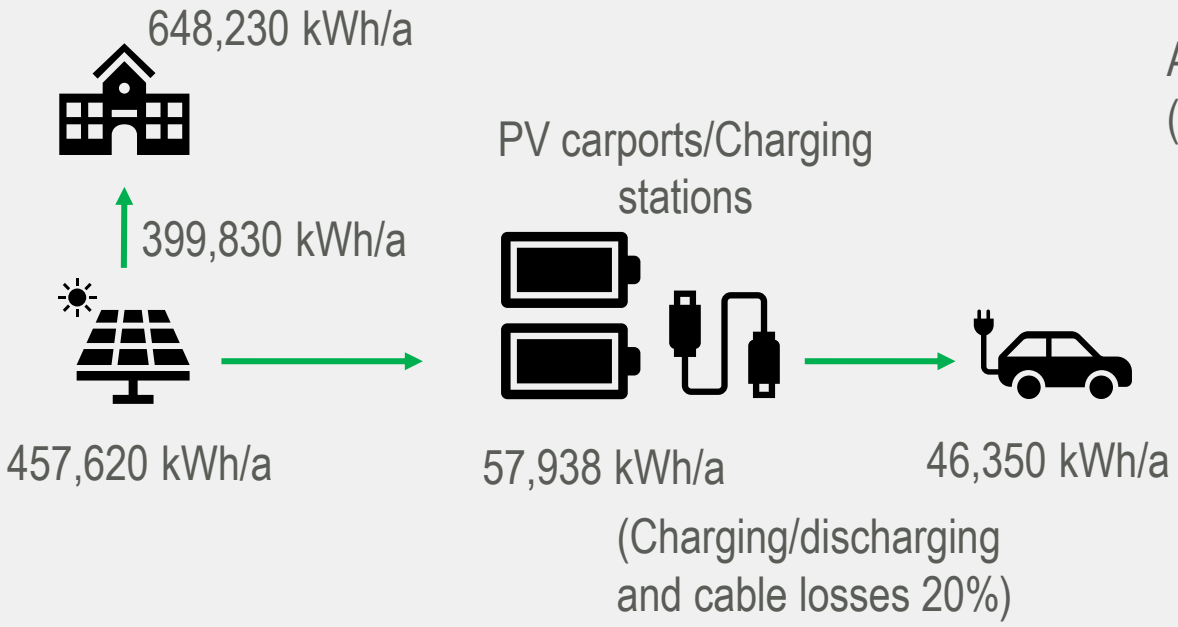
Total consumption is based on the simulated load profile for PV

Unitary turnkey price – 1,000 USD/kWp (3,473,000 TZS/kWp)
Current electricity price - 320 TZS/kWh

Energy supplied by generators	kWh/a	48,230
Total electricity supply covered by PV	KWh/a	399,830
Total GHG emission abatement	tCO_{2e}/a	158
Total cost savings	TZS/a	142,707,256
Available excess generation	kWh/a	57,938



Ideas & Strategy: Photovoltaic for green mobility



Average energy consumption of electric vehicles: 0.4 – 0.6 kWh/km
(Including all the losses in the vehicle battery and performance)

92,700 km/a equivalent

9,270 liters of diesel equivalent
(average 10 km/l of diesel)

Cost savings: 30.75 mil TZS/a
Emission savings in mobility: 24 tCO_{2e}/a

ITEM	UNIT	AMOUNT
Total installed capacity	kWp	235
Specific annual yield	kWh/kWp	1,947
Estimated investment (PV & charging station)	TZS	725,290,381
LCoE	TZS/kWh	101.0
LCoE (With 9% loan)	TZS/kWh	138.0
Total GHG savings (electricity, generators and mobility)	tCO_{2e}/a	182
Payback period	Years	7

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Mobility

Status quo: Mobility

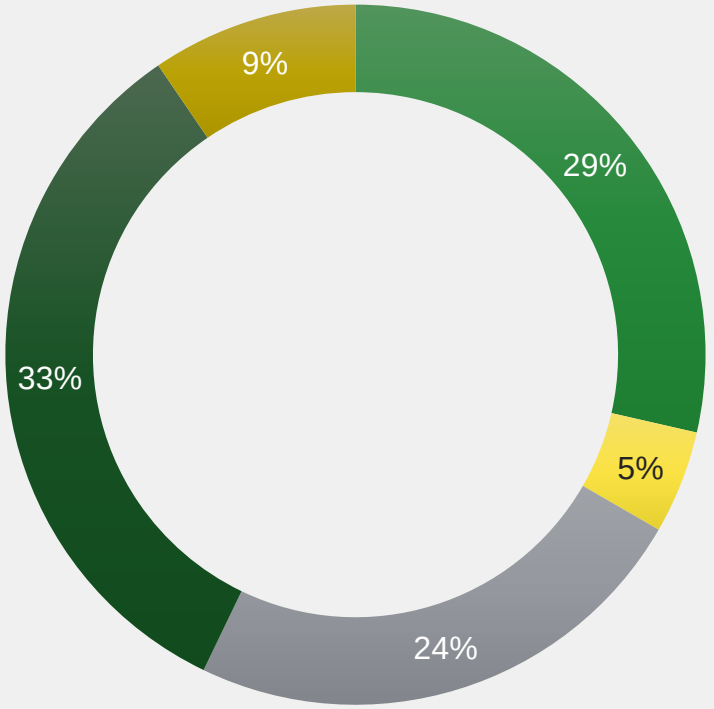
SUVs 06

Bus 01

Trucks 05

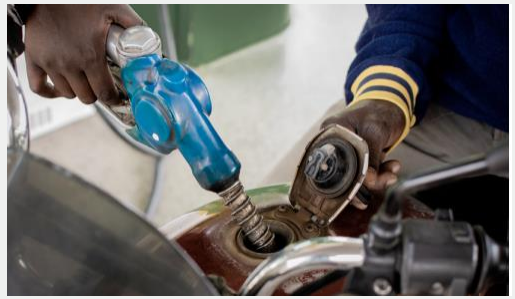
Cruisers 07

Motorcycles 02



Ideas & Strategies: Life cycle cost analysis

ITEM	UNIT	PETROL MOTORCYCLE	E-MOTORCYCLE
CAPEX	TZS	3,282,758	5,019,796
Fuel consumption/100km	l or *kWh*	3	*3*
Annual mileage	km/a	25,000	25,000
Fuel costs	TZS/l or *TZS/kWh*	3,359	*138*
Total Fuel costs per year	TZS/a	2,519,250	103,500
Maintenance costs	TZS/a	328,276	250,990
GHG emissions	tCO_{2e}/a	1.7	0
Life cycle costs (10 Years)	TZS	3,175,802	856,469



SOURCE: https://a2ei.org/resources/uploads/2021/10/A2EI_Greenfooot_E-Mobility-Adoption-in-Tanzania_Business-and-technical-insights-on-productive-use-cases.pdf

Ideas & Strategies: Life cycle cost analysis

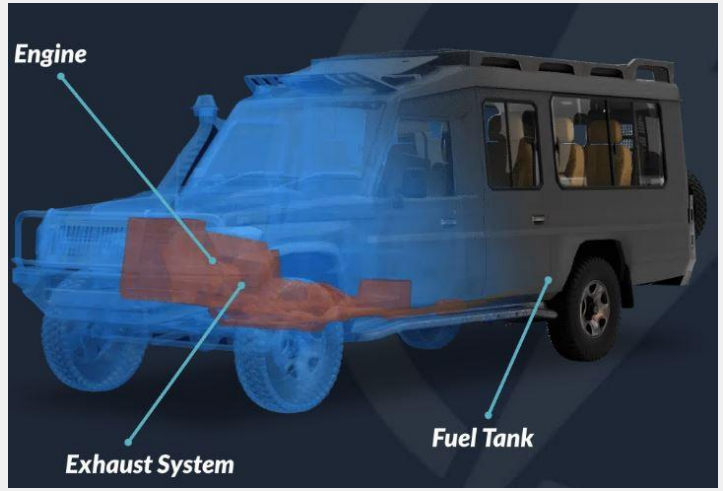
ITEM	UNIT	CURRENT VEHICLE	E-VEHICLE
Model		**TOYOTA HILUX**	**FORD F-150 LIGHTNING**
CapEx	TZS	83,581,802	93,675,715
Fuel consumption/100km	l or *kWh*	9	*26*
Annual mileage	km/a	50,000	50,000
Fuel costs	TZS/l or *TZS/kWh*	3,318	*138*
Total Fuel costs per year	TZS/a	14,102,180	1,794,000
Maintenance costs	TZS/a	4,179,090	2,810,271
GHG emissions	tCO_{2e}/a	6	0
Life cycle costs	TZS	10,186,307	9,827,999

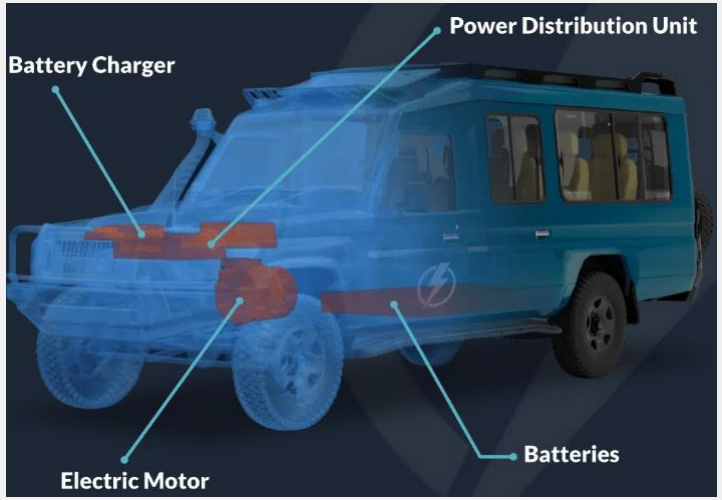
SOURCE: https://www.ford.com/trucks/f150/f150-lightning-electric-truck/ & https://www.cars-data.com/en/toyota-hilux/co2-emissions

Ideas & Strategies (Alternative solution)

Switching a fuel car system to an electric car system.

Removing the existing fuel car system and replacing it with a complete electrical system i.e. an electric motors, battery system, onboard charger, information display.





SOURCE: e-motion.africa

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Future: Reaching net zero

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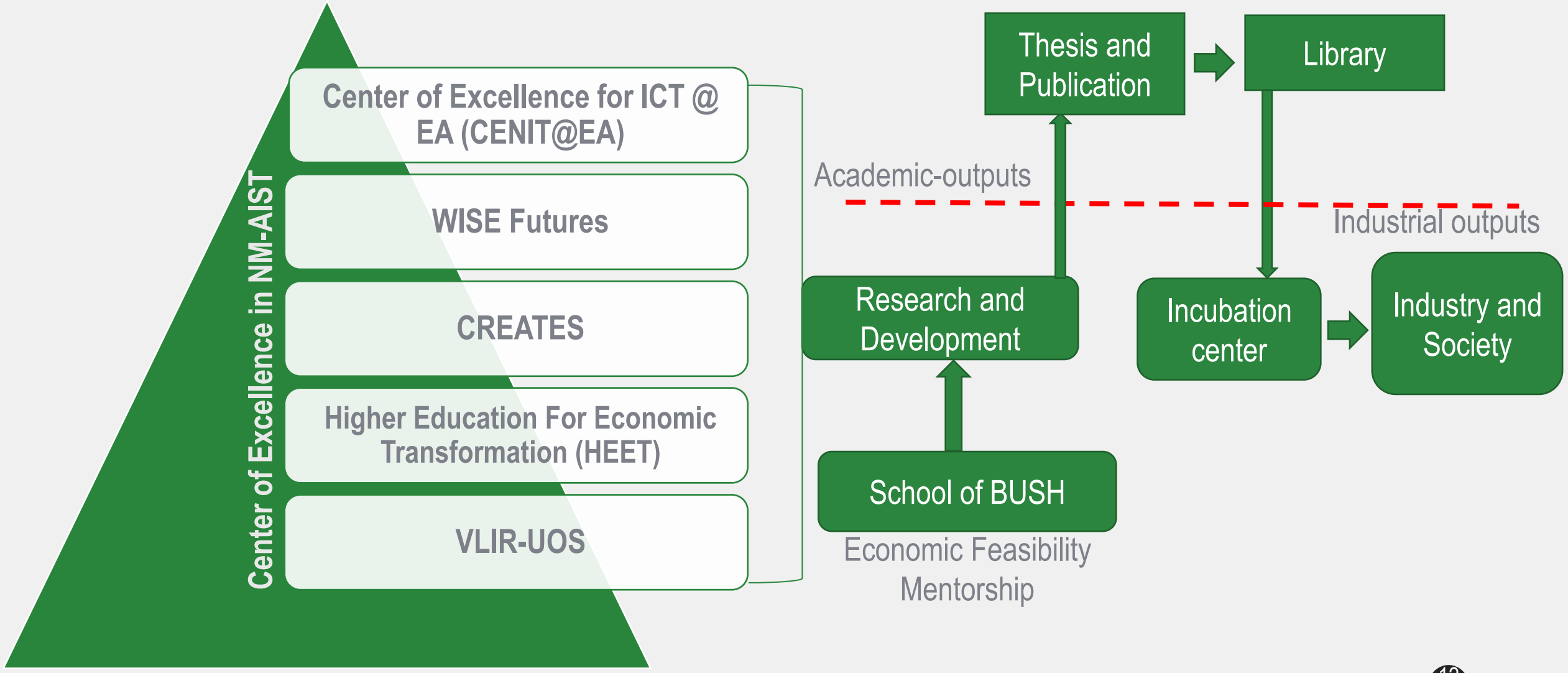
CECC

Status quo: Centers at NM-AIST



Circular Economy Competence Center

Societal Resilience

establishing a sustainable complex

Circular Economy

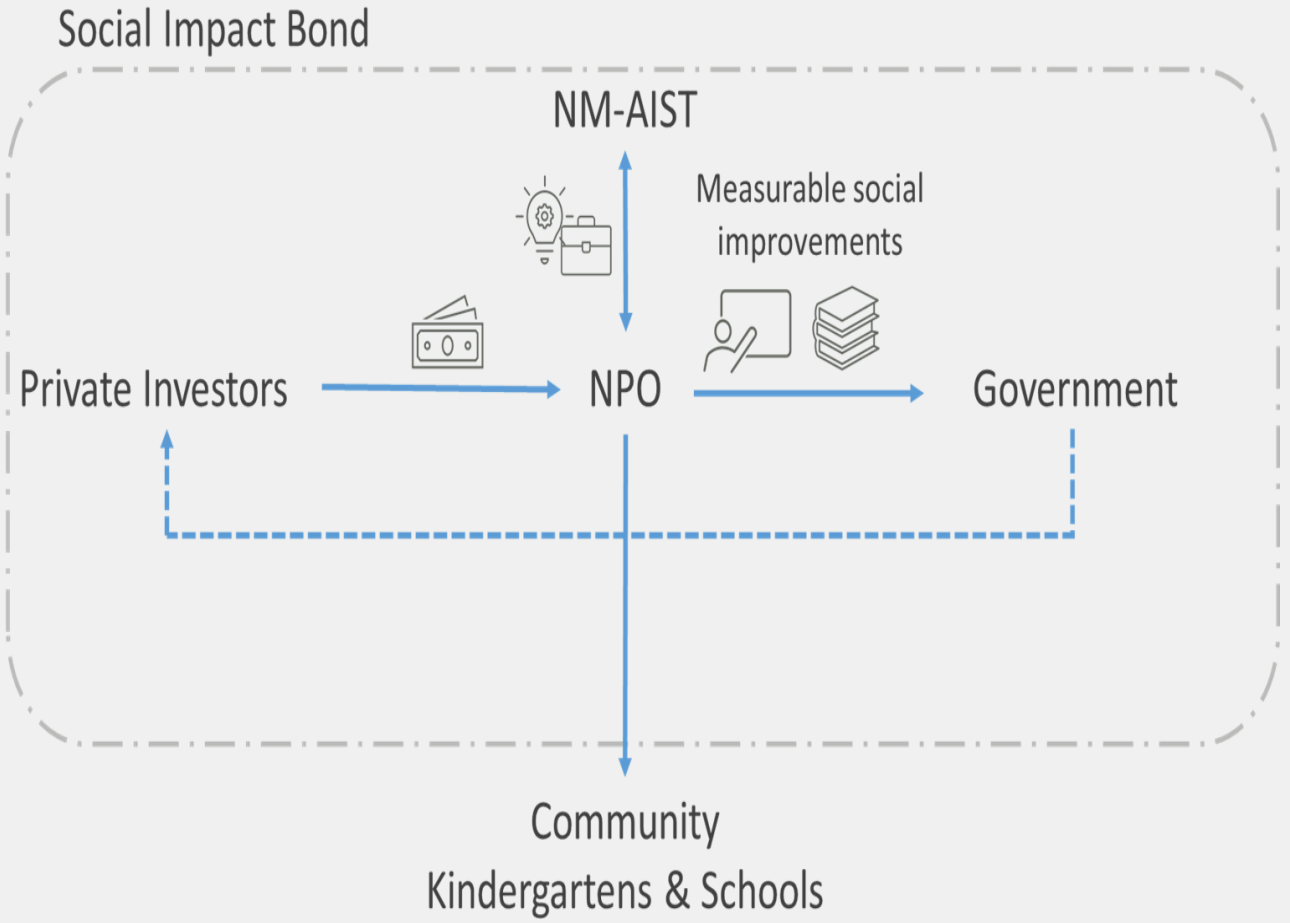
utilizing current resources

Community Awareness

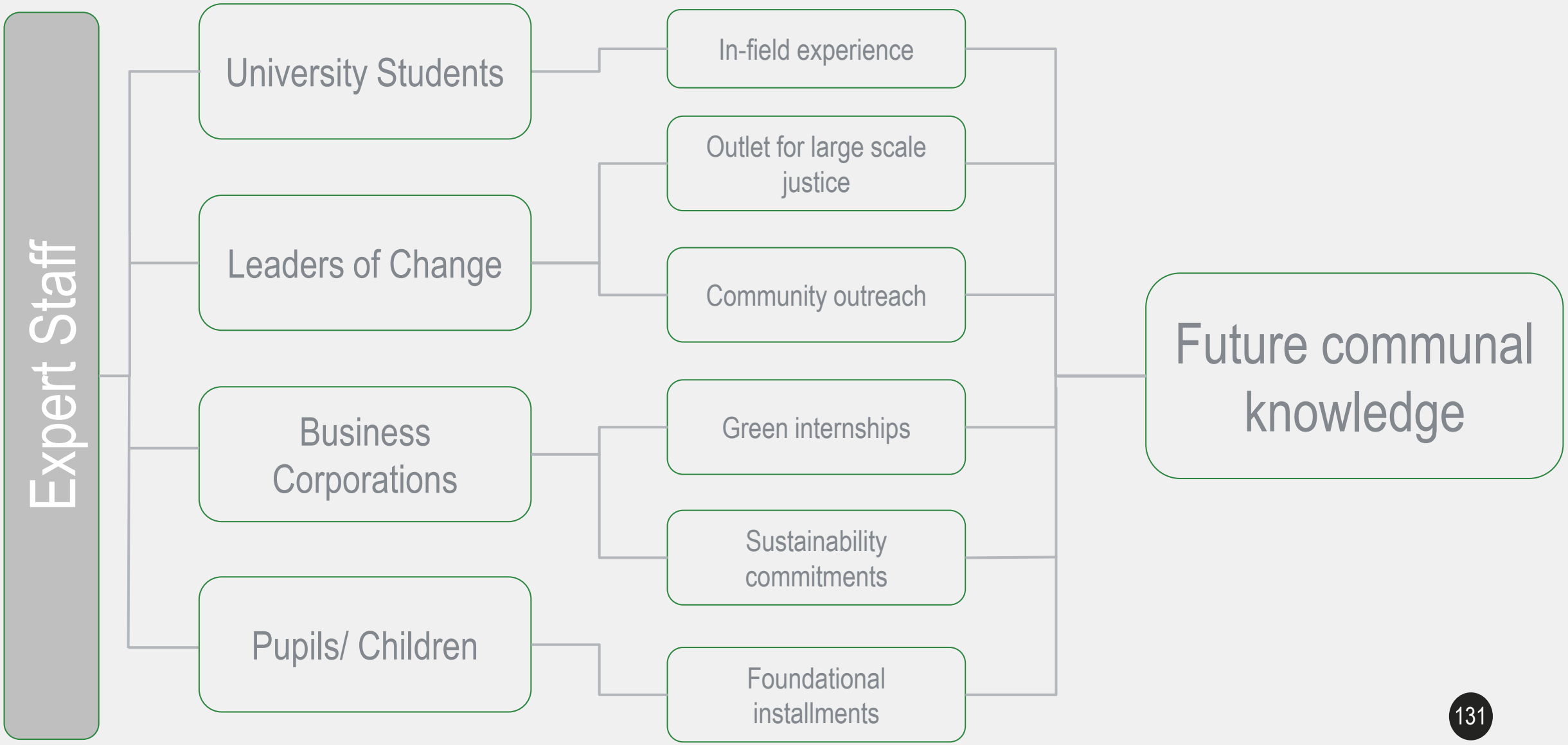
developing a bottom up system

Base financing CECC

	ITEM	UNIT	AMOUNT
CAPEX	Inventory (Computers)	TZS	7,700,000
	Electric Vehicles	TZS	77,000,000
	TOTAL	**TZS**	**84,700,000**
OPEX	Labour	TZS/a	30,000,000
	Running Costs (E-Vehicles)	TZS/a	243,529
	Electricity consumption CECC	TZS/a	327,600
	TOTAL	**TZS/a**	**30,571,129**



Branches of Impact



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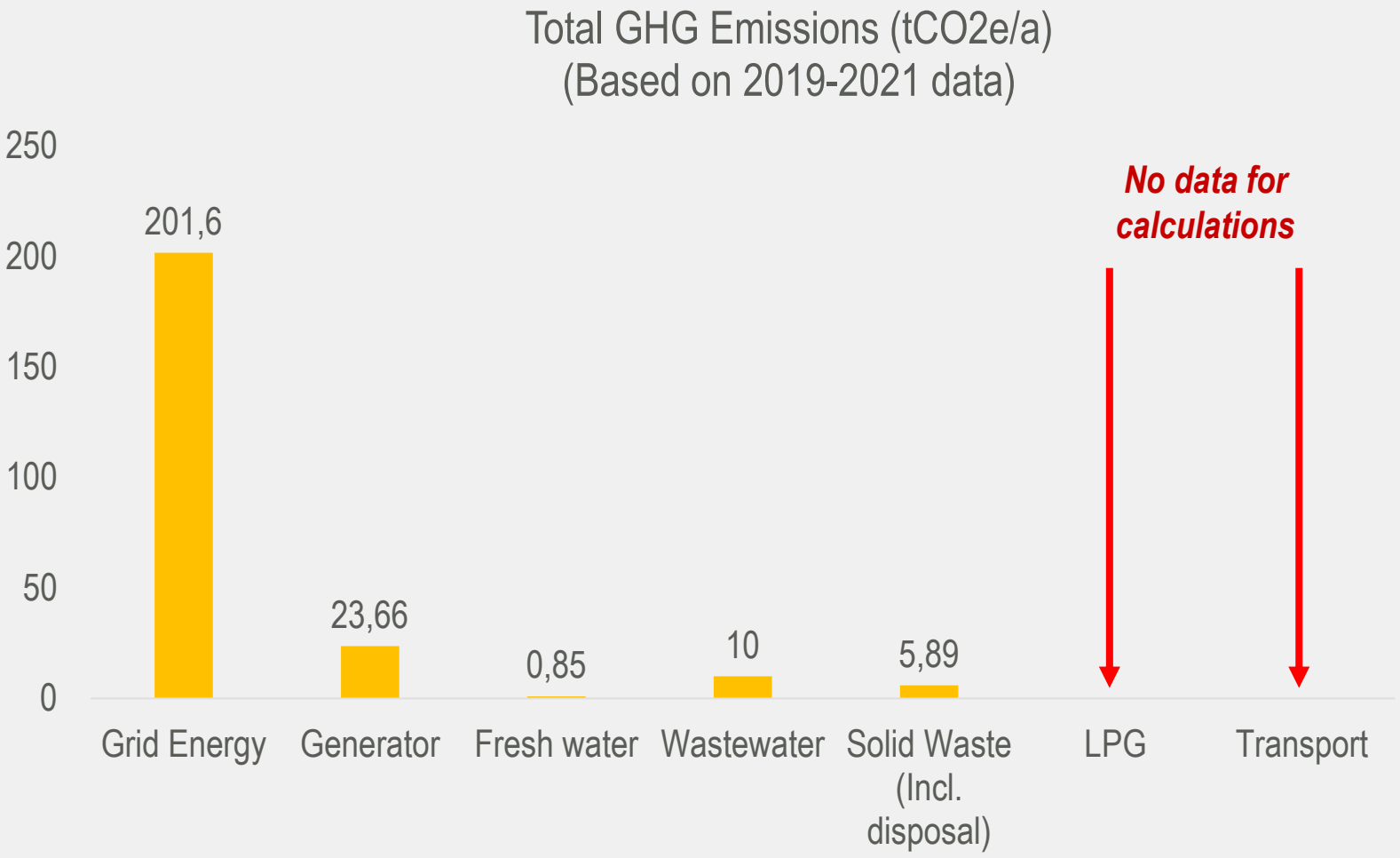
Conclusion

Status quo - GHG balance of NM-AIST



Total GHG emissions

242 tCO_{2e}/a

(Excluding Transport and LPG emissions)

Average GHG Emission (NM-AIST)

0.40 $tCO_{2e}/ca/a$

Average GHG Emission (Tanzania)

0.2 t $CO_{2e}/ca/a$

SOURCE: World bank (2019)

Total investments & savings

	ITEM	UNIT	AMOUNT	PAYBACK (YEARS)
MSW	**Waste Resource Center**			
	Total Potential Income - Plastic, Metal, etc.	TZS/a	20,160,000	
	Total Cost	TZS	16,500,000	1
	Biogas Digester			
	Monetary Savings	TZS/a	19,239,205	
	Estimated CAPEX	TZS	56,599,200.00	3
Fresh Water	**Faucets**			
	Monetary Savings	TZS/a	4,555,200	
	Estimated CAPEX	TZS	14,070,000.00	3
	Efficient Cisterns			
	Monetary Savings	TZS/a	1,138,800	
	Estimated CAPEX	TZS	5,266,000	5
	Waterless Urinals			
	Monetary saving	TZS/a	1,138,800	
	Estimated CAPEX & OPEX	TZS	11,256,000	10
	Rain Water Harvesting			
	Monetary saving	TZS/a	7,562,198	
	Estimated CAPEX	TZS	54,292,700	7

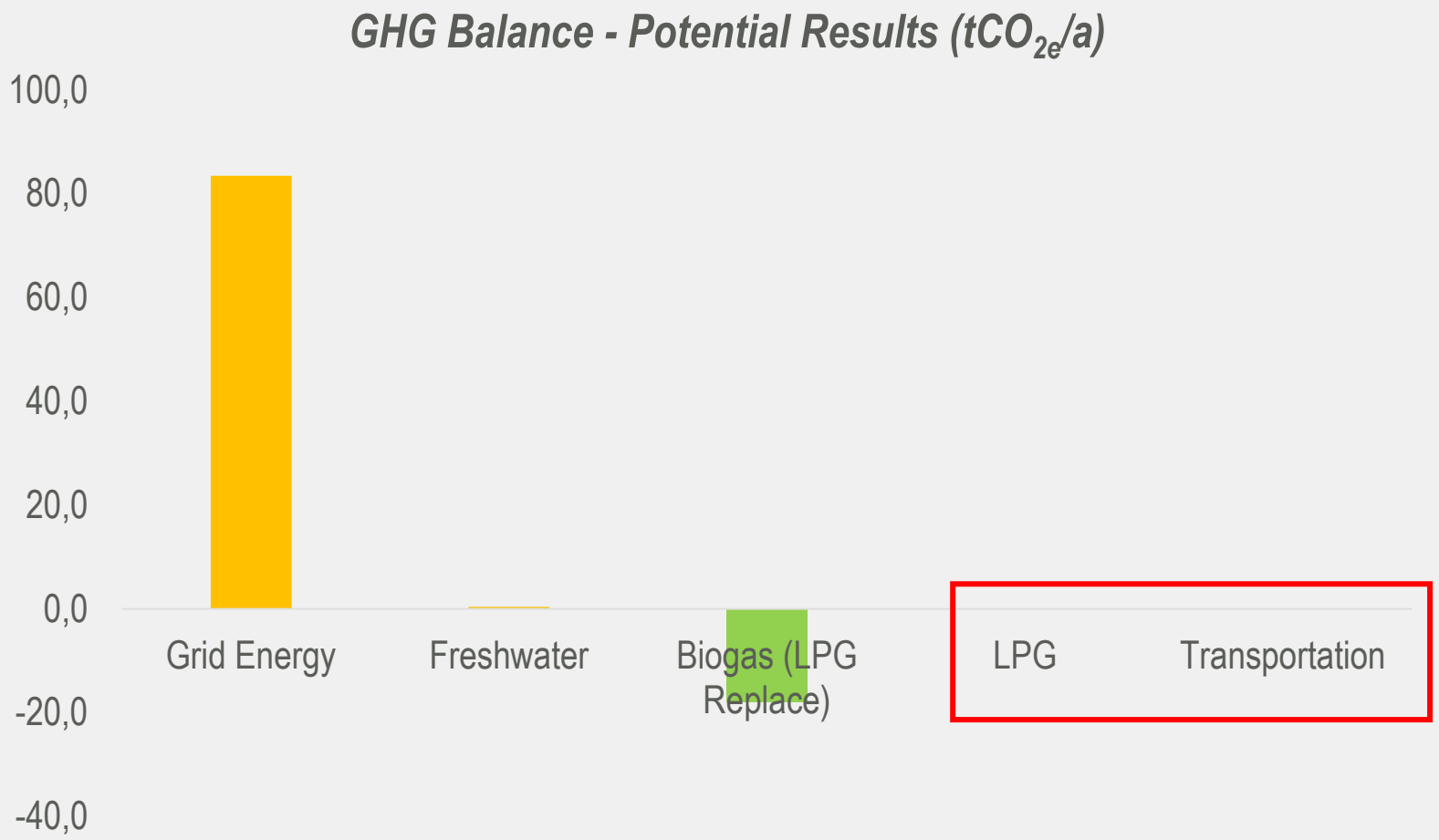
Total investments & savings *(cont.)*

	ITEM	UNIT	AMOUNT	PAYBACK (YEARS)
Wastewater	**Reed Bed Filter**			
	Total Savings in Water	TZS/a	5,306,600	
	Estimated investment cost	TZS	81,972,800	15
	Honey Production			
	Monetary Savings	TZS/a	143,369	6
	Estimated CAPEX	TZS	930,320	
Energy	**Lighting**			
	Monetary Savings	TZS/a	5,423,616	5
	Estimated Investment	TZS	26,172,200	
	Pump System			
	Monetary Savings	TZS/a	2,291,427	3
	Estimated CAPEX	TZS	6,421,909	
	Air-conditioning			
	Monetary Savings	TZS/a	5,996,009	6
	Estimated CAPEX	TZS	35,018,667	
	PV System			
	Monetary Savings	TZS/a	103,612,912	7
	Estimated CAPEX	TZS	725,290,381	
	E-Motorbike			
	Monetary Savings	TZS/a	2,248,620	2
	Estimated CAPEX	TZS	5,019,796	
	E-Truck			
	Monetary Savings	TZS/a	4,971,090	22
	Estimated CAPEX	TZS	109,510,000	

Total investments & savings *(cont.)*

ITEM	UNIT	AMOUNT	PAYBACK (YEARS)
TOTAL BENEFITS	TZS/a	183,787,845	
TOTAL INVESTMENTS	TZS	1,148,319,973	6
	EUR	510,004	

GHG Balance: Abatement potential



Total GHG emissions

65.9 tCO_{2e}/a

(Excluding the carbon stock)

NM-AIST emissions can be reduced to

0.11 $tCO_{2e}/ca/a$

Average GHG Emission (Tanzania)

0.2 t $CO_{2e}/ca/a$

SOURCE: World bank (2019)

Challenges & Opportunities: on the road to zero emissions

Challenges

- Organise the necessary investments
- Identify knowledge and technology gaps
- Asset management and maintenance
- Institutional capacity and policy framework(s)

Opportunities

- Empowerment: from donors to investors
- Participatory multistakeholder engagement
- Capitalise on carbon mitigation and sequestration potential
- Job and skills creation
- New (non) academic research & curriculum

...the complete picture

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Asante!

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Q & A

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