RAPID PLANNING

SUSTAINABLE INFRASTRUCTURE, ENVIRONMENTAL AND RESOURCE MANAGEMENT FOR HIGHLY DYNAMIC METROPOLISES

Rapid Planning Results for Kigali

November 12-14th 2019

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Introduction

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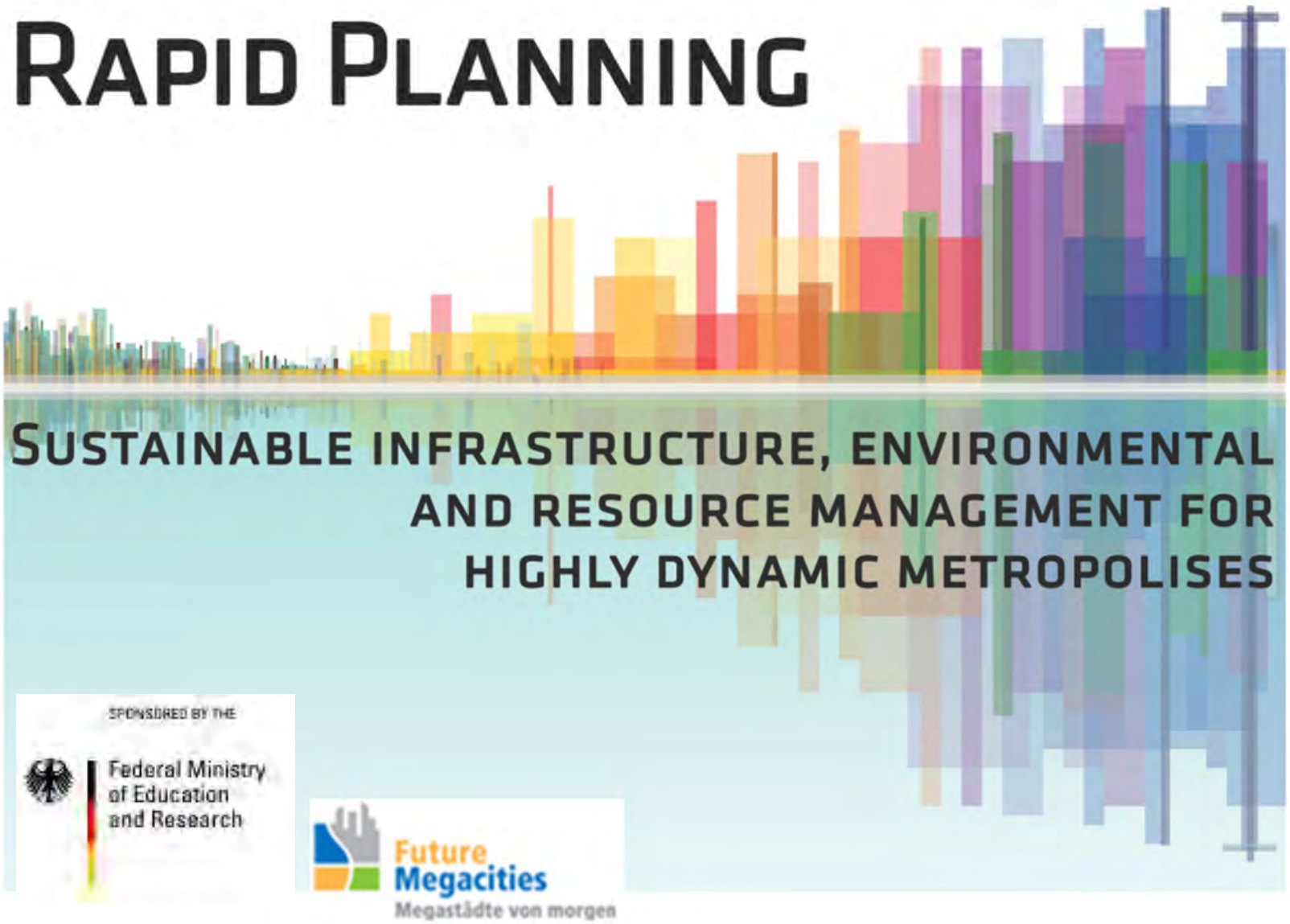

Duration 2014-2019 **Funded by** German Ministry of Education and Research BMBF

THE RAPID PLANNING PROJECT

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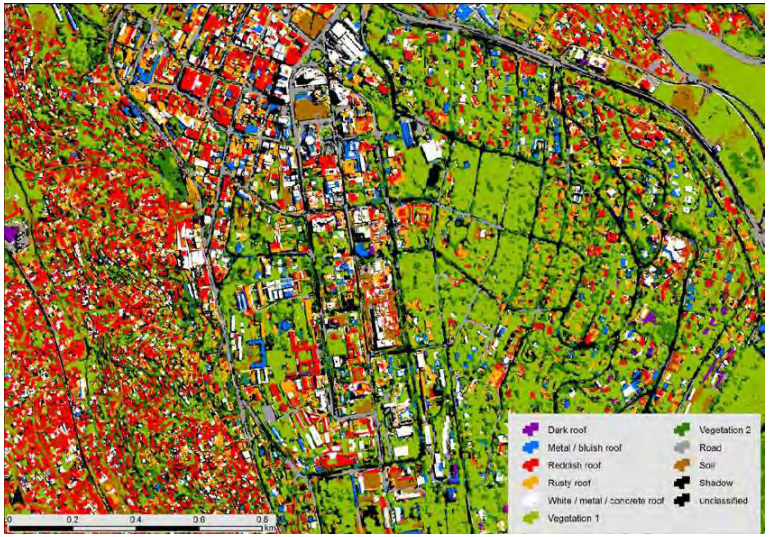
Development and testing of a rapid trans-sectoral and integrated planning methodology for regional resource management and supply & disposal infrastructure

→ strategic pre-planning



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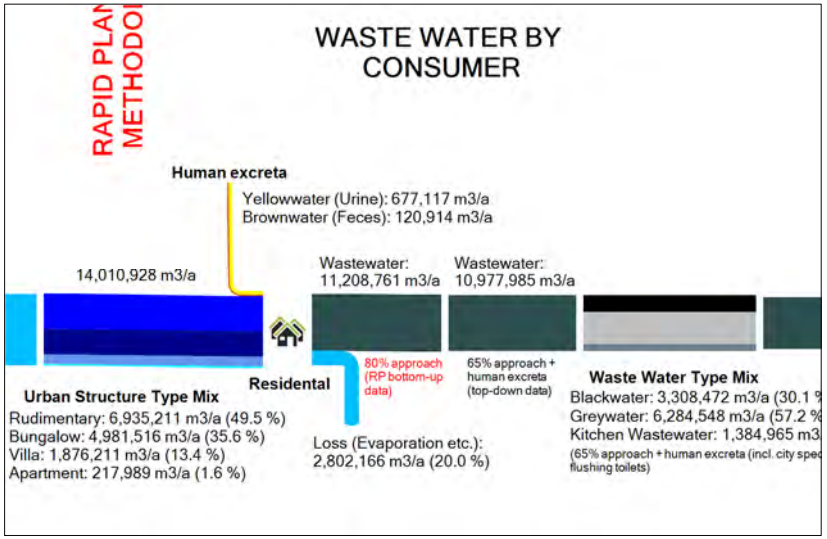

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TEAM

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AT-Verband, Verband zur Förderung angepasster, sozial- & umweltverträglicher Technologien e.V.

AT-Association, association for the promotion of socially & environmentally appropriate technologies e.V.

Brandenburgische Technische Universität (BTU) Cottbus

Brandenburg University of Technology Cottbus

Fachhochschule Frankfurt am Main – University of Applied Sciences

FFin / Frankfurt Research Institute for Architecture · Civil Engineering · Geomatics

FRANKFURT UNIVERSITY OF APPLIED SCIENCES

Institut für Automation und Kommunikation e. V. (ifak), Magdeburg

ifak

ifeu – Institut für Energie- und Umweltforschung Heidelberg GmbH

Institute for Energy and Environmental Research (IFEU)

ifeu

IUWA e.V.

IUWA

IZES gGmbH – Institut für ZukunftsEnergieSysteme

Institute for Future Energy Systems

izes gGmbH

Ostfalia University of Applied Sciences, Campus Suderburg

Ostfalia
Hochschule für angewandte Wissenschaften

Technische Universität Berlin (TU Berlin)
School VI. Planning Building Environment
Dept. of Landscape Architecture and Environmental Planning
Chair of Landscape Architecture. Open Space Planning

University of Stuttgart
Institute of Energy Economics and the Rational Use of Energy (IER)

IER

Eberhard Karls Universität Tübingen
Faculty of Science,
Department of Geosciences
Chair of Geoinformatics

EBERHARD KARLS UNIVERSITÄT TÜBINGEN

The United Nations Human Settlements Programme – UN HABITAT

UN HABITAT
FOR A BETTER URBAN FUTURE

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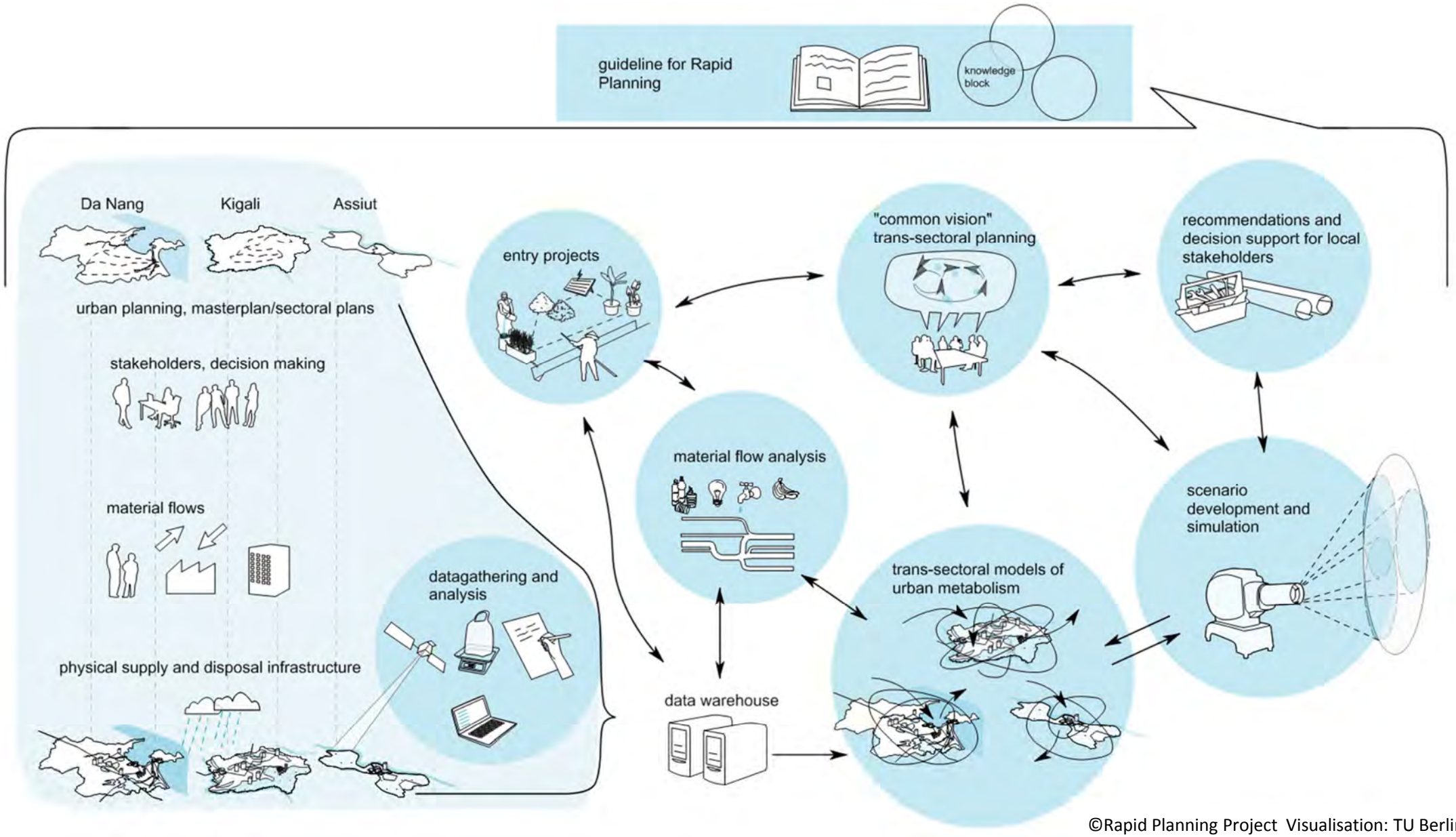

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Session 1

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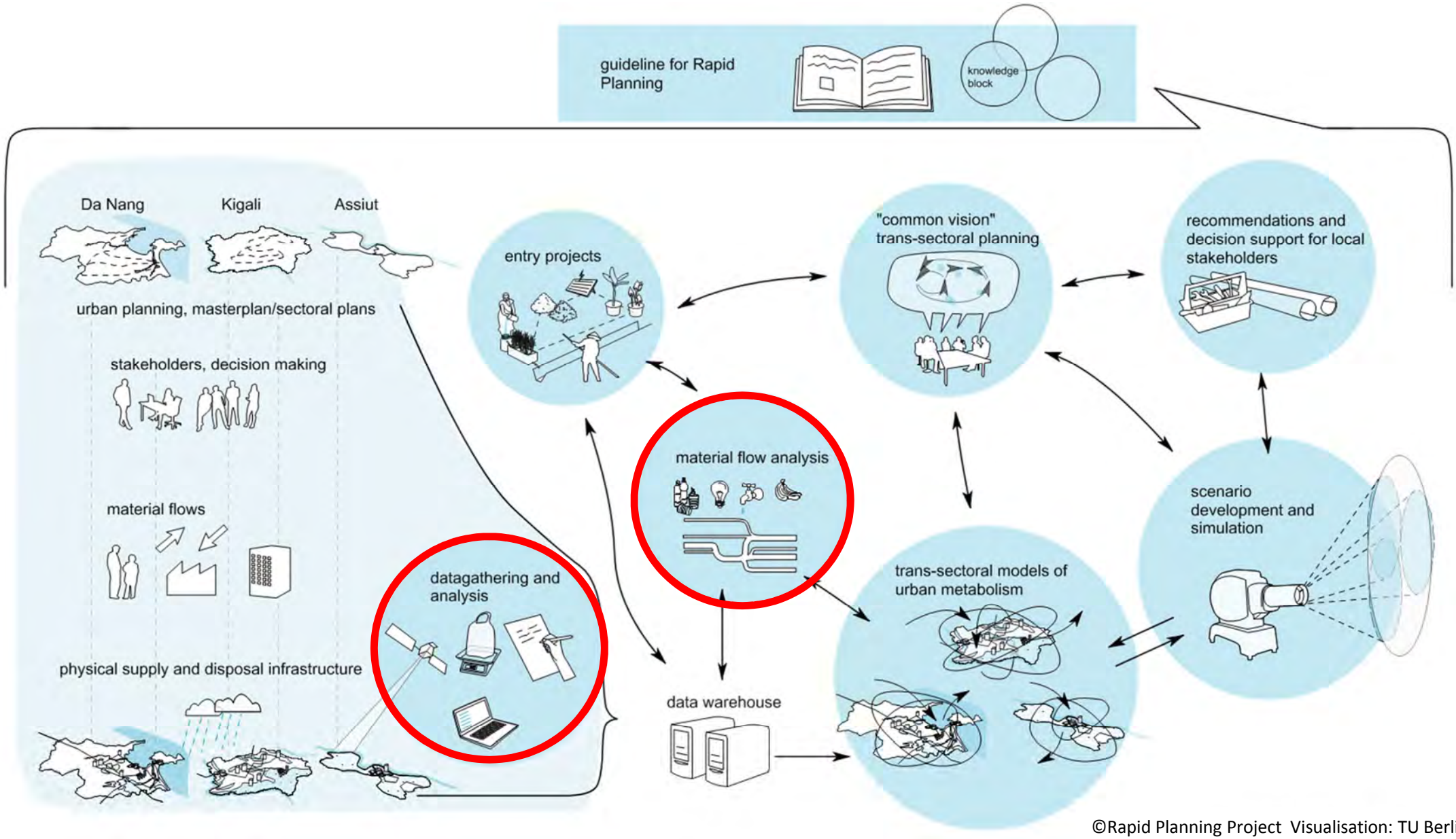
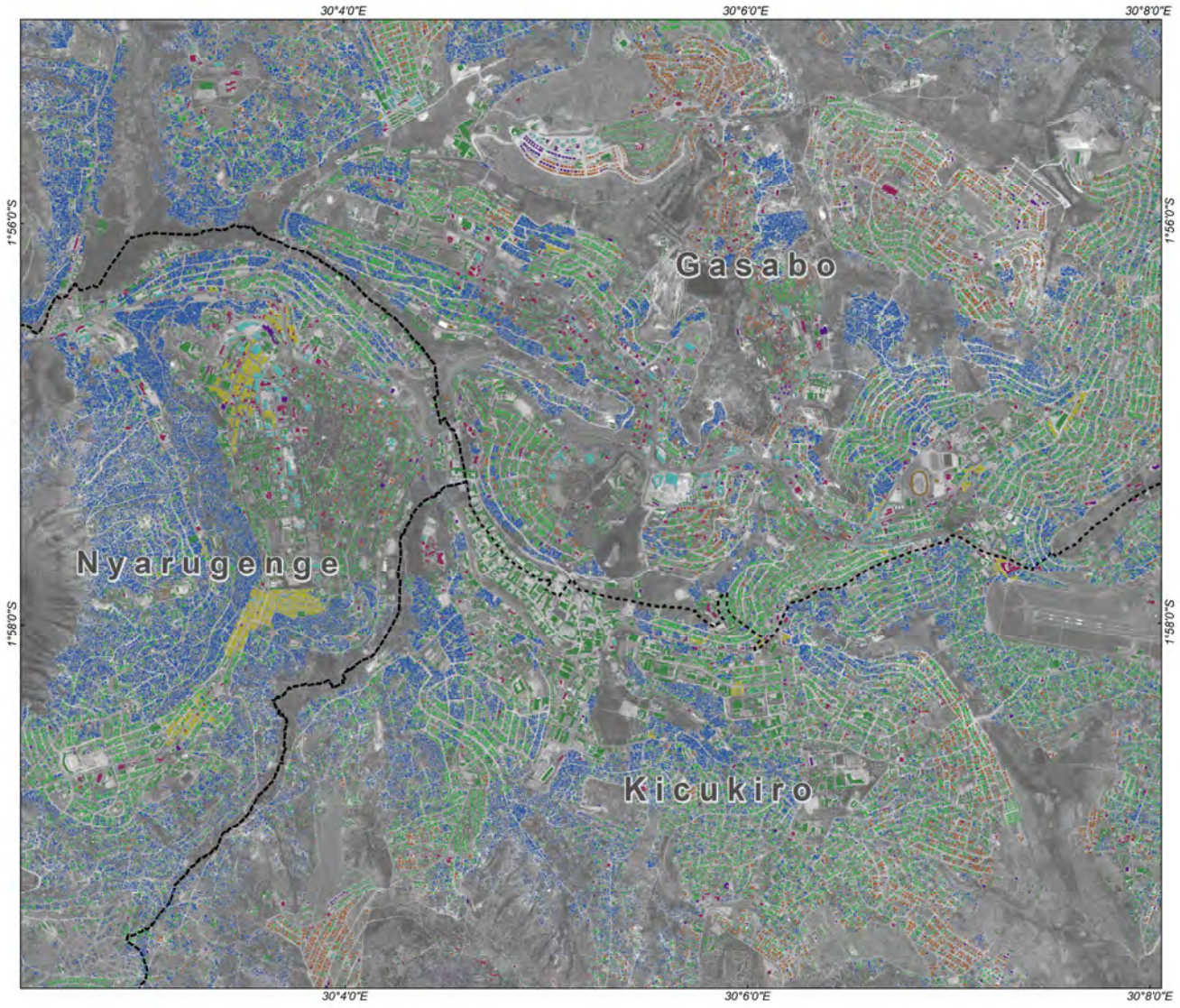


SPATIALLY RESOLVED RESULTS - KIGALI STATUS QUO

Building Types



Legend

building type

- basic
- bungalow
- villa
- midrise
- highrise
- block
- construction
- hall
- special

Administrative boundaries:
The province of Kigali is divided into 3 districts,
The boundaries are provided by the Rwanda Natural Resource Authority (RNRA).

The basemap is a RapidEye image acquired on 14.07.2015

This map was compiled for Rapid Planning

Author: Dr. Andreas Braun
University of Tuebingen
Department of Geography
Version: 10/2019

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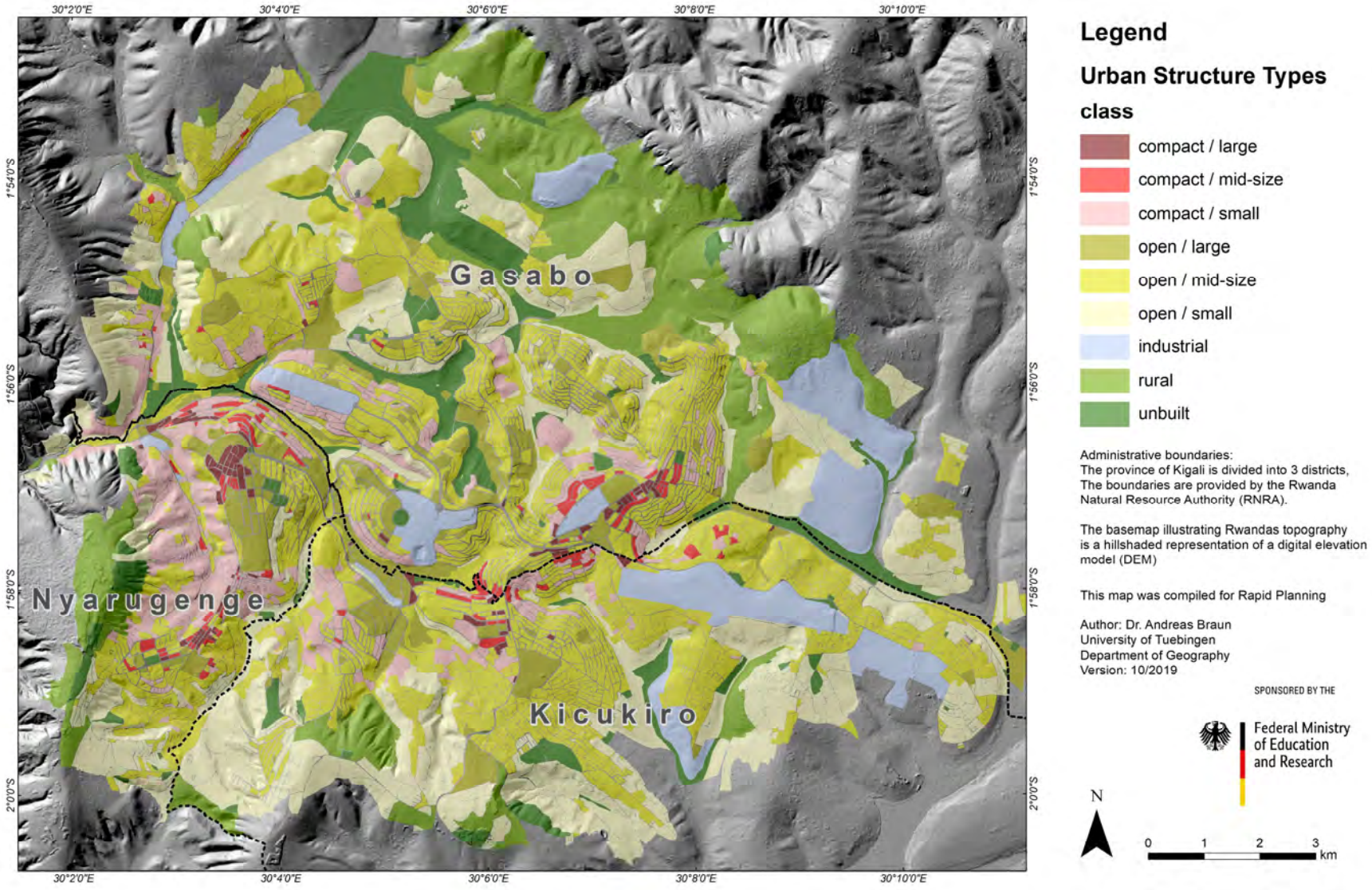
0 1 2 km

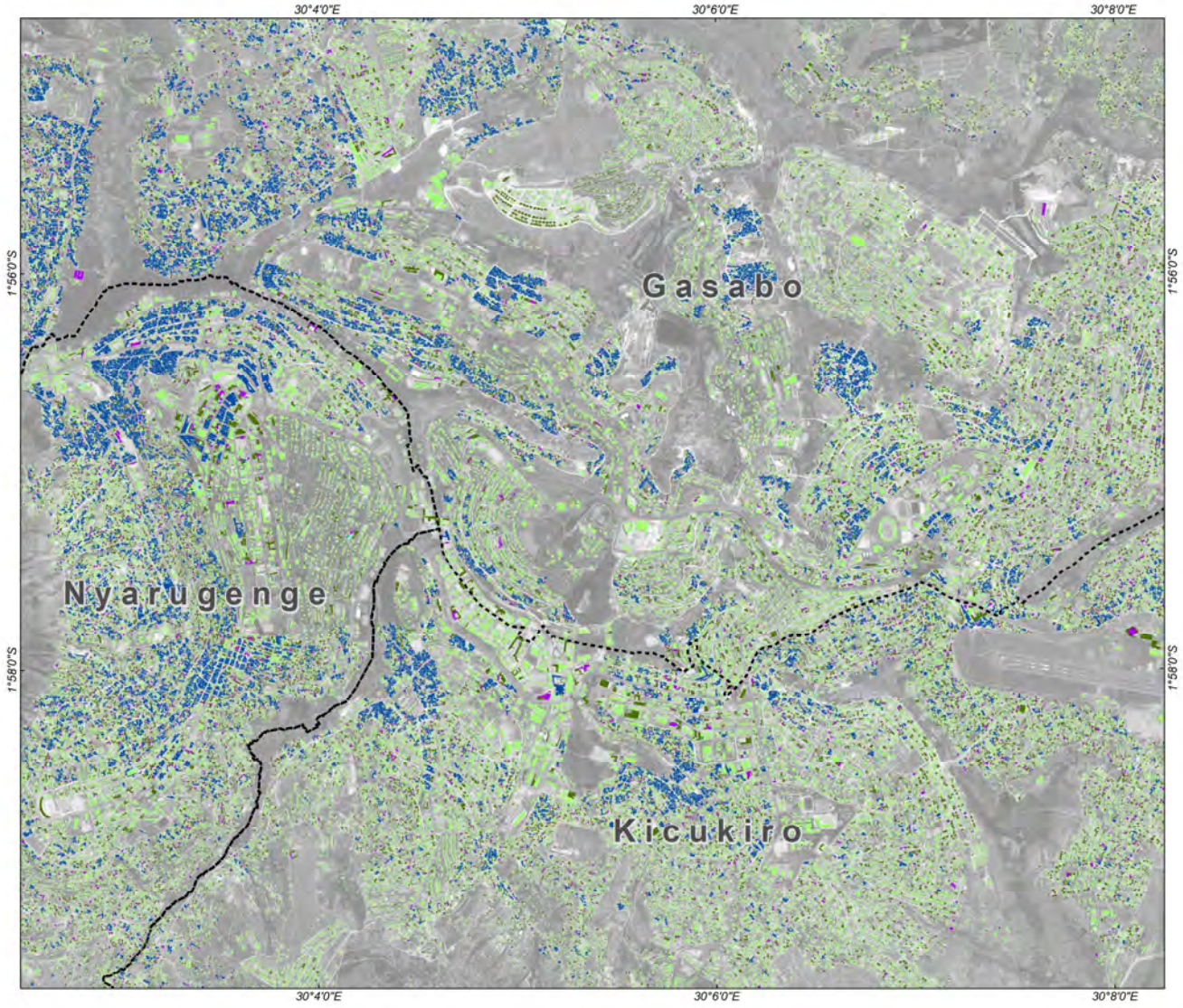
SPATIALLY RESOLVED RESULTS - KIGALI STATUS QUO

Urban Structure Types (USTs)



SPATIALLY RESOLVED RESULTS - KIGALI STATUS QUO

Building morphology – neighbourhood types



Legend

Neighbourhood morphology

- Single detached
- Single attached
- Grouped or terraced (attached)
- Cluster of attached buildings
- Row houses

Administrative boundaries:
The province of Kigali is divided into 3 districts, The boundaries are provided by the Rwanda Natural Resource Authority (RNRA).

The basemap is a Pléiades image acquired on 14.07.2015

This map was compiled for Rapid Planning

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SPATIALLY RESOLVED RESULTS - KIGALI STATUS QUO

Aggregated building statistics, e.g. villas-type buildings

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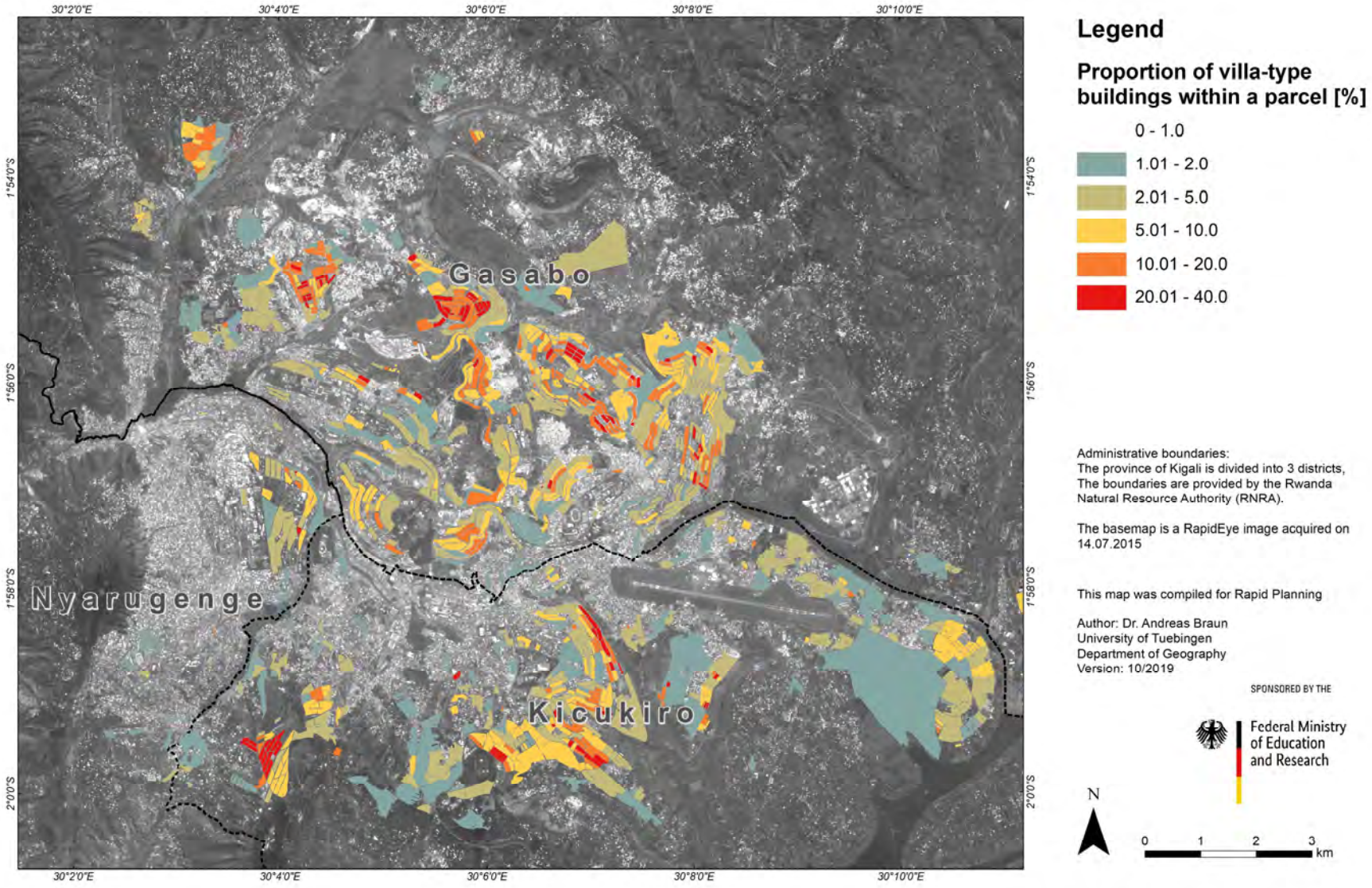
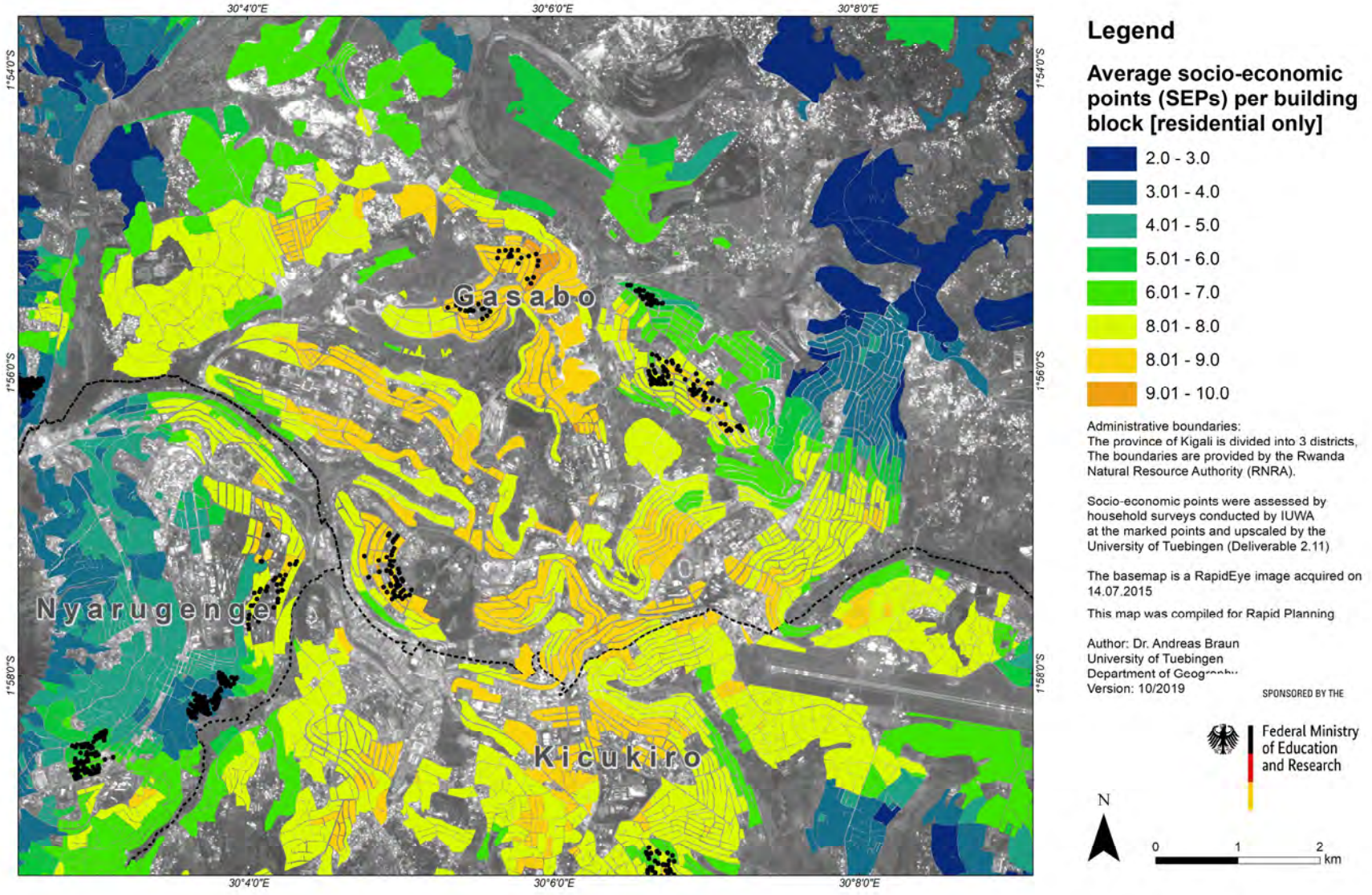


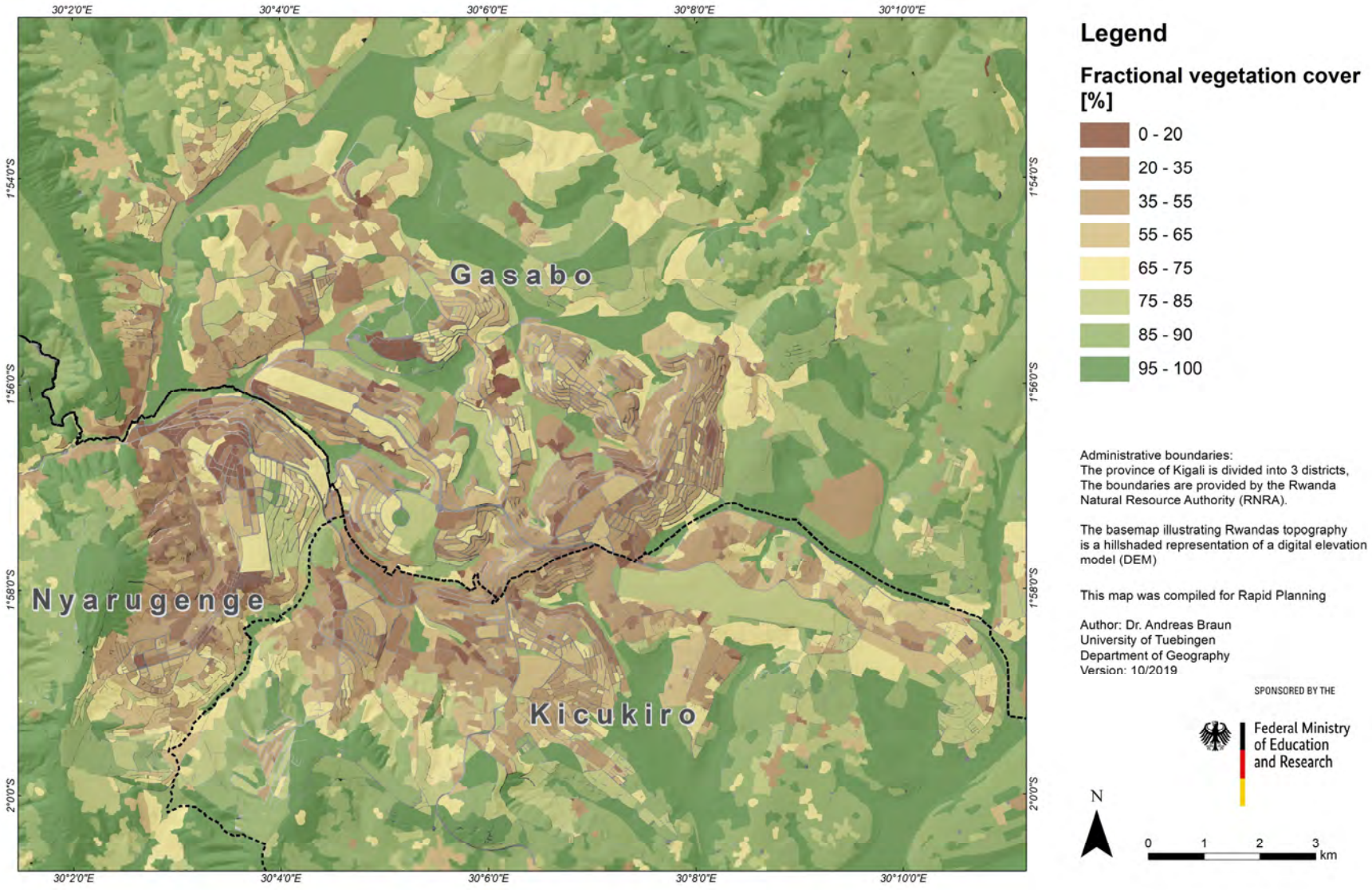
SPATIALLY RESOLVED RESULTS - KIGALI STATUS QUO

Socio-economic conditions



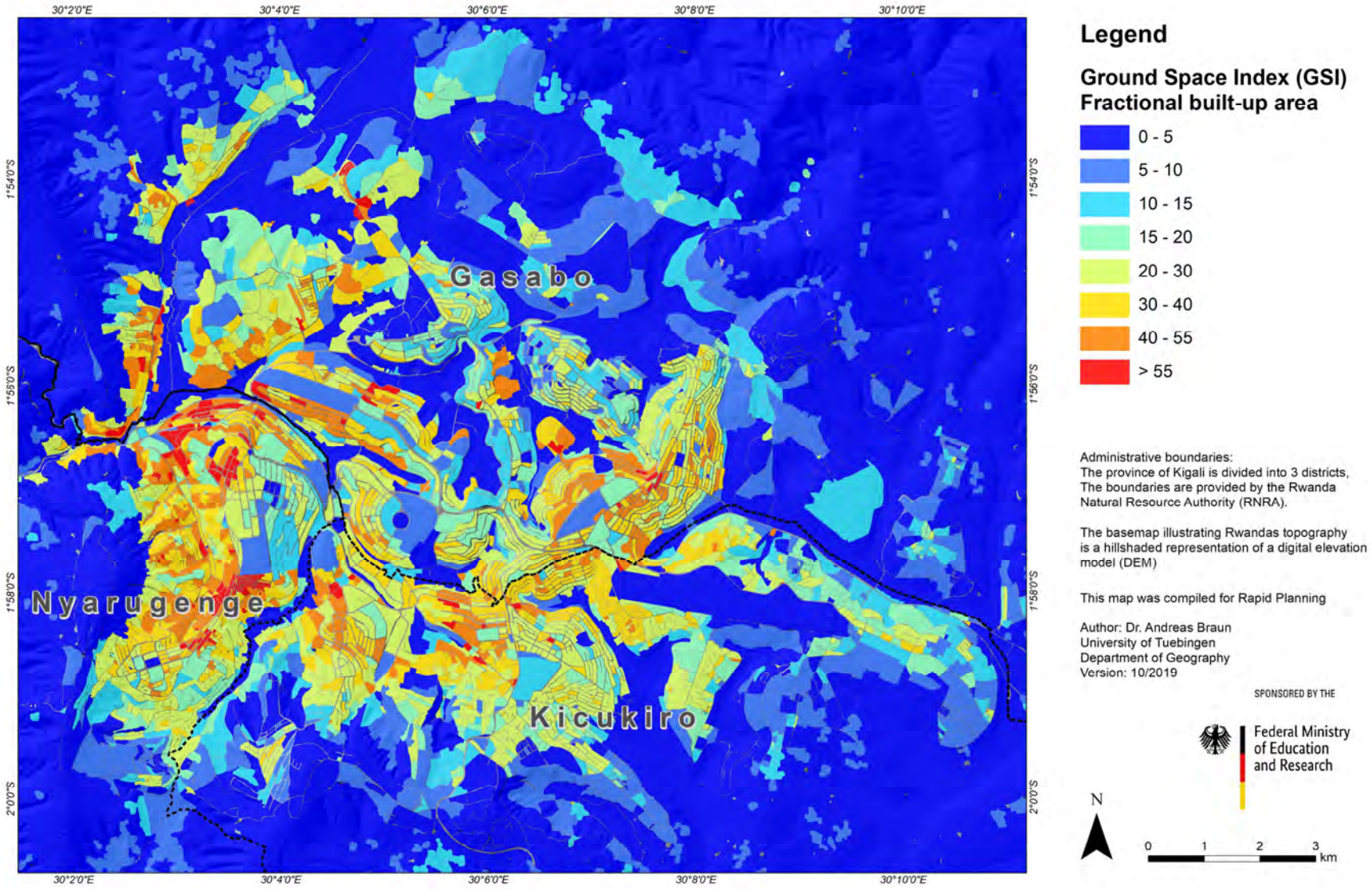
SPATIALLY RESOLVED RESULTS - KIGALI STATUS QUO

Spatial indicators, natural: vegetation



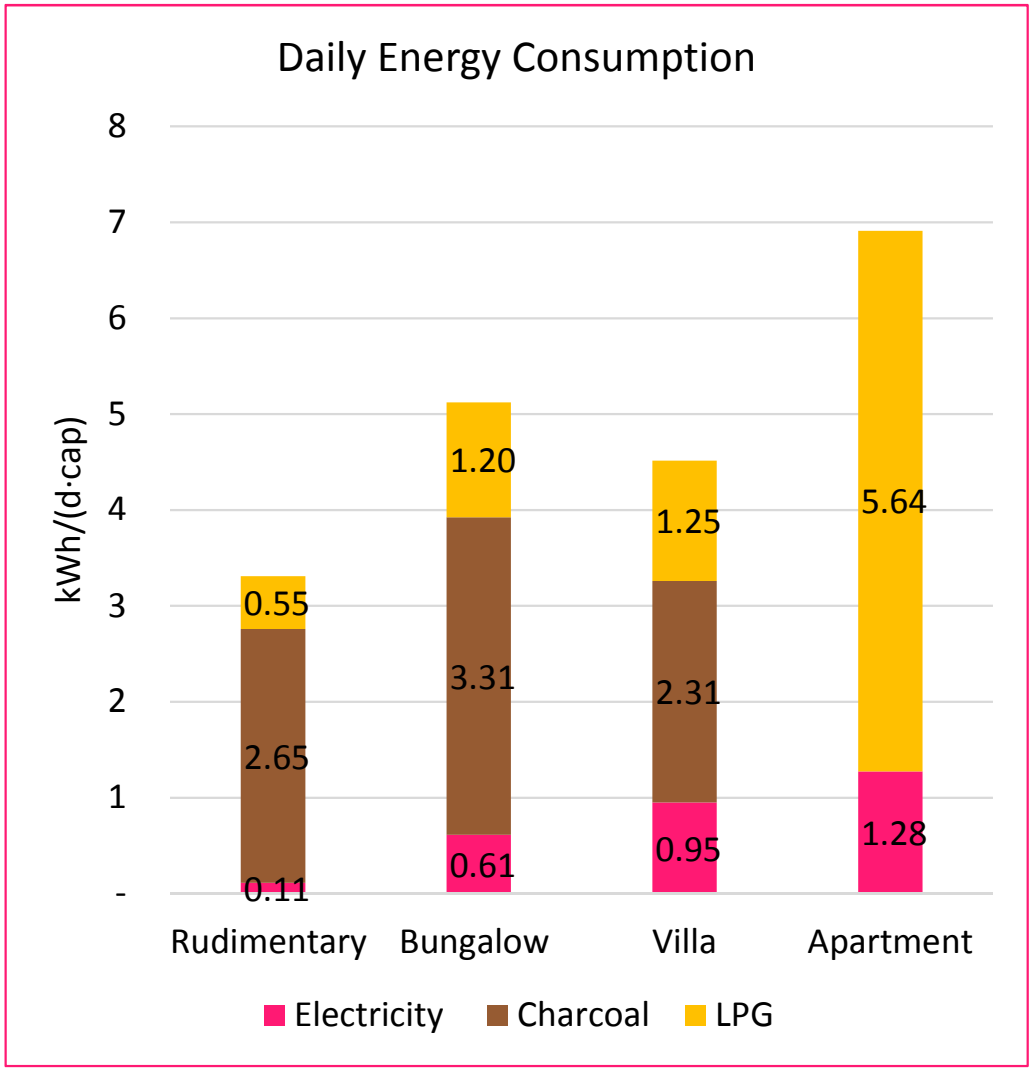
SPATIALLY RESOLVED RESULTS - KIGALI STATUS QUO

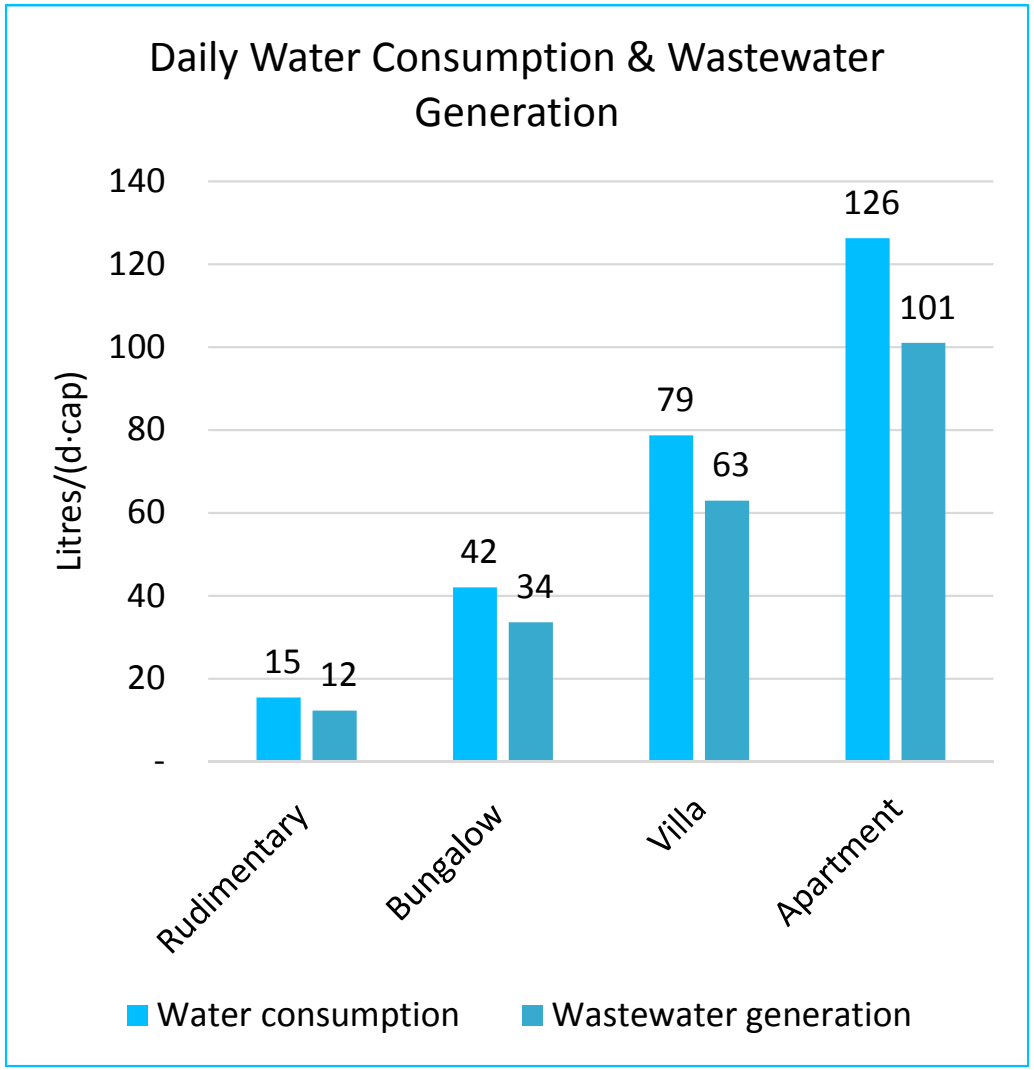
Spatial indicators, urban: built-up area



SPATIALLY RESOLVED RESULTS - KIGALI STATUS QUO

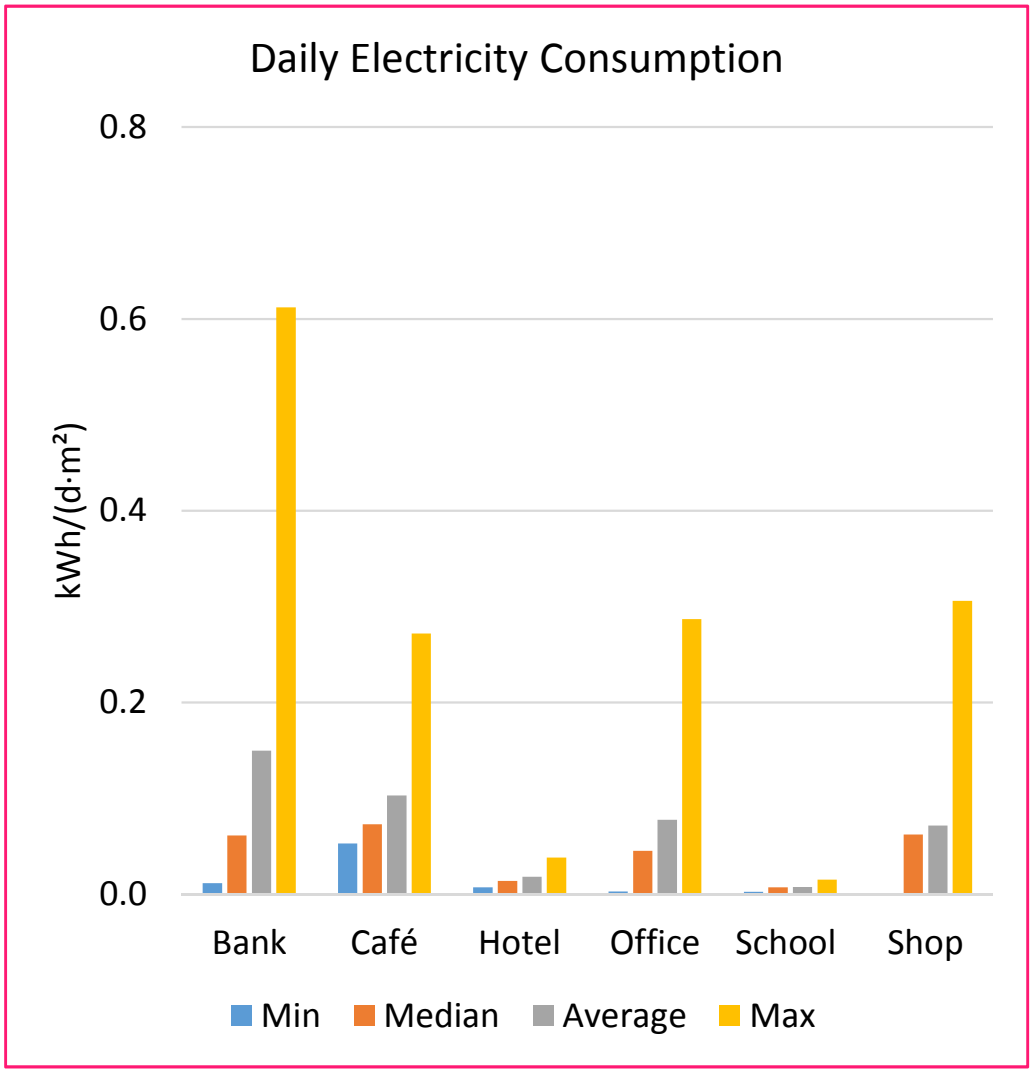
HOUSEHOLDS: EXAMPLES ON CONSUMPTION AND GENERATION PATTERNS

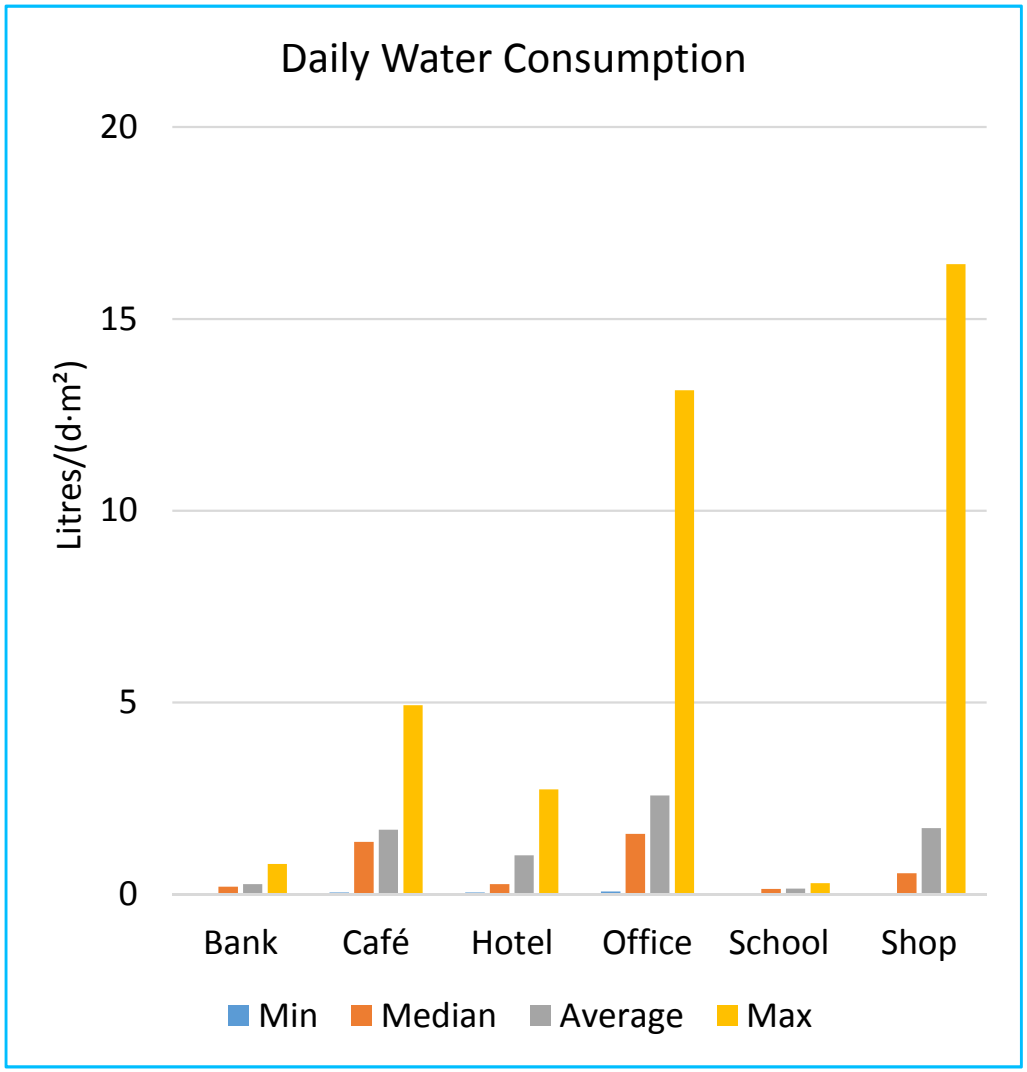




SPATIALLY RESOLVED RESULTS - KIGALI STATUS QUO

PUBLIC AND COMMERCE: EXAMPLES ON CONSUMPTION AND GENERATION PATTERNS





SPATIALLY RESOLVED RESULTS - KIGALI STATUS QUO
MASS FLOW ANALYSIS

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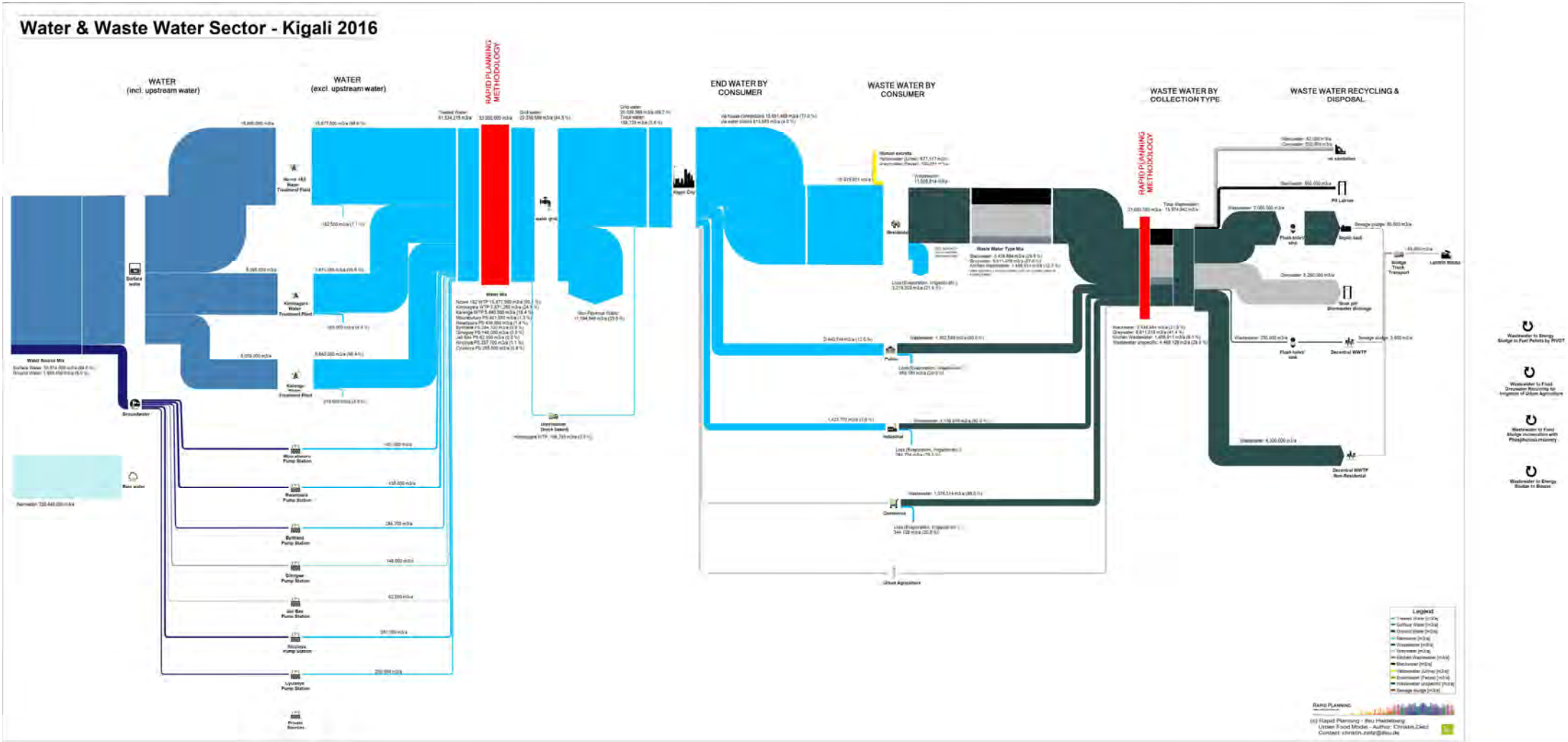
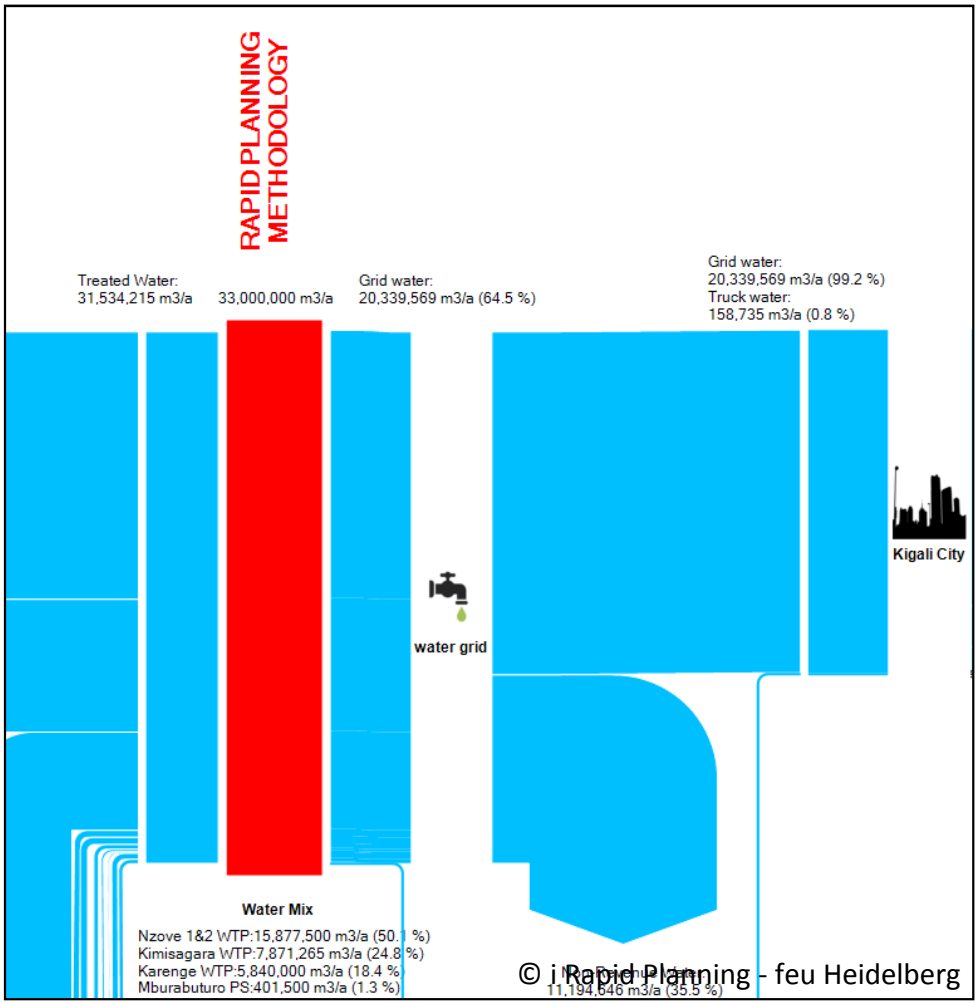
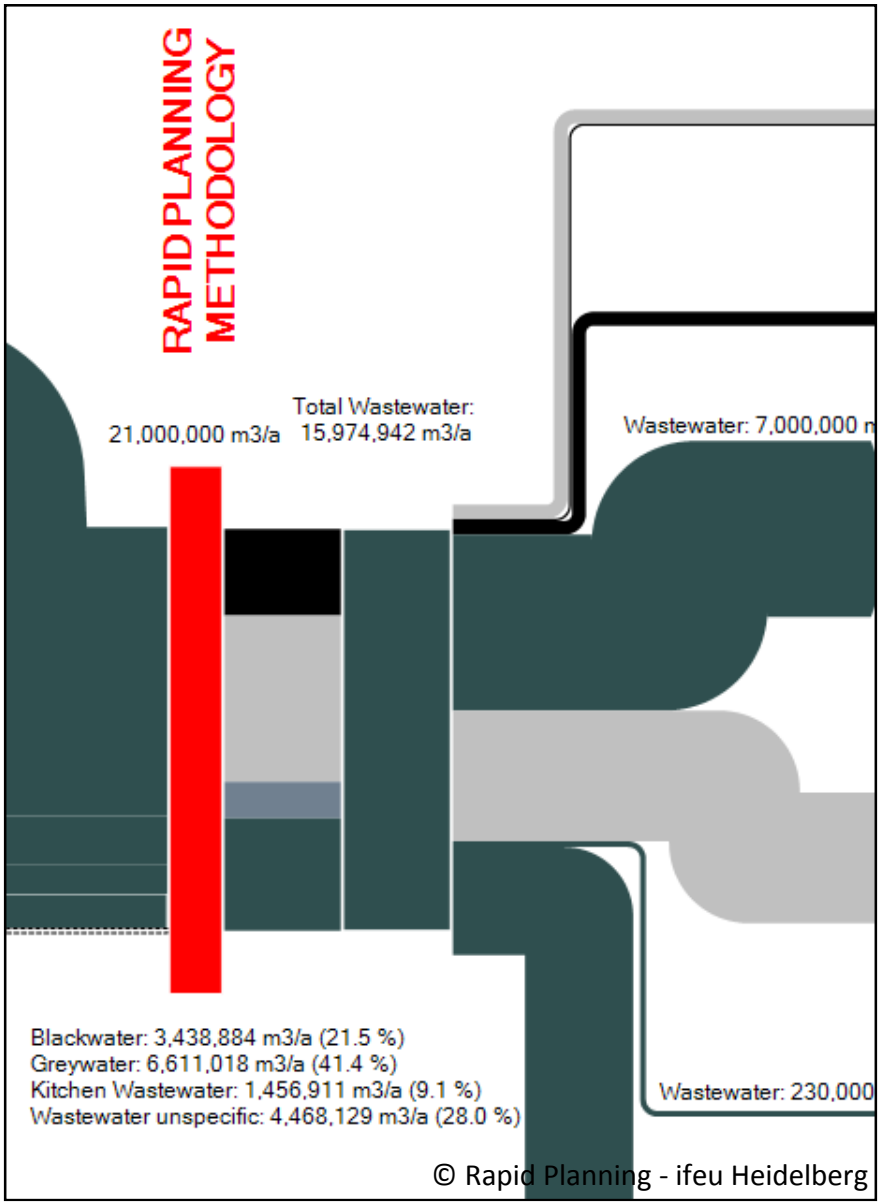
WATER & WASTEWATER Sector



SPATIALLY RESOLVED RESULTS - KIGALI STATUS QUO
MASS FLOW ANALYSIS

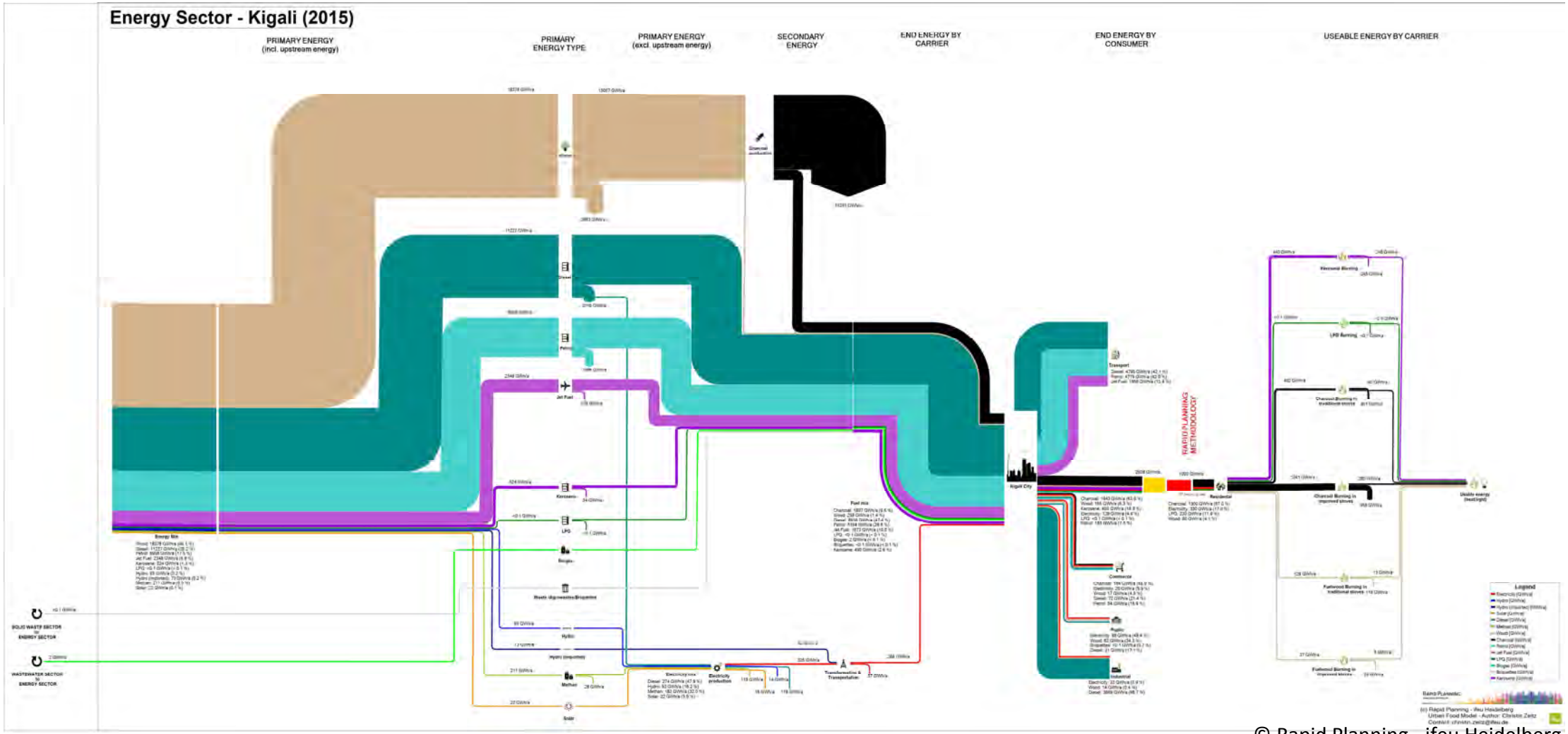
WATER & WASTEWATER Sector ZOOM





SPATIALLY RESOLVED RESULTS - KIGALI STATUS QUO
MASS FLOW ANALYSIS

ENERGY Sector



SPATIALLY RESOLVED RESULTS - KIGALI STATUS QUO
MASS FLOW ANALYSIS

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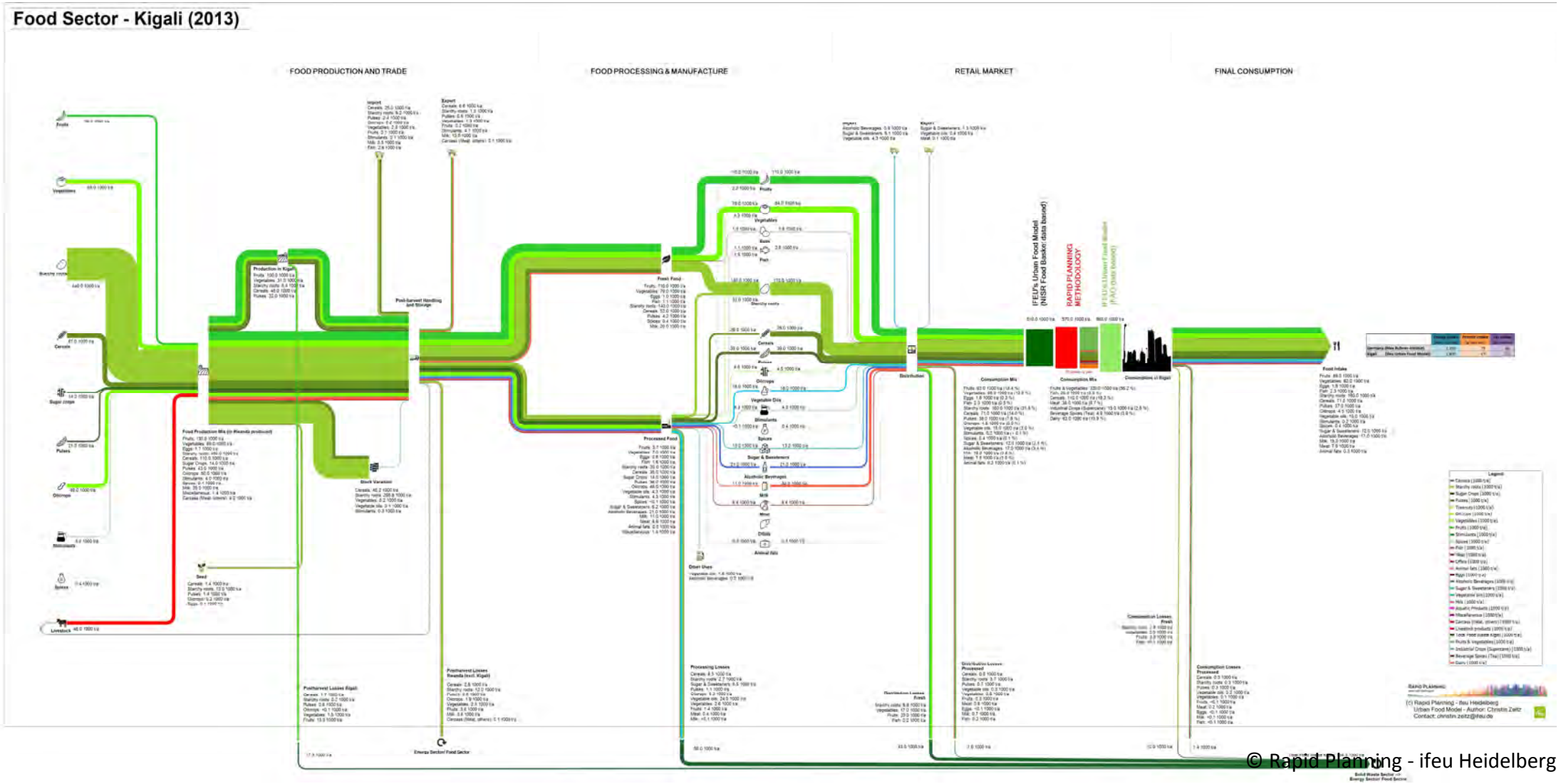
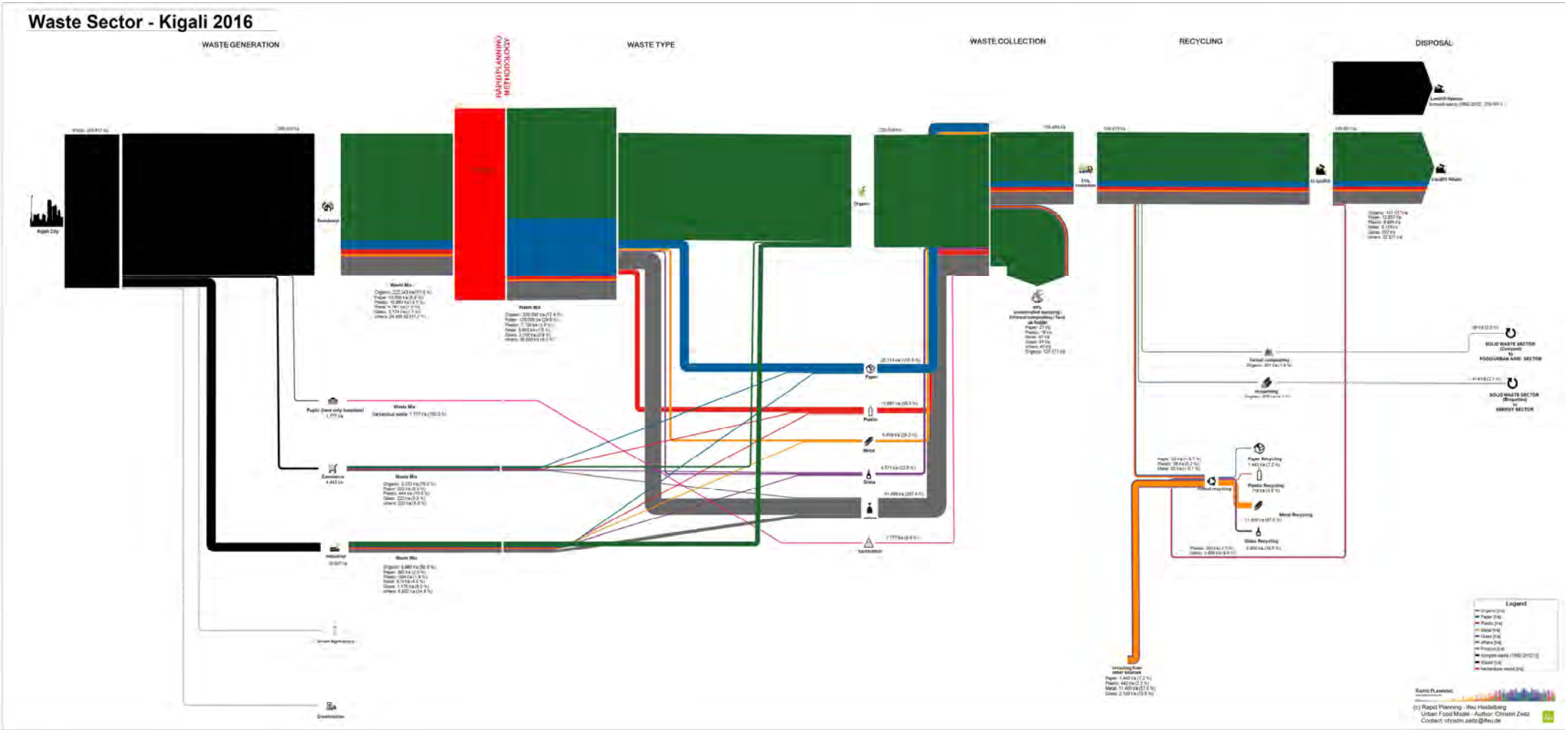
FOOD Sector



SPATIALLY RESOLVED RESULTS - KIGALI STATUS QUO
MASS FLOW ANALYSIS

SOLID WASTE Sector



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Session 2

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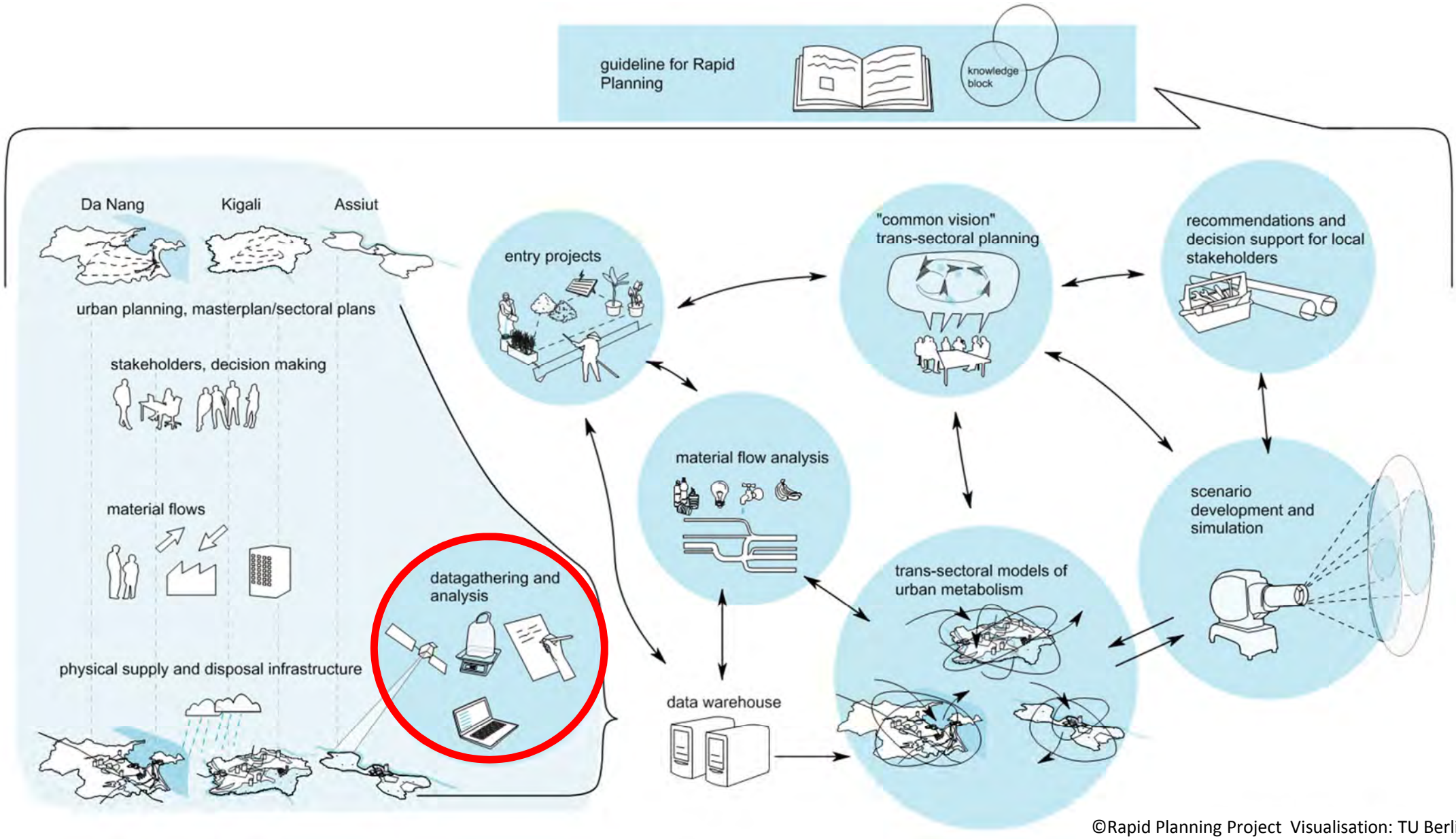

Process of Data Generation

IER

1. *Identification and Classification of Building Types*

reference data collection and object remote sensing

building types,
testing areas

correlation building type +
socio-economic category

2. *Determination of Socio-Economic Categories*

socio-economic data gathering (surveys)

socio-economically
homogenous areas

correlation socio-economic category/
building type + specific data

3. *Specific Data Gathering on Household Level*

determination of consumption/ generation patterns
(energy/water/food/waste/wastewater)

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Manual on the use of spatial data and satellite images

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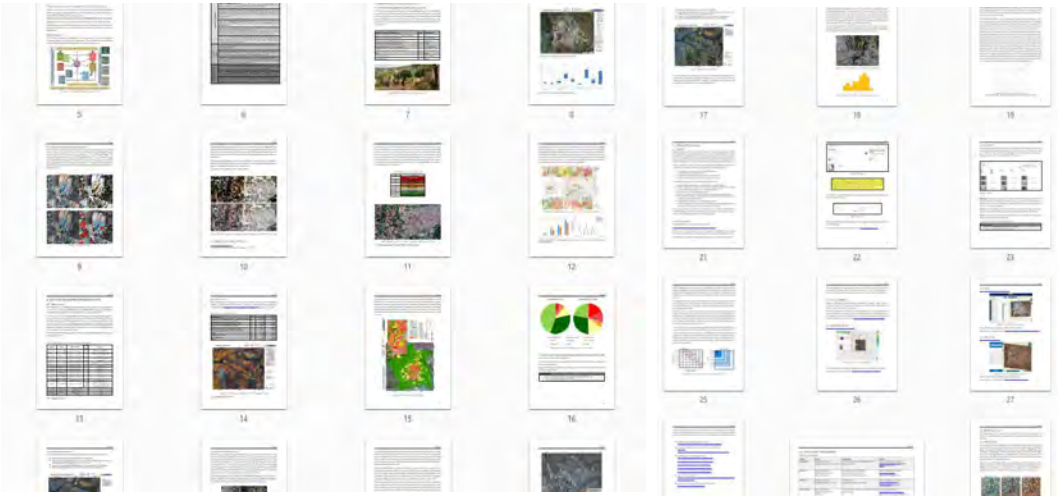
1.

- 60 pages with numerous illustrations
- Results of Rapid Planning
- Spatial datasets of Kigali
- Definitions and typologies
  - Building Types
  - Urban Structure Types
- Manual on their use, updating and continuation
- Recommendations on the work with satellite images
- Large literature section and references on external resources



RAPID PLANNING TECHNIQUES

Building typology (part of the manual)

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1.

Rudimentary, basic or unplanned buildings

Rudimentary, basic or unplanned buildings are the predominant building type in Kigali. This type is a low-rise building with 1 floor. It is abundant in densely built-up areas and rural areas. It is constructed of basic building materials and the roof materials are corrugated metal or metal sheets on a single slope roof. Identifying "Bungalow"-type buildings can be difficult when the roof structure is not clearly visible, due to density and similar appearance to the ground and nearby buildings.

Code	Short-name	Min. area (m²)	Max. area (m²)	Min. height (m)	Max. height (m)
1	Basic	5	150	2.1	6

Reference Pictures

Building in block structure/large courtyard buildings

The building class "Building in block structure/large courtyard buildings" consists of dense buildings around the perimeter of a block, with one to three floors, typically higher quality than "rudimentary" buildings, and including densely built-up courtyard buildings. The assignment of this class is largely an expert-based decision on the basis of the constellation of neighboring buildings. The roofs are flat roofs or single slope roofs with metal sheets (including corrugated metal). Distinguishing this typology from densely built-up informal settlements and halls is difficult. The class is predominantly found in the CBD or in central areas with a high road network density.

Code	Short-name	Min. area (m²)	Max. area (m²)	Min. height (m)	Max. height (m)
2	Block	5	-	2.1	8

Reference Pictures

Bungalow-type buildings

Bungalow-type buildings occur mostly in detached, semi-detached and terraced building patterns. They have a clearly defined ridge on a gabled roof, but also variations with dormers, hip roof shapes and simple valley shapes. Here, the footprint of the buildings can also be L-shaped or plus-shaped. The property includes often a small garden and/or courtyard. Higher quality construction and building materials help to identify the buildings. The delineation to "Basic"-type buildings and relatively small "Villa"-type buildings can be difficult.

Code	Short-name	Min. area (m²)	Max. area (m²)	Min. height (m)	Max. height (m)
3	Bungalow	40	600	3.1	12

Reference Pictures

Villa-type buildings

Villa-type buildings are predominantly detached buildings (besides some small outbuildings). Size of the building is with 150-600 m² large. In most cases the building is surrounded by a large open space (courtyard and garden). High quality construction materials are used. The roofs have in most cases complex structures with multiple dormers and/or valley shapes. The delineation to "Villa"-type buildings and relatively low "Mid-rise" buildings can be difficult.

Code	Short-name	Min. area (m²)	Max. area (m²)	Min. height (m)	Max. height (m)
4	Villa	150	600	3.2	15

Reference Pictures

Halls

Halls are buildings with a large ground floor area (> 100 m²). The roof of the building has a uniform structure with variations of single and double slopes. The basic shape of the building is in most cases rectangular or L-shaped. Halls are mostly detached buildings or are grouped with other halls. Distinguishing this typology from relatively large "Basic", as well as "Mid-rise" buildings can be difficult.

Code	Short-name	Min. area (m²)	Max. area (m²)	Min. height (m)	Max. height (m)
7	Hall	100	-	3	-

Reference Pictures

Special structures

Special structures are structures with morphological properties that are not covered by the other classes. Examples are: power plants, refineries, transformer-stations, silos, silotowers, etc.

Code	Short-name	Min. area (m²)	Max. area (m²)	Min. height (m)	Max. height (m)
8	Special	3	-	-	-

Reference Pictures

Construction sites

The class "construction sites" is assigned when both i) no other building (completed) type can be assigned, and ii) construction activity can be identified from the imagery. The class is also valid for buildings that are being demolished.

Code	Short-name	Min. area (m²)	Max. area (m²)	Min. height (m)	Max. height (m)
9	Construction	3	-		

Reference Pictures

RAPID PLANNING TECHNIQUES

Rapid Planning web-based GIS data warehouse

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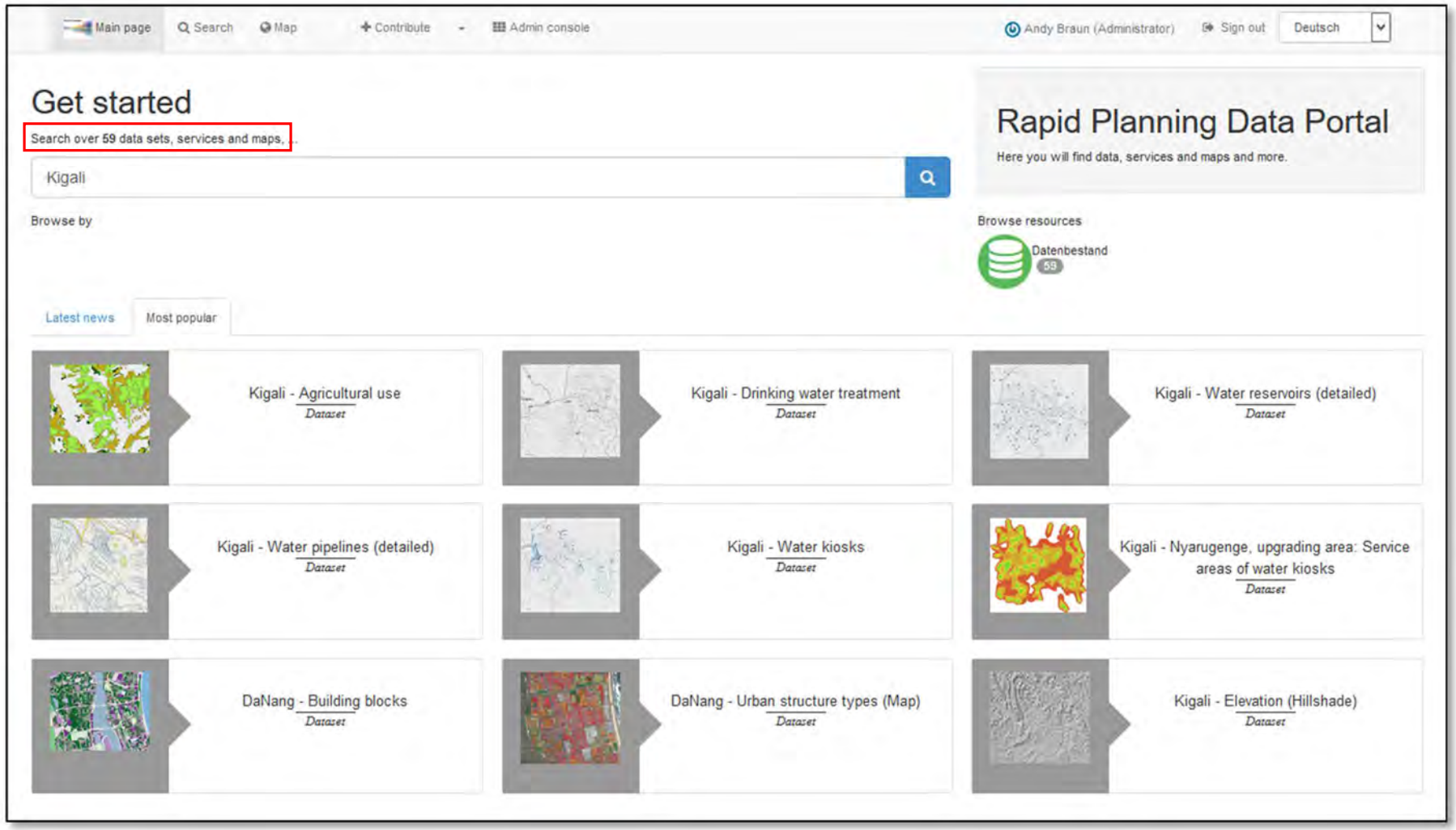
http://134.2.216.52:8080/geonetwork-rp (login provided by Uni Tübingen)



RAPID PLANNING TECHNIQUES
SURVEY: Digital Questionnaire (CAPI*)

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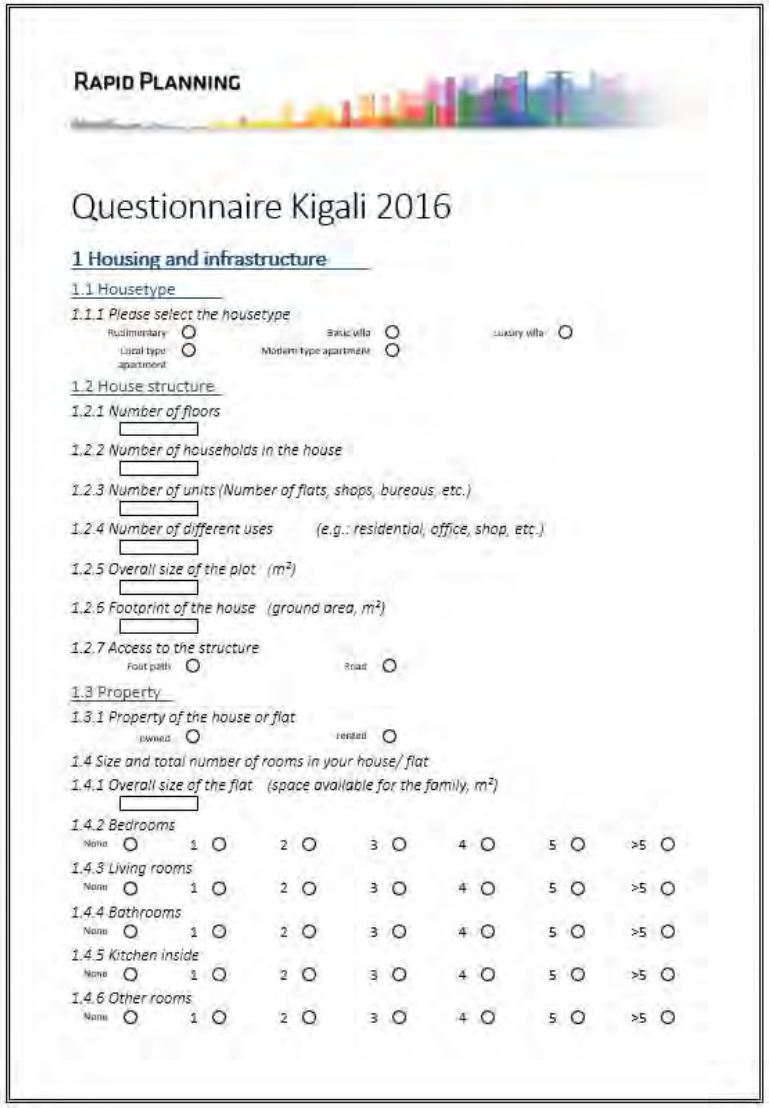
2.

*Computer Assisted Personal Interviewing

- Development of a questionnaire for the socio-economic household survey
- On-site check of preselected test areas
- Conduction of survey in the test areas
- Derivation of socio-economic categories
- Analyses of the gathered survey data
- Linking SEC to building types (BT)



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Questionnaire Kigali 2016

1 Housing and infrastructure

1.1 Housetype

1.1.1 Please select the housetype

Rudimentary ○ Basic villa ○ Luxury villa ○
Local type apartment ○ Modern type apartment ○

1.2 House structure

1.2.1 Number of floors

1.2.2 Number of households in the house

1.2.3 Number of units (Number of flats, shops, bureaus, etc.)

1.2.4 Number of different uses (e.g.: residential, office, shop, etc.)

1.2.5 Overall size of the plot (m²)

1.2.6 Footprint of the house (ground area, m²)

1.2.7 Access to the structure

Foot path ○ Road ○

1.3 Property

1.3.1 Property of the house or flat

owned ○ rented ○

1.4 Size and total number of rooms in your house/ flat

1.4.1 Overall size of the flat (space available for the family, m²)

1.4.2 Bedrooms

None ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ >5 ○

1.4.3 Living rooms

None ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ >5 ○

1.4.4 Bathrooms

None ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ >5 ○

1.4.5 Kitchen inside

None ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ >5 ○

1.4.6 Other rooms

None ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ >5 ○

RAPID PLANNING TECHNIQUES

Average of socio-economic points in the different test areas Kigali with associated Socio-economic categories

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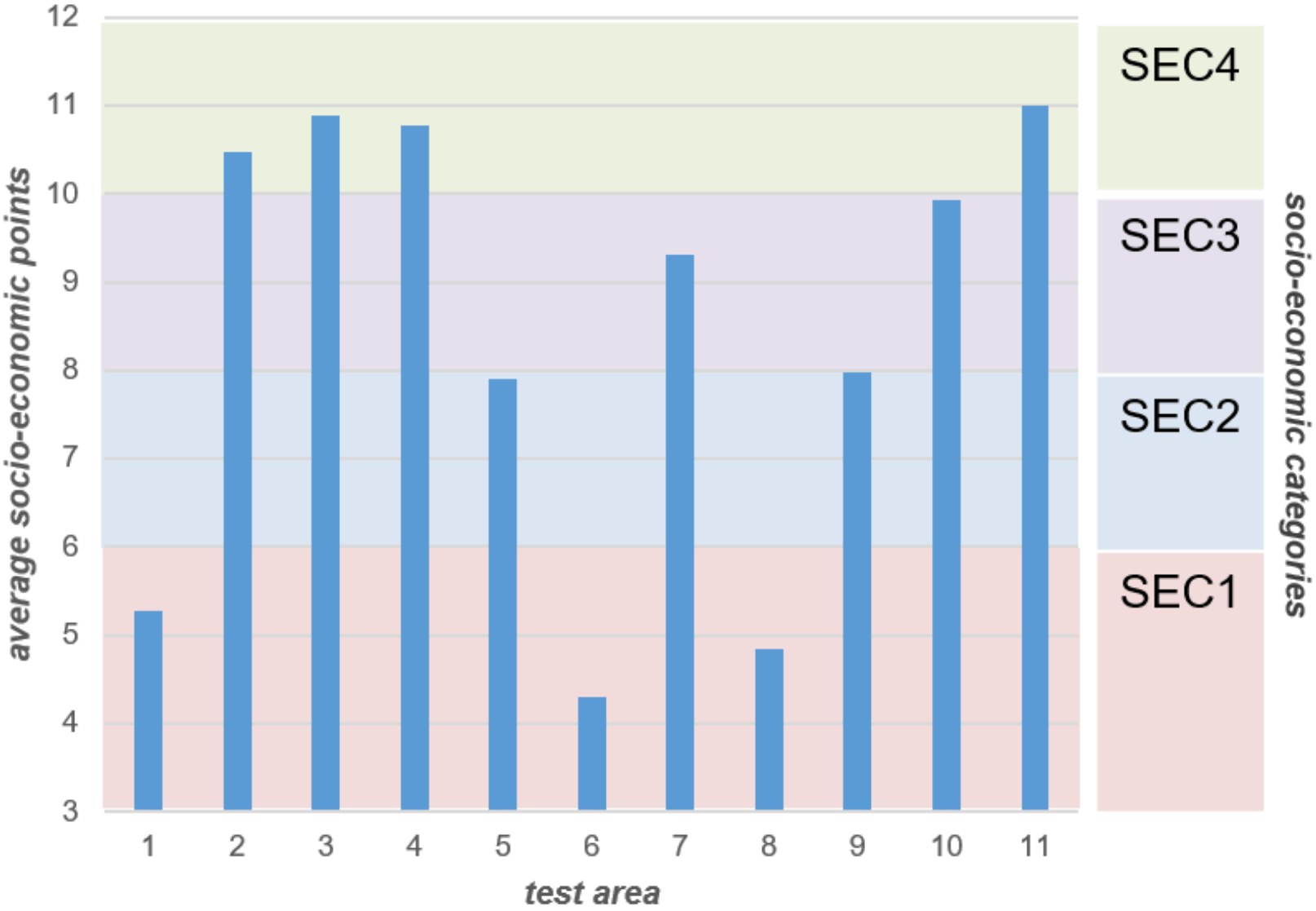

RAPID PLANNING TECHNIQUES

Linking socio-economic category (SEC) with building type (BT)

Building Type (BT 1)

Building Type (BT 2)

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1. 2.

no image rights

RAPID PLANNING TECHNIQUES

Surveyed Areas with socio-economic categories (SEC) allocated to Building types (BT)

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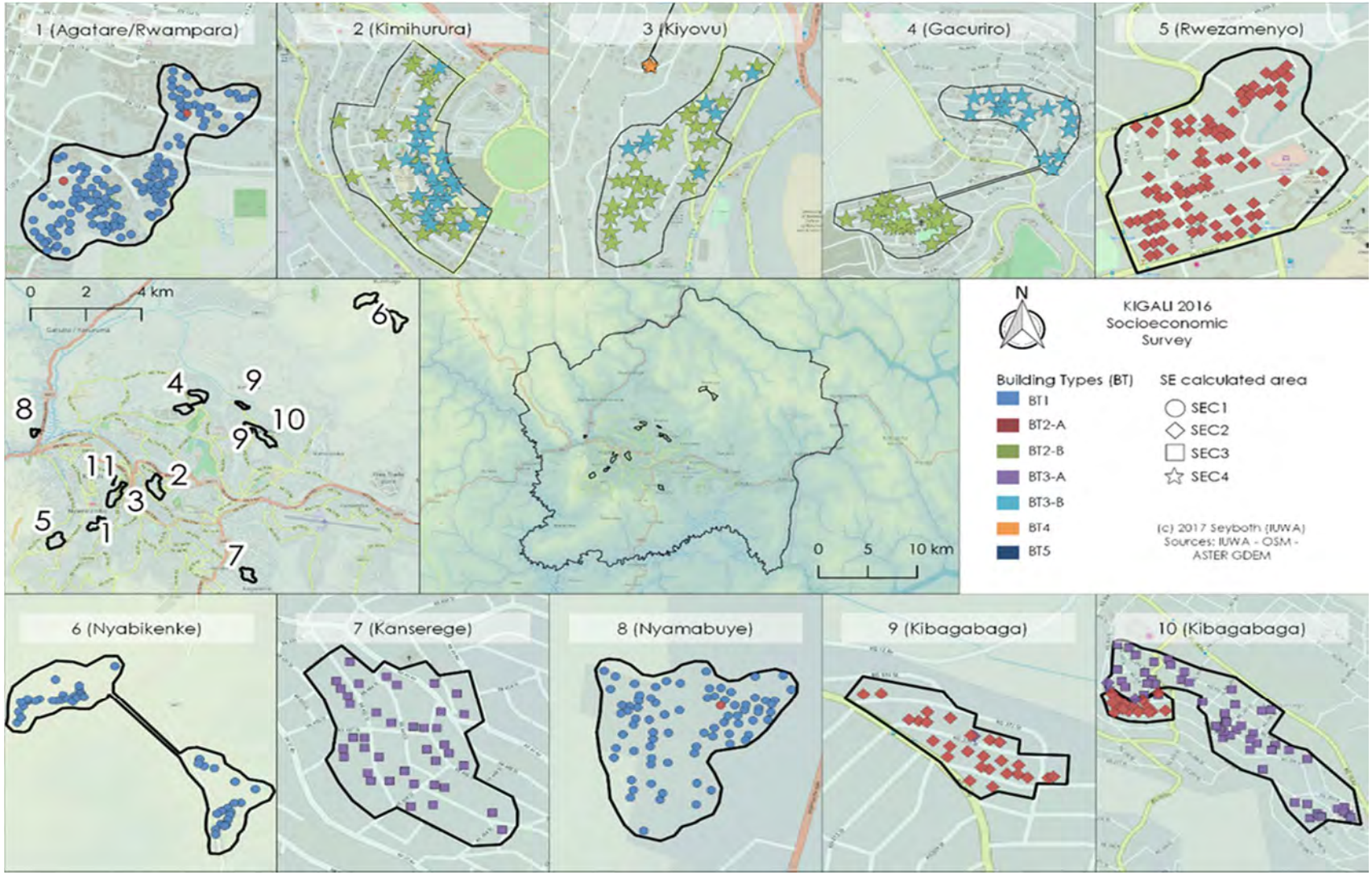

RAPID PLANNING TECHNIQUES

PROCEDURE OF SPECIFIC DATA GATHERING IN ALL 5 INFRASTRUCTURE SECTORS:

energy - food - solid waste - water - wastewater

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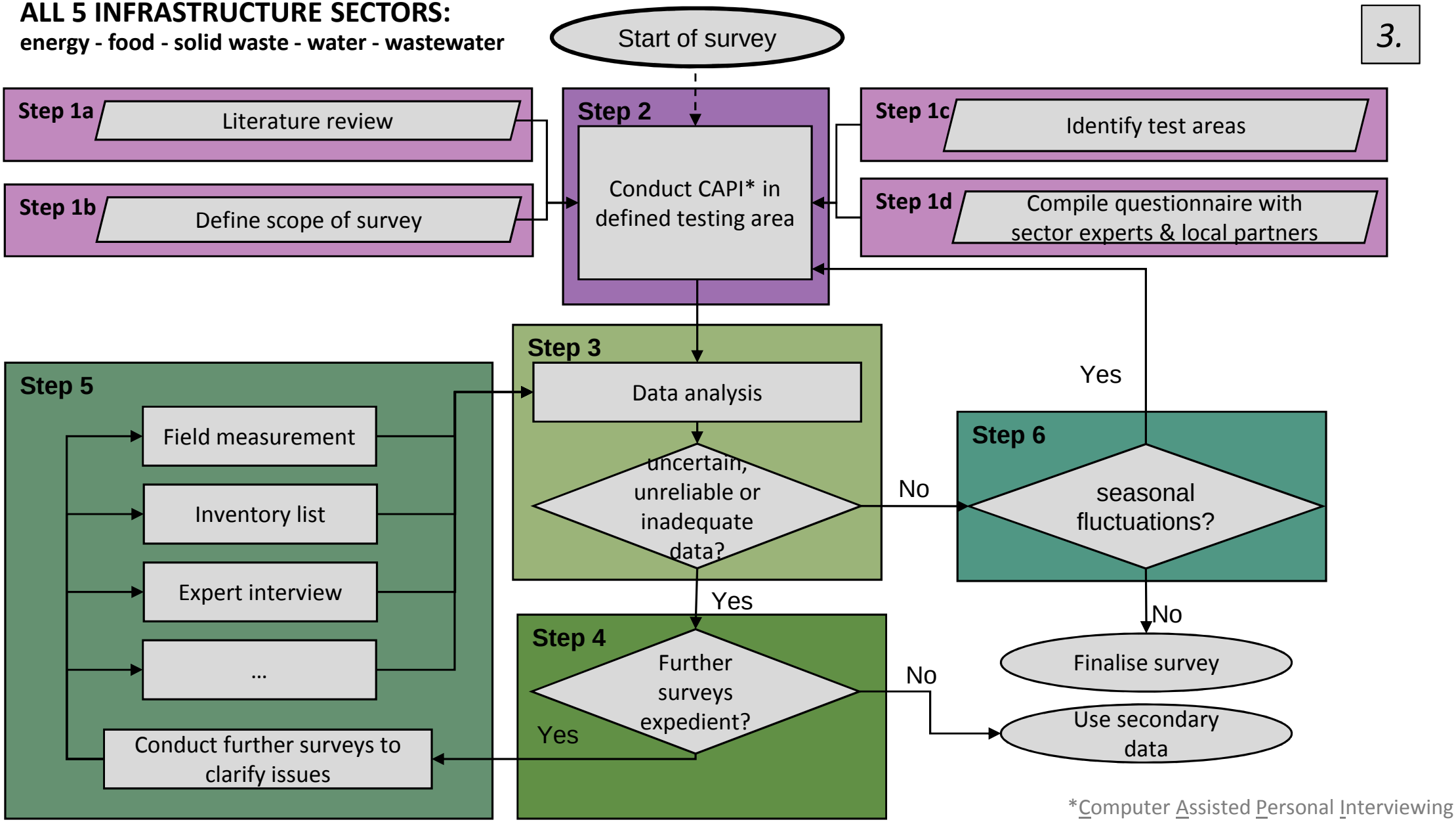
3.



*Computer Assisted Personal Interviewing

RAPID PLANNING TECHNIQUES

SURVEY: Digital Questionnaire (CAPI*)

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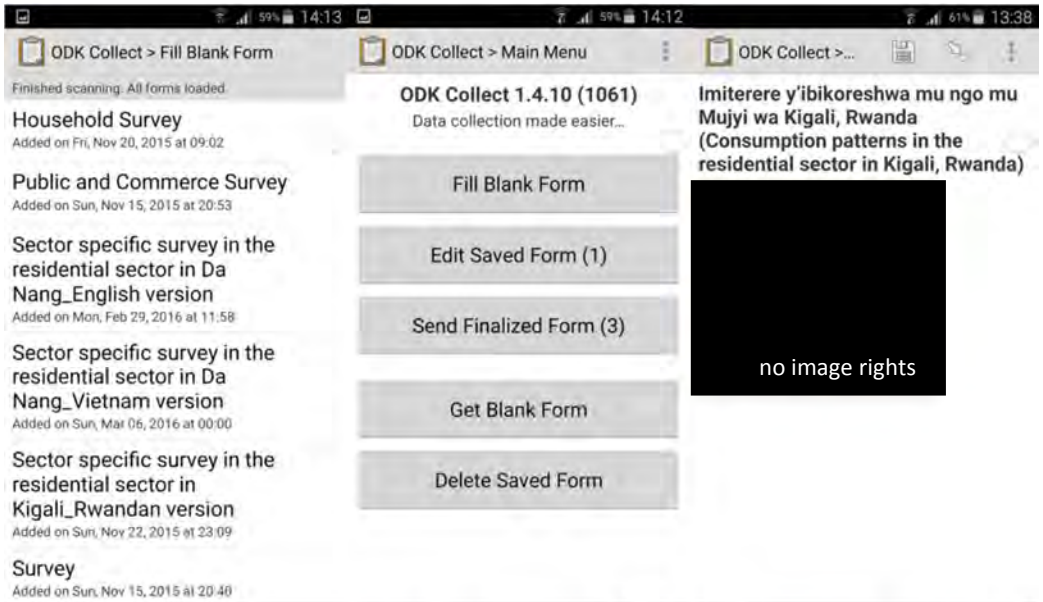
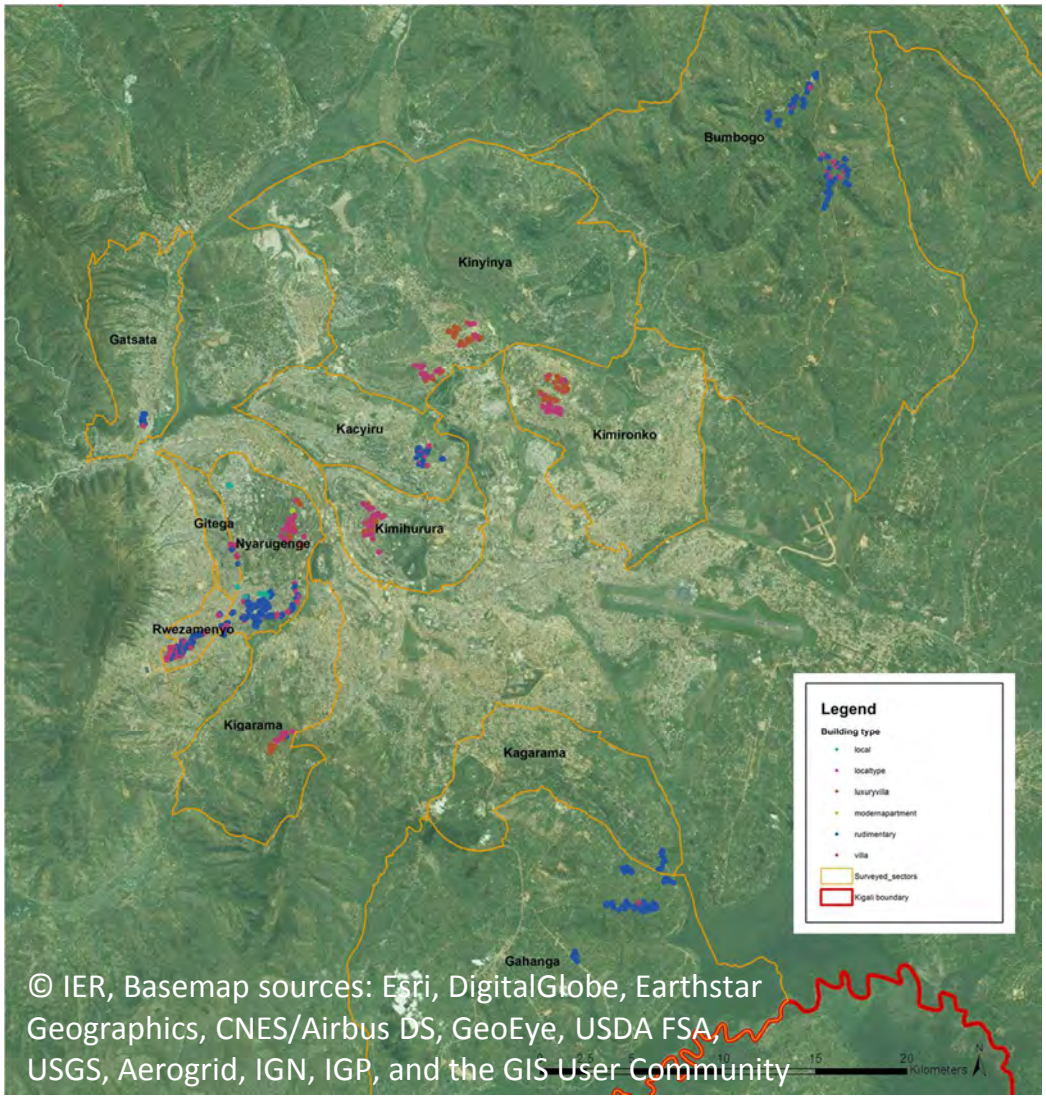


Block zone type	UST type	Life style class	Building type					Acronym
			Rudimentary	Bungalow	Villa	Apartment	Total	
Commercial	Compact/mid	mid	46	25	0	0	71	CCMM
	Compact/mid	high	0	51	13	3	67	CCMH
	Compact/small	low	171	0	0	0	171	CCSL
	Compact/small	mid	0	30	0	0	30	CCSM
	Open	high	8	9	4	0	21	COH
Urban	Compact/mid	mid	1	19	20	0	40	UCMM
	Compact/mid	mid to high	1	9	30	0	40	UCMMH
	Compact/mid	high	0	26	14	0	40	UCMH
	Compact/small	low	44	9	0	0	53	UCSL
	Open	low	8	0	2	0	10	UOL
	Open	mid	0	2	6	0	8	UOM
Rural	Open	low	88	4	0	0	92	ROL
	Sparsely built	low	78	7	0	0	85	RSL
TOTAL			445	191	89	3	728	



*Computer Assisted Personal Interviewing

RAPID PLANNING TECHNIQUES

Field measurement (solid waste) & inventory list (food)

RAPID PLANNING

IER Uni Stuttgart

Consumption patterns in the residential sector in Kigali, Rwanda

1. Surveyor (name): _____
2. Household numeration/GPS Position: _____
3. Address: _____
4. How many people live in this household? _____Total; _____Adults; _____Children (<16 y)
5. Date: ____/____/2016
6. How much of the following food items were purchased for your household today?
   (be as precise as possible, if you can't say anything about the amount write "?" or another unit)

☐ Grains / cereal products	_____ kg
☐ Roots / tubers	_____ kg
☐ Fruits	_____ kg or _____ piece(s)
☐ Vegetables & salad	_____ kg or _____ piece(s)
☐ Dairy products	_____ kg or _____ litre(s)
☐ Fresh meat and meat products	_____ kg
☐ Fish	_____ kg or _____ piece(s)
☐ Eggs	_____ piece(s)
☐ Fats / oils	_____ kg
☐ Nuts	_____ kg
☐ Pulses	_____ kg
☐ Convenience food (e.g. cans)	_____ kg or _____ piece(s)
☐ Soft drinks & juices	_____ litres
☐ Water bottles	_____ litres or _____ bottles (Bottle size: _____ litre)
☐ Other Beverages (e.g. tea, coffee)	_____ litres
☐ Others (please specify)	_____

7. How much is paid for food and beverages in your household today? _____RWF
8. If you buy rice in big sacks: How often? _____; How much _____kg/sack
9. How often do you buy oil? _____; Size of bottle _____litre

RAPID PLANNING TECHNIQUES

DATA SHEETS & MANUAL: DELIVERABLE REPORTS

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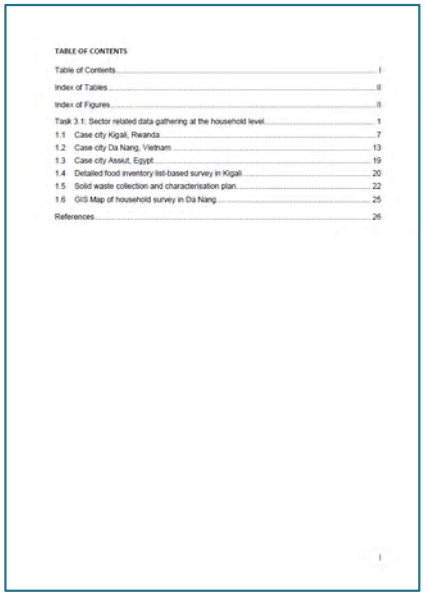
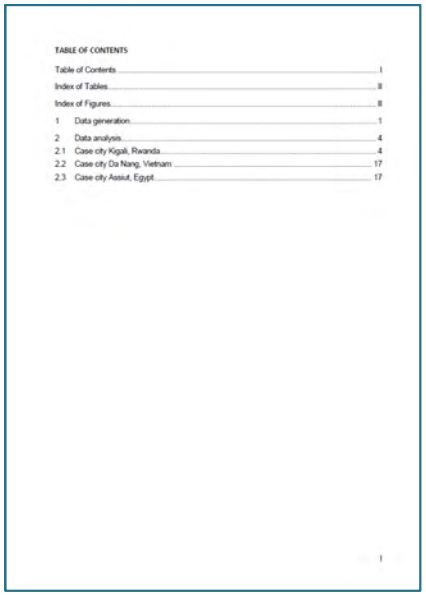
3.

Building type			Household size [#]	Electricity consumption [kWh/(a*cap)]	Charcoal consumption [kWh/(a*cap)]	LPG consumption [kWh/(a*cap)]	Water consumption [litre/(d*cap)]	Wastewater generation [litre/(d*cap)]
Rudimentary	N	Valid	445	379	170	12	443	443
		Missing	0	66	275	433	2	2
	Mean		5,12	59,82	1148,67	312,47	24,25	19,40
	Std. Error of Mean		,10	5,11	53,95	84,60	1,42	1,14
	Median		5,00	40,91	966,72	200,28	15,47	12,38
	Std. Deviation		2,21	99,48	703,41	293,08	29,94	23,95
	Variance		4,87	9896,08	494790,20	85893,06	896,49	573,75
	Range		11,00	1298,99	4501,47	1091,49	251,84	201,47
	Minimum		1,00	4,79	332,13	51,51	,67	,53
	Maximum		12,00	1303,78	4833,60	1143,00	252,51	202,01
Bungalow	N	Valid	191	189	45	94	191	191
		Missing	0	2	146	97	0	0
	Mean		5,33	410,09	1235,86	611,68	103,20	82,56
	Std. Error of Mean		,18	44,00	73,95	63,32	10,61	8,49
	Median		5,00	223,51	1208,40	437,33	42,08	33,67
	Std. Deviation		2,49	604,94	496,05	613,93	146,70	117,36
	Variance							





Scenario simulation – How to do it?

Embedded in the „Rapid Planning“ Methodology

Rapid Planning provides …

- Information by satellite images
- Socio-economic data
- Data and information on sectoral infrastructure
- Specific planning values
- Visions and ideas, inspired also by “Entry projects”
- Scenario definition

culminate into

supports

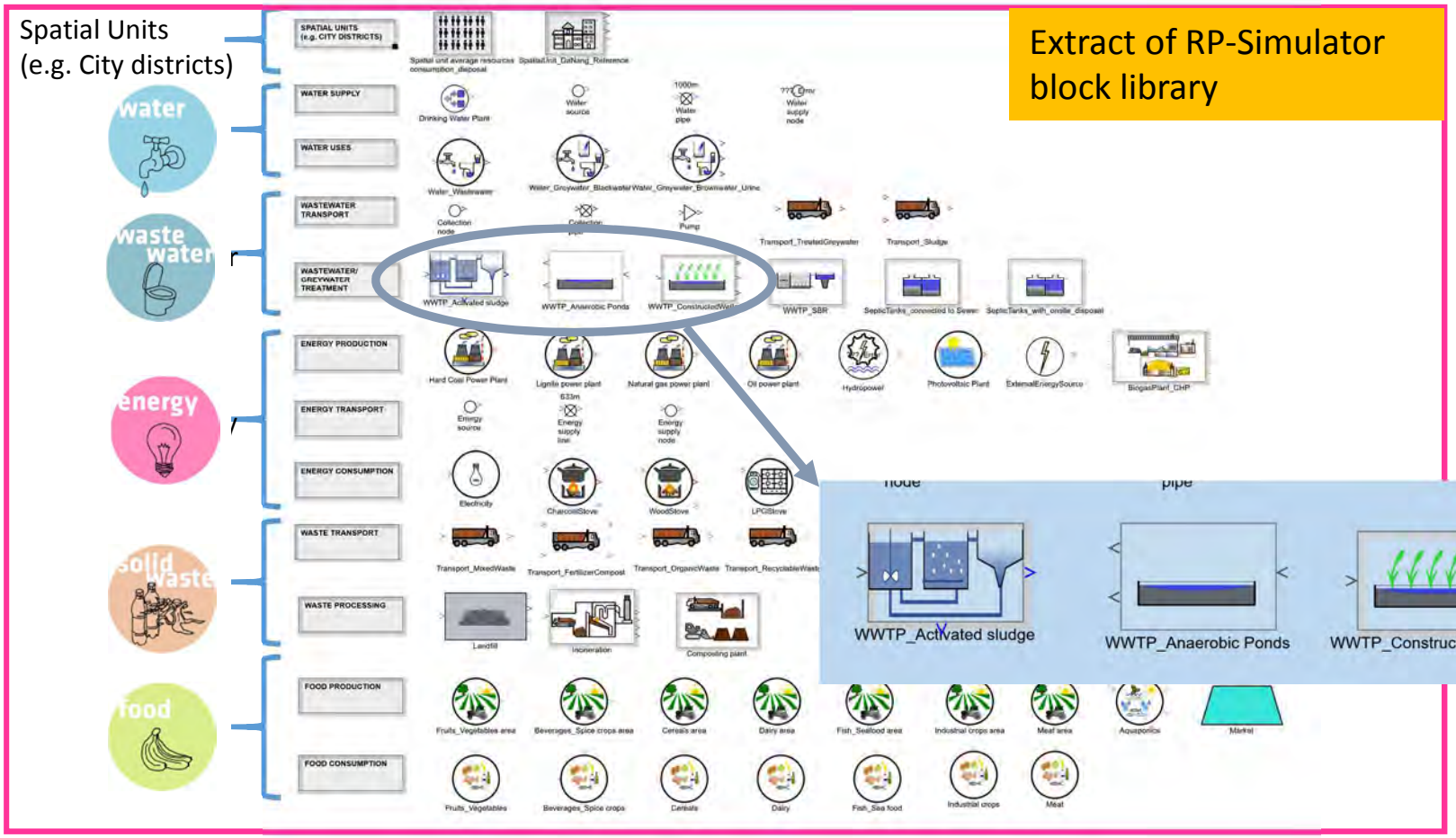
- Stakeholder involvement, planning processes
- System understanding → Capacity building

RAPID PLANNING TECHNIQUES

RP SCENARIO SIMULATOR

Scenario simulation – How to do it?

Build a model of your city



RAPID PLANNING TECHNIQUES
RP SCENARIO SIMULATOR (cont'd)

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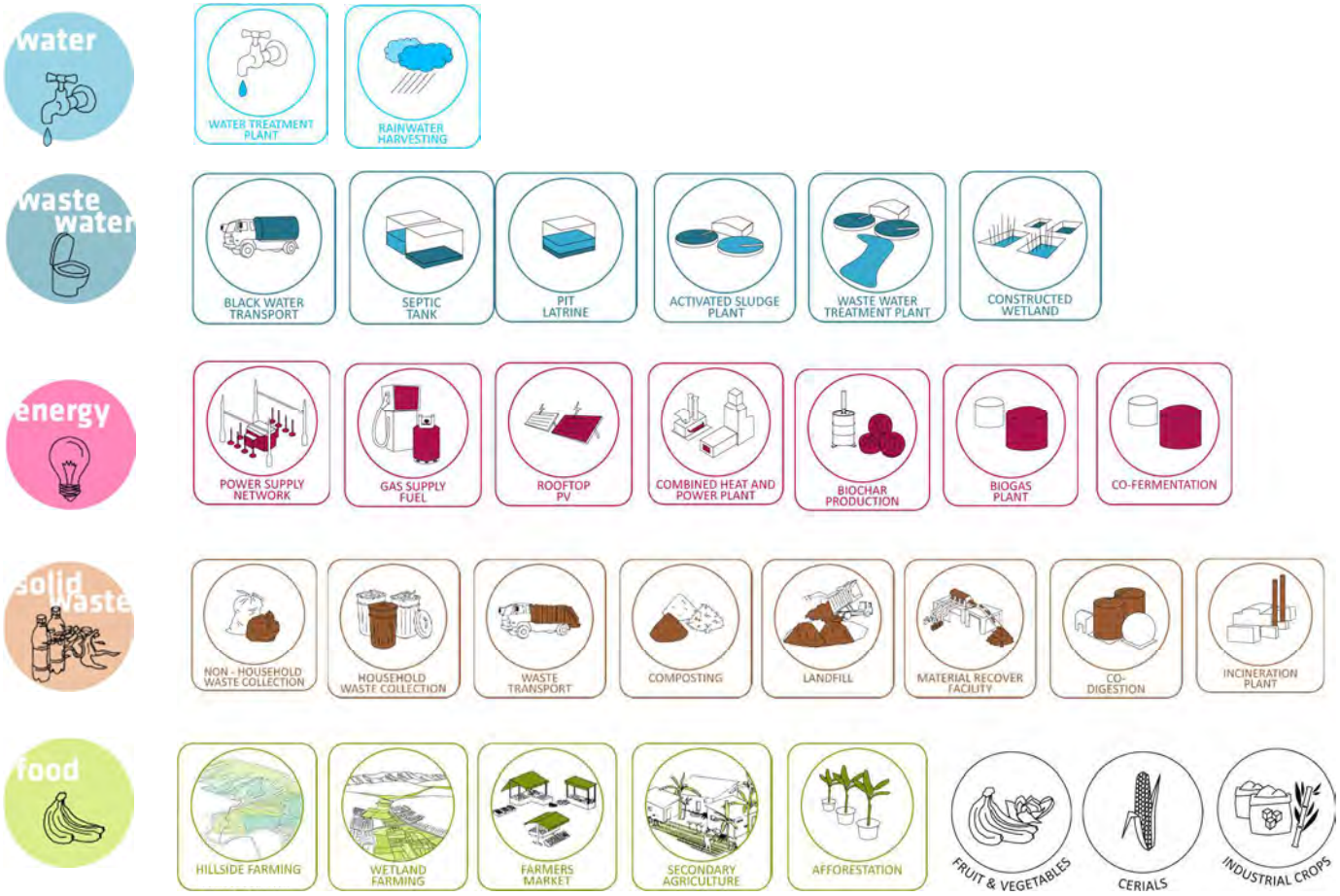
Spatial Units

Scenario simulation – How to do it?

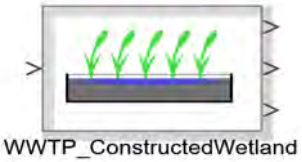
Build a model of your city

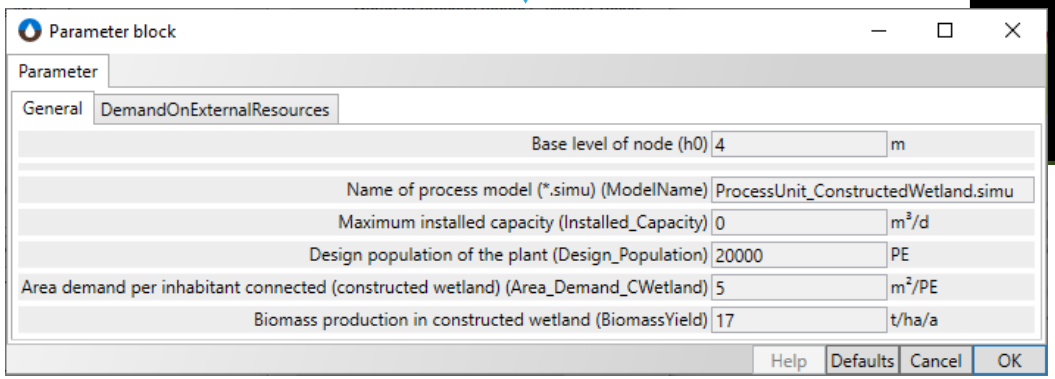


Simulator Modules as illustrated in Process Chains

RP-Simulator: Modelling modules

Example: Module „Constructed Wetland“





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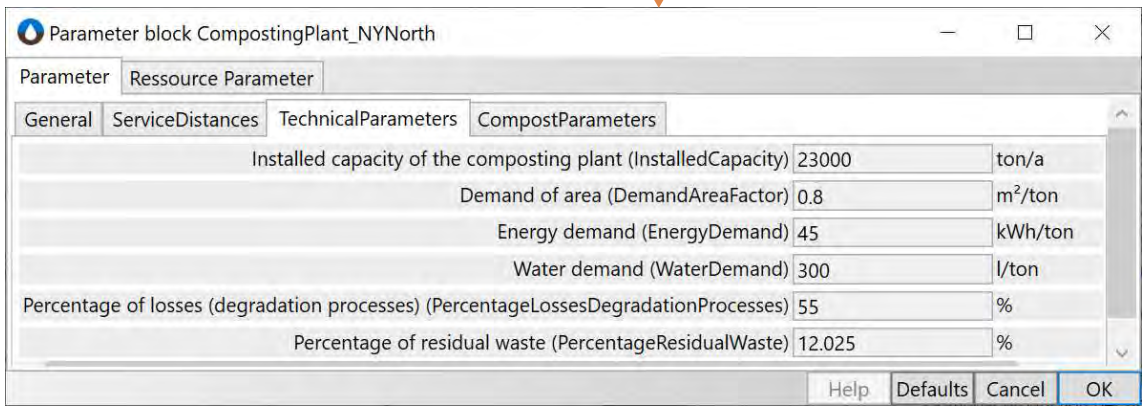
Constructed Wetland

RAPID PLANNING TECHNIQUES
RP SCENARIO SIMULATOR : TRANS-SECTORAL TECHNOLOGIES

RP-Simulator: Modelling modules

Example: Module „Composting Plant“



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Composting

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RAPID PLANNING SCENARIO

SIMULATION MODULES

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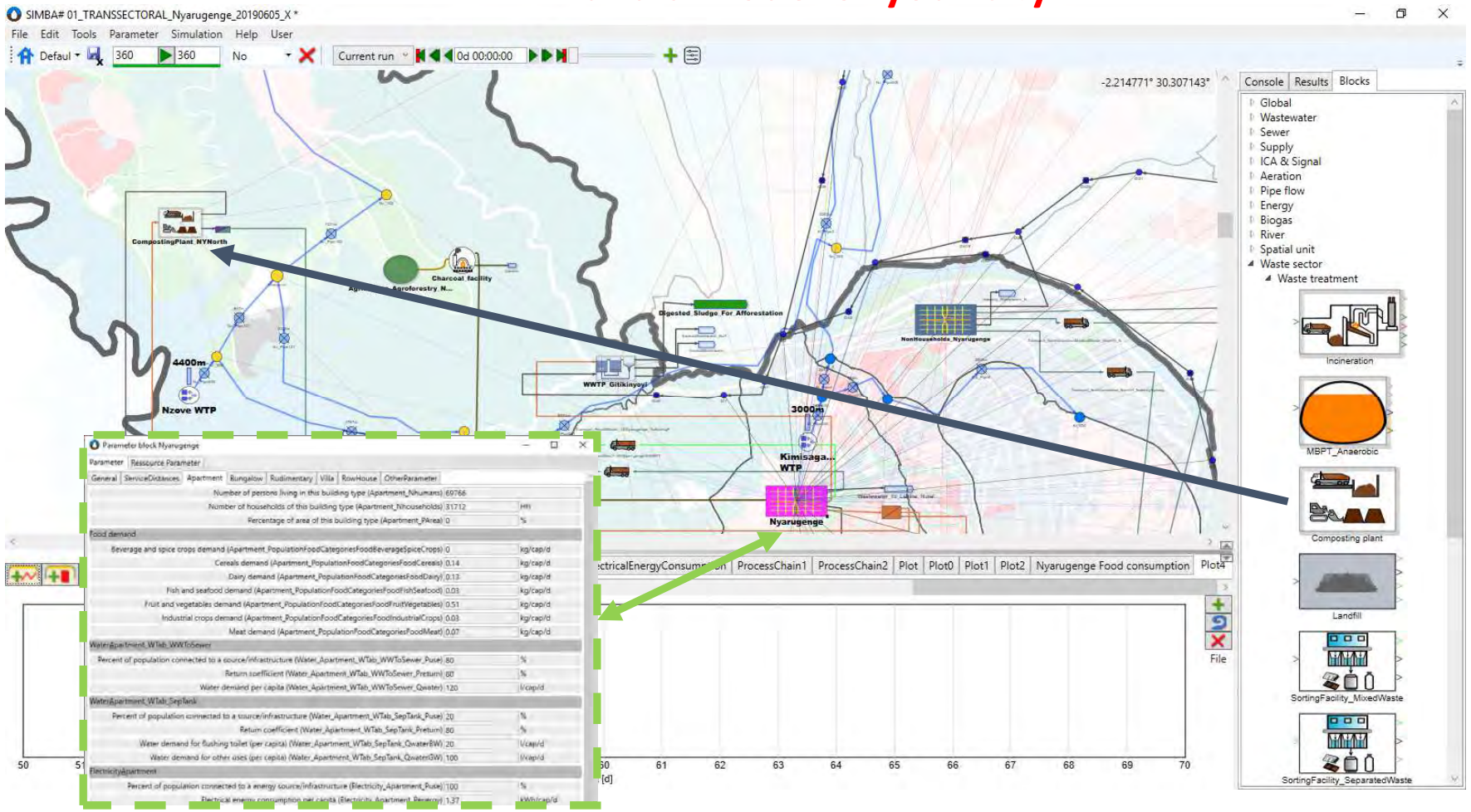
Scenario simulation – How to do it?

Build a model of your city

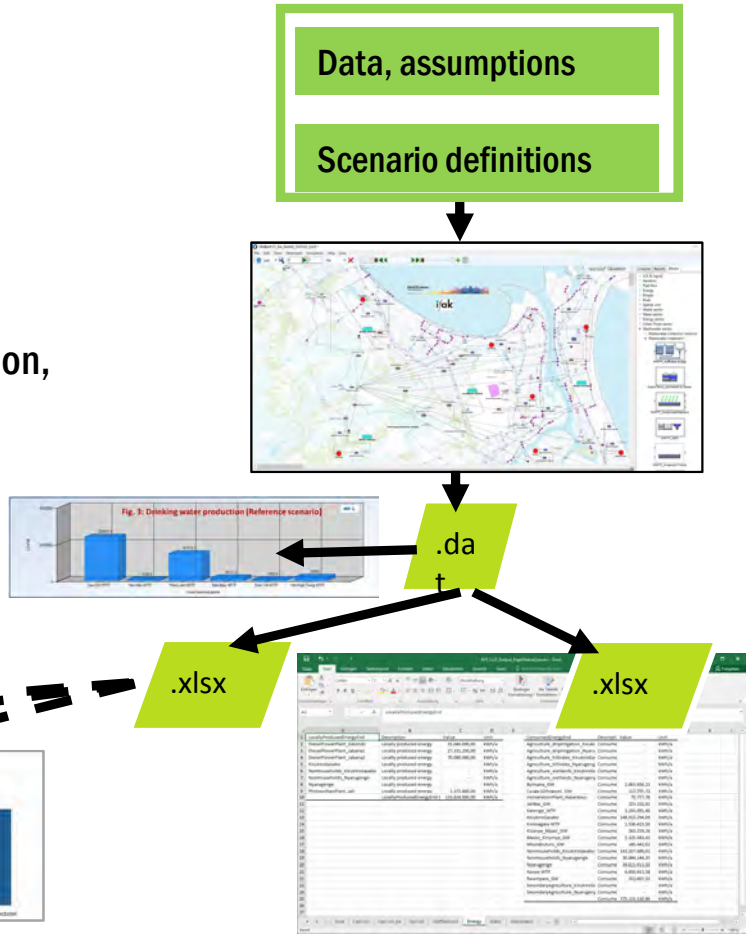


Scenario simulation for Kigali

Characteristics of the Rapid Planning Simulator

- Managing **availability - demand**
- State-of-the-art **algebraic** and **dynamic solvers**
- High degree of **flexibility, subsystems**
- Some graphics, **data export to Excel**
- **Compatible to water simulator** Simba#
- (time series, process dynamics)
- **Freely definable parameters** for resource consumption, efficiencies, cost functions, ...
- Links **process modelling** with **Life Cycle Analysis**
- Calculation of **many criteria** (GHG, ...)
- **Applicable to any city**

- **Free**



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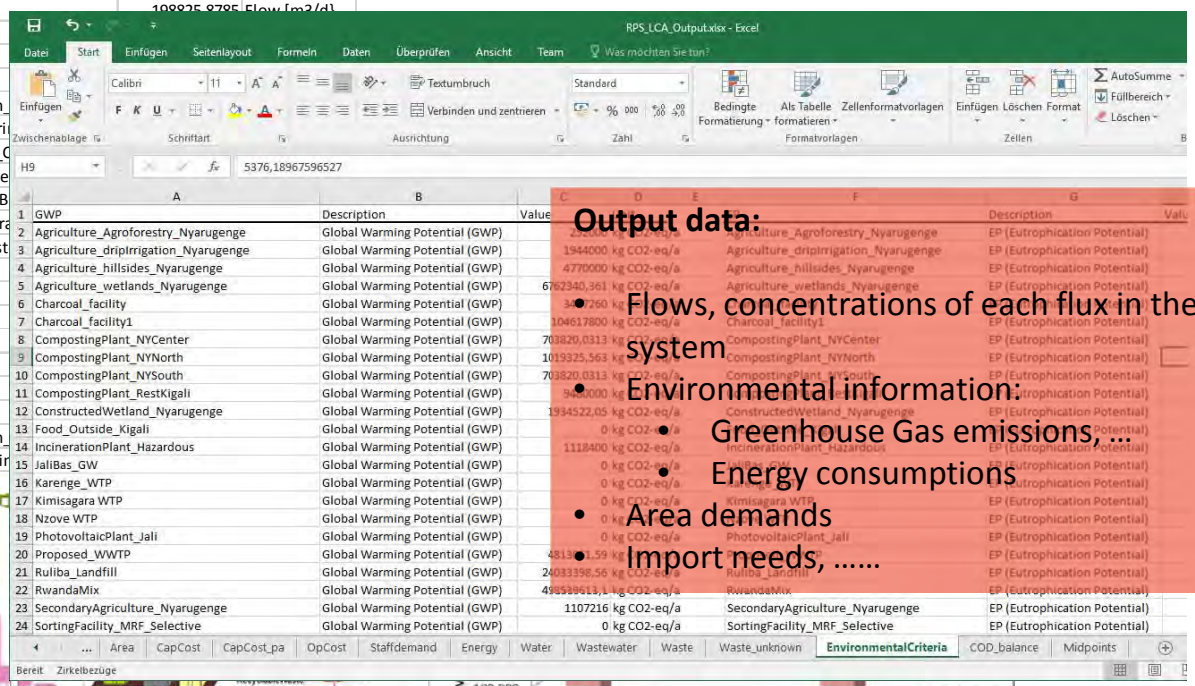
Scenario simulation for Kigali:

Results

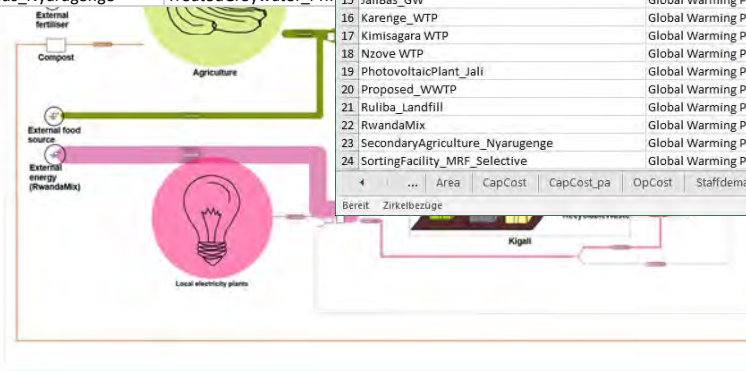
Here: Trans-sectoral scenario

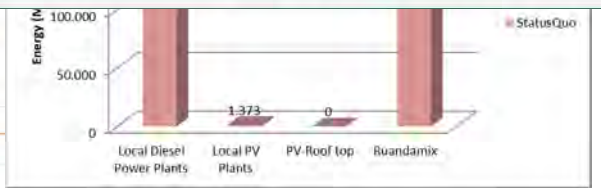
RPS Kigali TranssectoralScenario	Information/Port	Value	Unit
Nzove WTP	o		
Kimisagara WTP	o		
Karenge_WTP	o		
JaliBas_GW	o		
Agriculture_dripIrrigation_Nyarugenge	Total_FoodProduction_		
Agriculture_dripIrrigation_Nyarugenge	OtherWaterSource_Pri		
Agriculture_dripIrrigation_Nyarugenge	PrimaryAgricultureIn_C		
Agriculture_dripIrrigation_Nyarugenge	Total_ArtificialFertilize		
Agriculture_dripIrrigation_Nyarugenge	AgriculturalWaste_ToB		
Agriculture_dripIrrigation_Nyarugenge	ExcessFlow_Agricultura		
Agriculture_dripIrrigation_Nyarugenge	Total_AgriculturalWast		
Agriculture_dripIrrigation_Nyarugenge	FruVeg_ToMarket1		
Agriculture_dripIrrigation_Nyarugenge	Cereal_ToMarket1		
Agriculture_dripIrrigation_Nyarugenge	IndCrops_ToMarket1		
Agriculture_dripIrrigation_Nyarugenge	Beverage_ToMarket1		
Agriculture_dripIrrigation_Nyarugenge	Meat_ToMarket1		
Agriculture_dripIrrigation_Nyarugenge	Dairy_ToMarket1		
Agriculture_dripIrrigation_Nyarugenge	Fisch_ToMarket1		
Agriculture_wetlands_Nyarugenge	Total_FoodProduction_		
Agriculture_wetlands_Nyarugenge	TreatedGreywater_Prir		



Output data:

- Flows, concentrations of each flux in the system
- Environmental information:
  - Greenhouse Gas emissions, …
  - Energy consumptions
  - Area demands
  - Import needs, ……





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Session 3

SIMULATE THE URBAN FUTURE

TU Berlin • ifak • ifeu

WHY SCENARIO SIMULATION?

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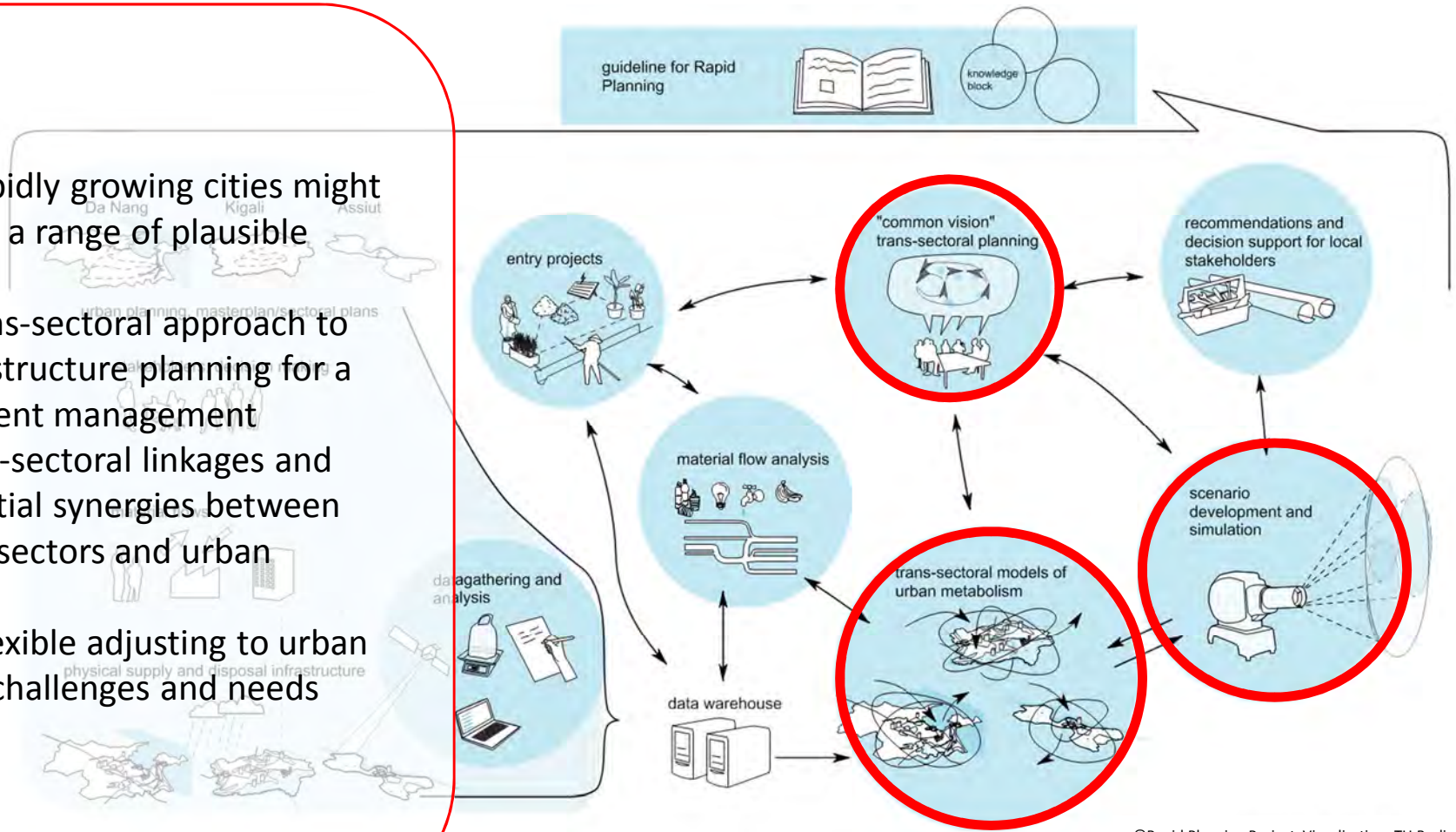
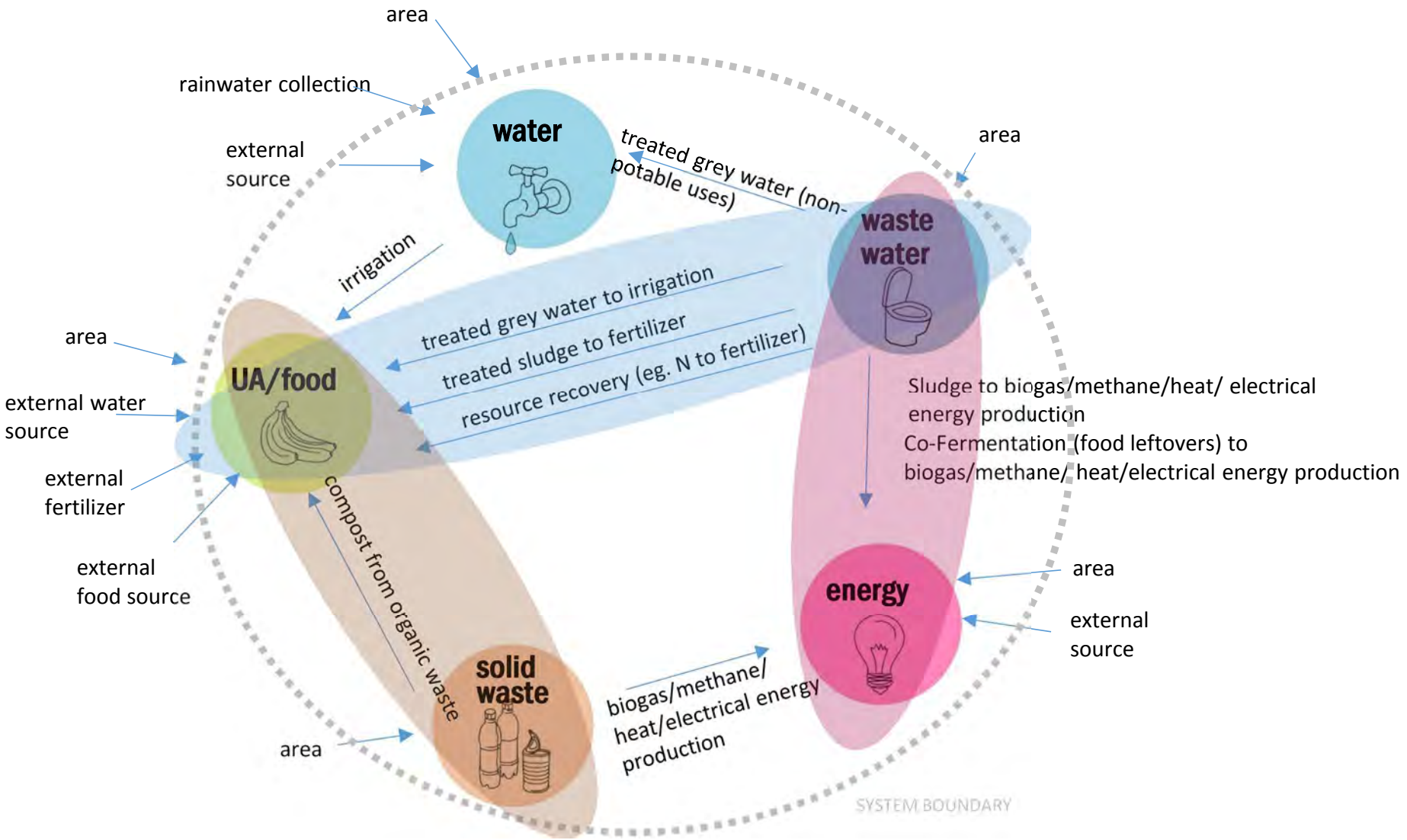
- assess how rapidly growing cities might develop under a range of plausible futures
- applying a trans-sectoral approach to optimise infrastructure planning for a resource efficient management
- generate trans-sectoral linkages and harness potential synergies between infrastructure sectors and urban development
- allowing for flexible adjusting to urban development challenges and needs



©Rapid Planning Project Visualisation: TU Berlin

SCENARIO SIMULATION

TRANS-SECTORAL LINKAGES



obvious interactions such as use of energy for pumping/treating water are not shown in this figure

SCENARIO SIMULATION
SCENARIO DEFINITION

Status quo
based on current state

Reference scenario
Kigali + Nyarugenge Masterplans + sectoral development plans

- based on general parameters, e.g. population growth, urbanization, consumption/demand patterns
- based on goals and parameters of existing masterplans and strategic sectoral plans

Trans-sectoral scenario(s)

- based on same general parameters - may deviate in some cases
- in addition, sectoral optimization and trans-sectoral interlinkages with resulting synergies
- developing scenarios for context-specific cases

GOAL: revealing potential effects of applying trans-sectoral planning:

- possible to achieve an optimized resource management by harnessing synergies?

- what are the effects on urban quality, climate related and economic aspects?

SCENARIO SIMULATION
ASSUMPTIONS POPULATION DEVELOPMENT

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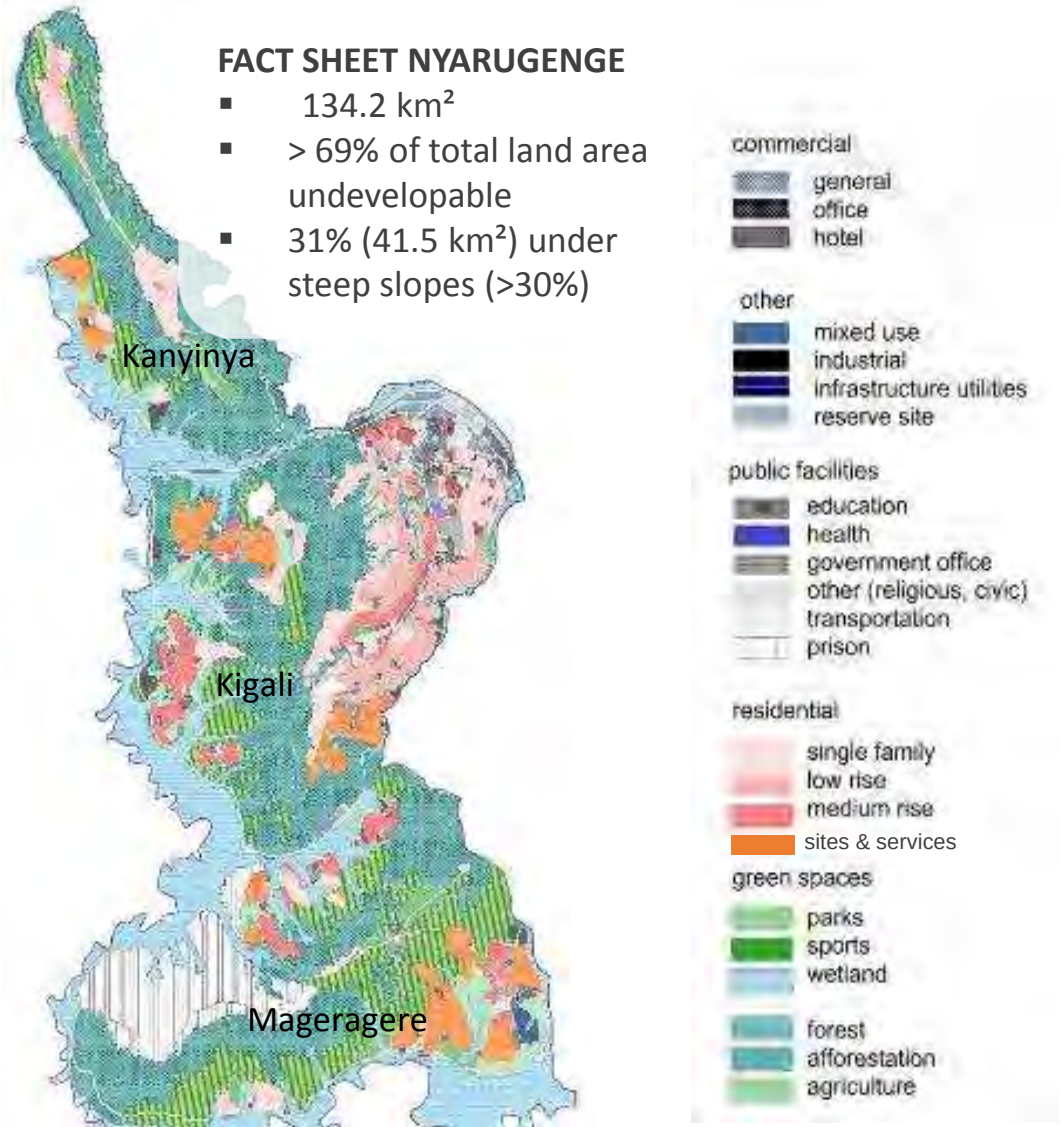
FACT SHEET NYARUGENGE

- 134.2 km²
- > 69% of total land area undevelopable
- 31% (41.5 km²) under steep slopes (>30%)

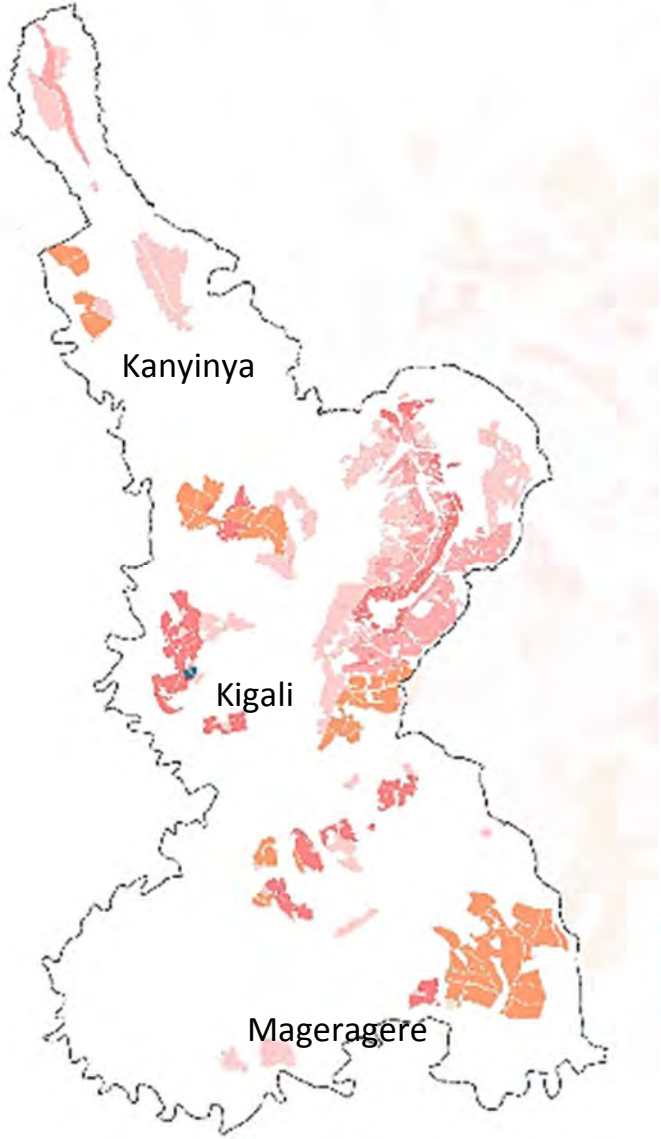


Sources: COK Masterplan (c) Openstreetmap Contributers;
agriculture: remote sensing by University Tübingen (TU Berlin, Lindschulte, Olbertz)

RP ASSUMPTIONS POPULATION NYARUGENGE			
2012	Census		284,561
2016	**Status quo**		**304,193**
2040	**Reference (Masterplan) Scenario**		**421,987**
2040	**Rapid Planning Scenario**		**421,987**
RP ASSUMPTIONS POPULATION REST OF KIGALI			
2012	Census		848,125
2016	**Status Quo**		**1.080.966**
2040	**Reference Scenario**		**2.478.013**
2040	**Rapid Planning Scenario**		**2.478.013**
RP ASSUMPTIONS POPULATION KIGALI TOTAL			
2012	Census		1.132.686
2016	Status quo		1.385.159
2040	Reference Scenario		2.900.000
2040	Rapid Planning Scenario		2.900.000

Sources: NISR Census 2012, Kigali Masterplan Presentation Update Feb. 2019, High Growth Scenario

SCENARIO SIMULATION
ASSUMPTIONS SPATIAL UNITS

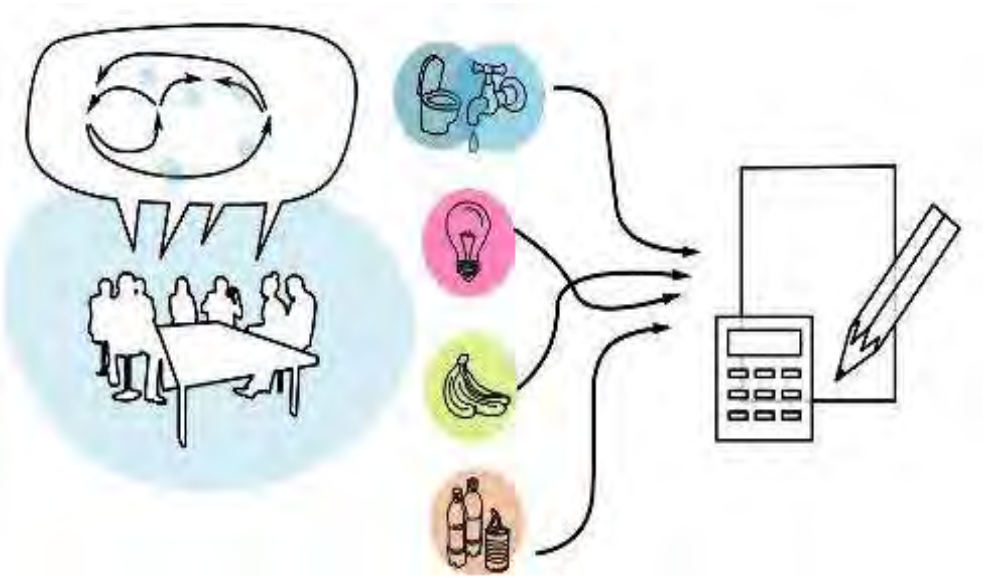


Sources: COK Masterplan (c) Openstreetmap Contributers; Updated Kigali Masterplan Feb. 2019 (TU Berlin, Lindschulte, Olbertz)

	NYARUGENGE		REST OF KIGALI	
Building type	**Status Quo 2018**	**Assumptions 2040**	**Status Quo 2018**	**Assumptions 2040**
Rudimentary	25,6532	64,133	819,397	259,197
Bungalow	30,231	30,986	154,854	138,768
Villa	704	23,659	43,911	123,900
Apartment	16,725	69,766	62,803	473,705
Row house	0	233,442	0	148,3406
Total population	**304,193**	**421,986**	**1.08**	**2.47 mil**

Sources: Rapid Planning, Kigali Masterplan Presentation Update Feb. 2019

SCENARIO SIMULATION
SECTOR DATA AND ASSUMPTIONS



Assumptions on generation and consumption parameters by urban infrastructure sector

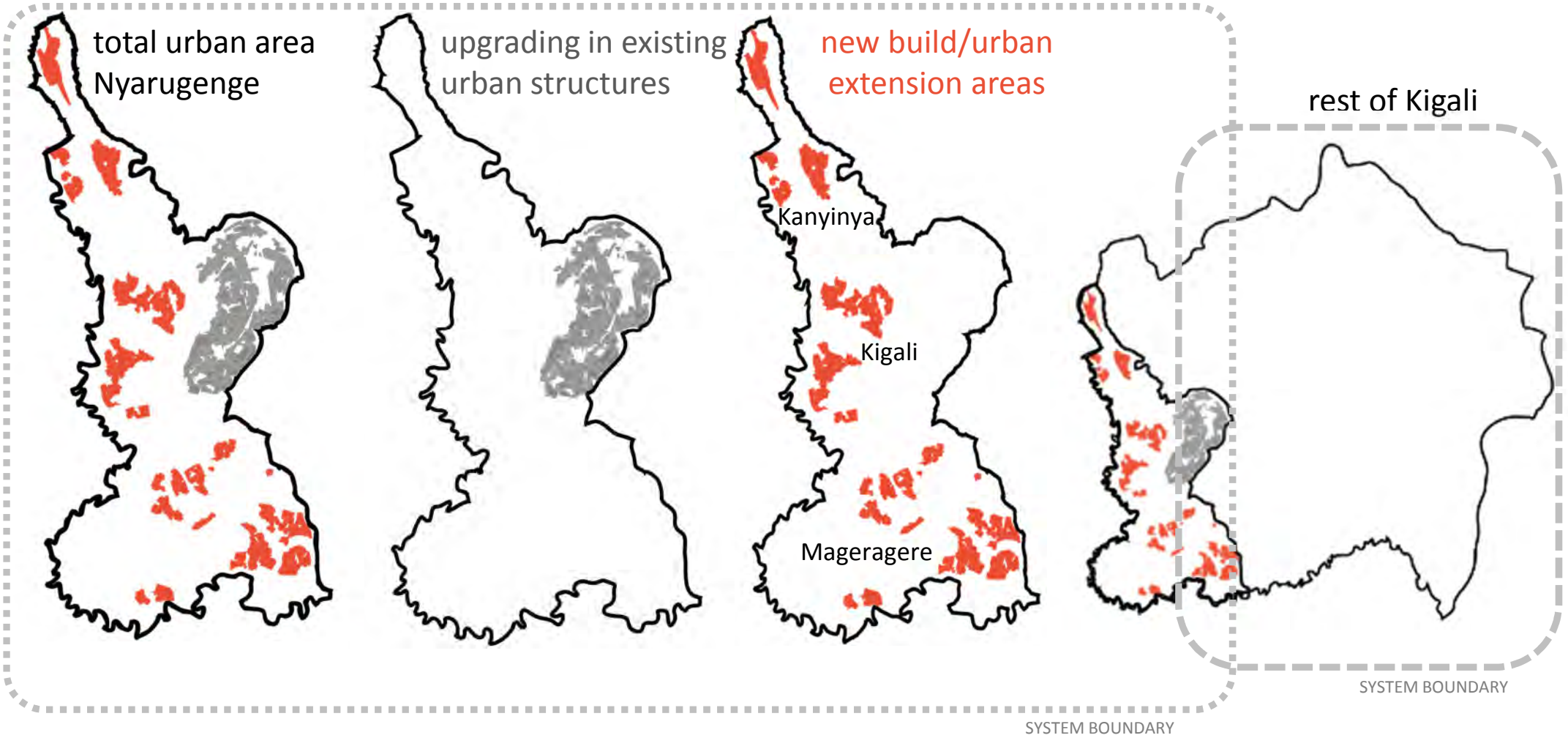
- STATUS QUO
- REFERENCE SCENARIO 2040
- TRANS-SECTORAL SCENARIOS 2040

- waste generation and disposal and treatment technologies
- water consmption per capita/day
- wastewater generation and treatment technologies
- energy consumption per capita/day and energy mix
- urban agriculture production area by primary and secondary agriculture and consumption

**The reference scenario is based on the Nyarugenge and Kigali Masterplan 2013. Due to parallel timing, the Kigali Masterplan Update 2019 has been integrated in parts only. Stakeholder feedback during the first scenario workshop held in Kigali in October 2018 has also been considered.*

SCENARIO SIMULATION

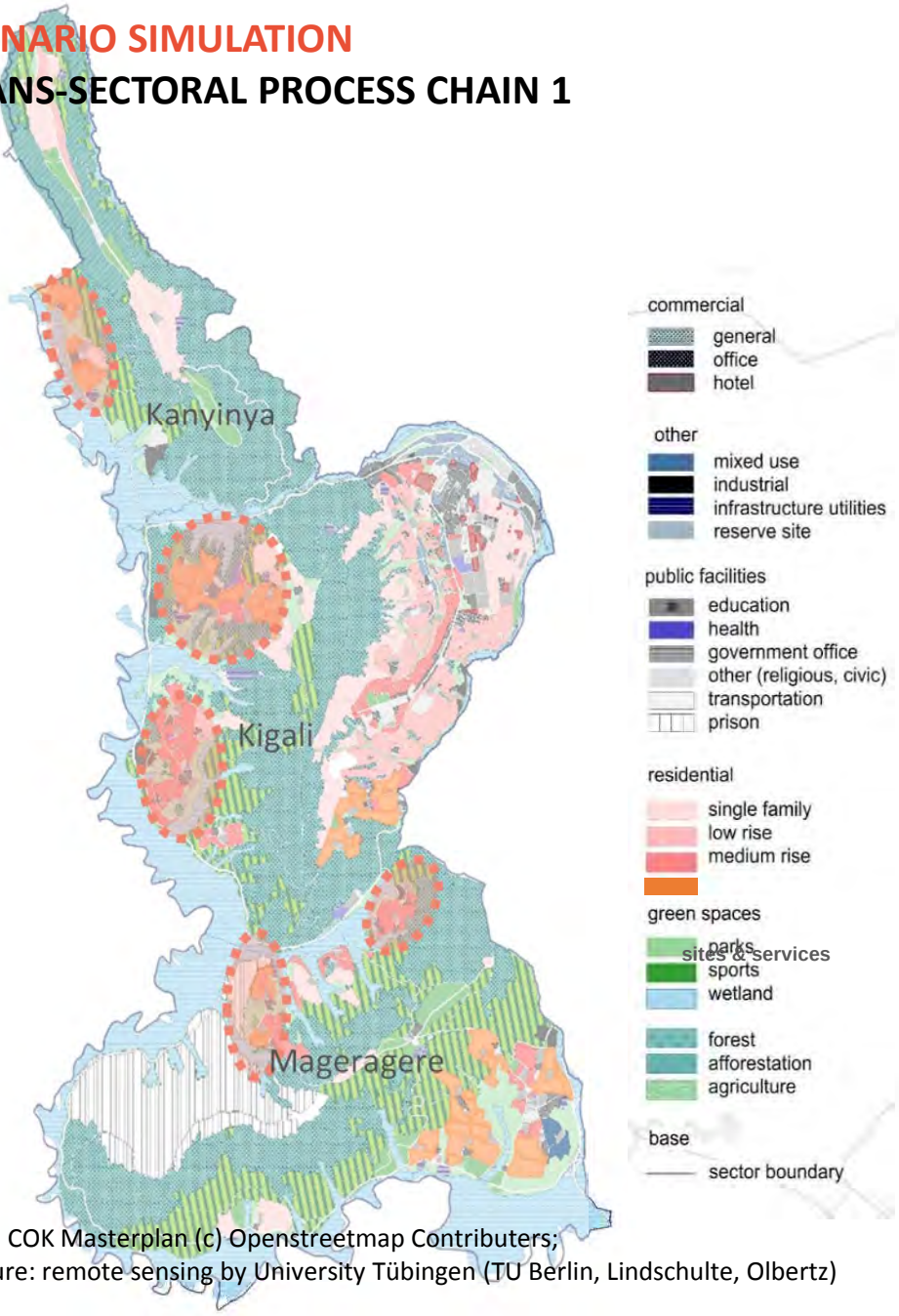
SPATIAL APPROACH – SYSTEM BOUNDARIES



Sources: COK Masterplan (c) Openstreetmap Contributers; Updated Kigali Masterplan Feb. 2019 (TU Berlin, Lindschulte, Olbertz)

SCENARIO SIMULATION

TRANS-SECTORAL PROCESS CHAIN 1



Sources: COK Masterplan (c) Openstreetmap Contributers;
agriculture: remote sensing by University Tübingen (TU Berlin, Lindschulte, Olbertz)

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WATER - WASTEWATER - ENERGY – URBAN AGRICULTURE

Possible application area:
Urban extension areas

- strategy for low-cost-housing and other building types, pre-dominately in peri-urban areas that are not connected to any WWTP

- decentral solid waste management, e.g. composting facilities in the vicinity of agricultural areas

SCENARIO SIMULATION
PROCESS CHAIN 1

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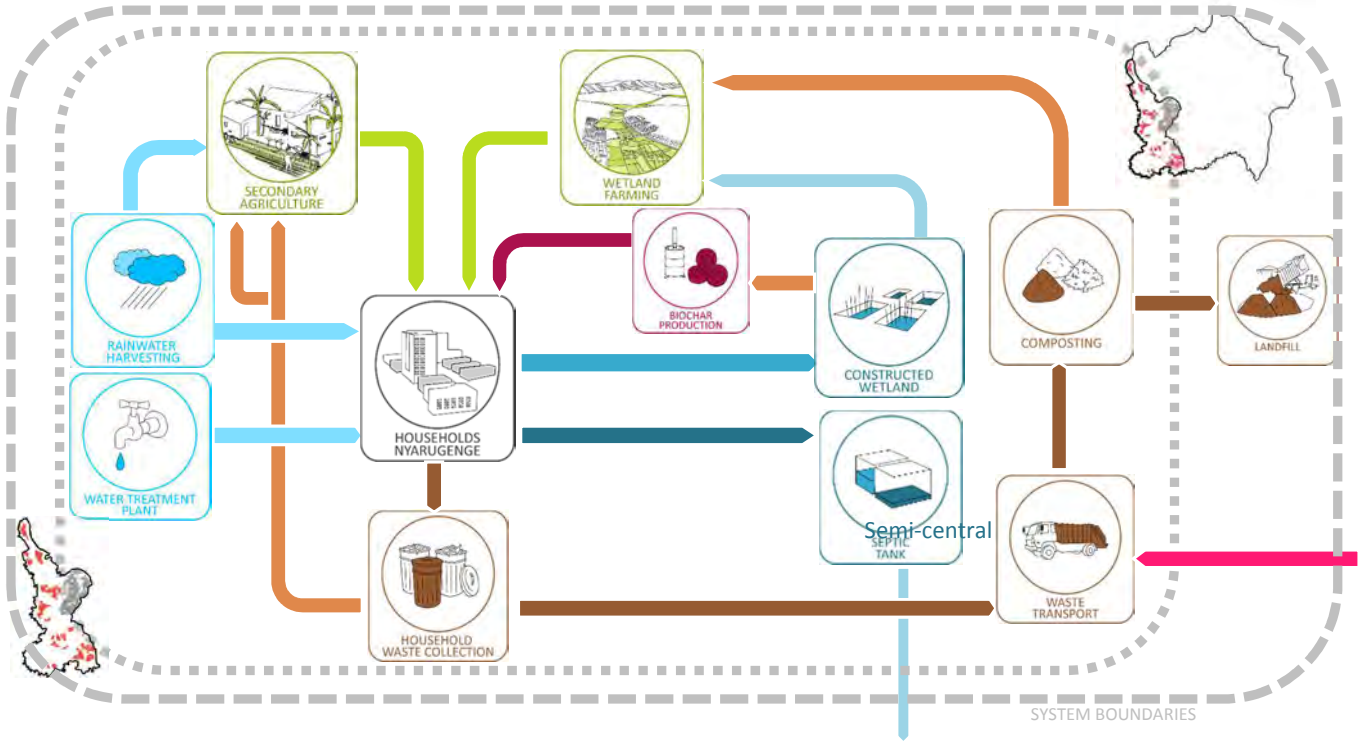
WATER - WASTEWATER - ENERGY – URBAN AGRICULTURE



SIMULATION MODULES

SCENARIO SIMULATION

TRANS-SECTORAL PROCESS CHAIN 1

WATER - WASTEWATER - ENERGY – URBAN AGRICULTURE

DESCRIPTION

- Greywater and blackwater is separated by private households in new buildings/urban extension areas
  - ✓ Greywater is treated in constructed wetlands.
  - ✓ Effluent is re-used as irrigation water, e.g. for wetland farming during Season C
  - ✓ Produced biomass from constructed wetland processes into biocharcoal
  - ✓ Blackwater is treated in decentralised WWTP (compact wastewater treatment plants, UASB, septic tank, etc.)
- Organic waste is separated and composted at home or in one of the 3 industrial composting plants
- Generated compost is used in fruit&vegetable wetland farming to substitute artificial fertilizer
- Rooftop rainwater harvesting, which is used for cleaning and irrigation of secondary agriculture

ASSUMPTIONS

- 133.818 inh. / 42.421 HH in Nyarugenge and 522.062 inh. / 177.508 HH in Rest Kigali separate wastewater into grey and blackwater
- 22 ha are used as constructed wetlands in Nyarugenge (84 ha in Rest of Kigali) (2 m²/capita)
- 70% of organic waste is separated at source and collected, of this is processed:
  - 86% in three industrial composting plants
  - 8% home composting
  - 6% in co-fermentation process
- At household level in Nyarugenge, rainwater is harvested from 72,8751m^2 roof top area and 5.2 mil. m^2 in the rest of Kigali; assumed rainwater availability is 0.0016$m^3/m^2/d$: of rainwater harvested
  - 60% is used for cleaning
  - 40% is used for irrigating secondary urban agriculture

SCENARIO SIMULATION

TRANS-SECTORAL PROCESS CHAIN 1

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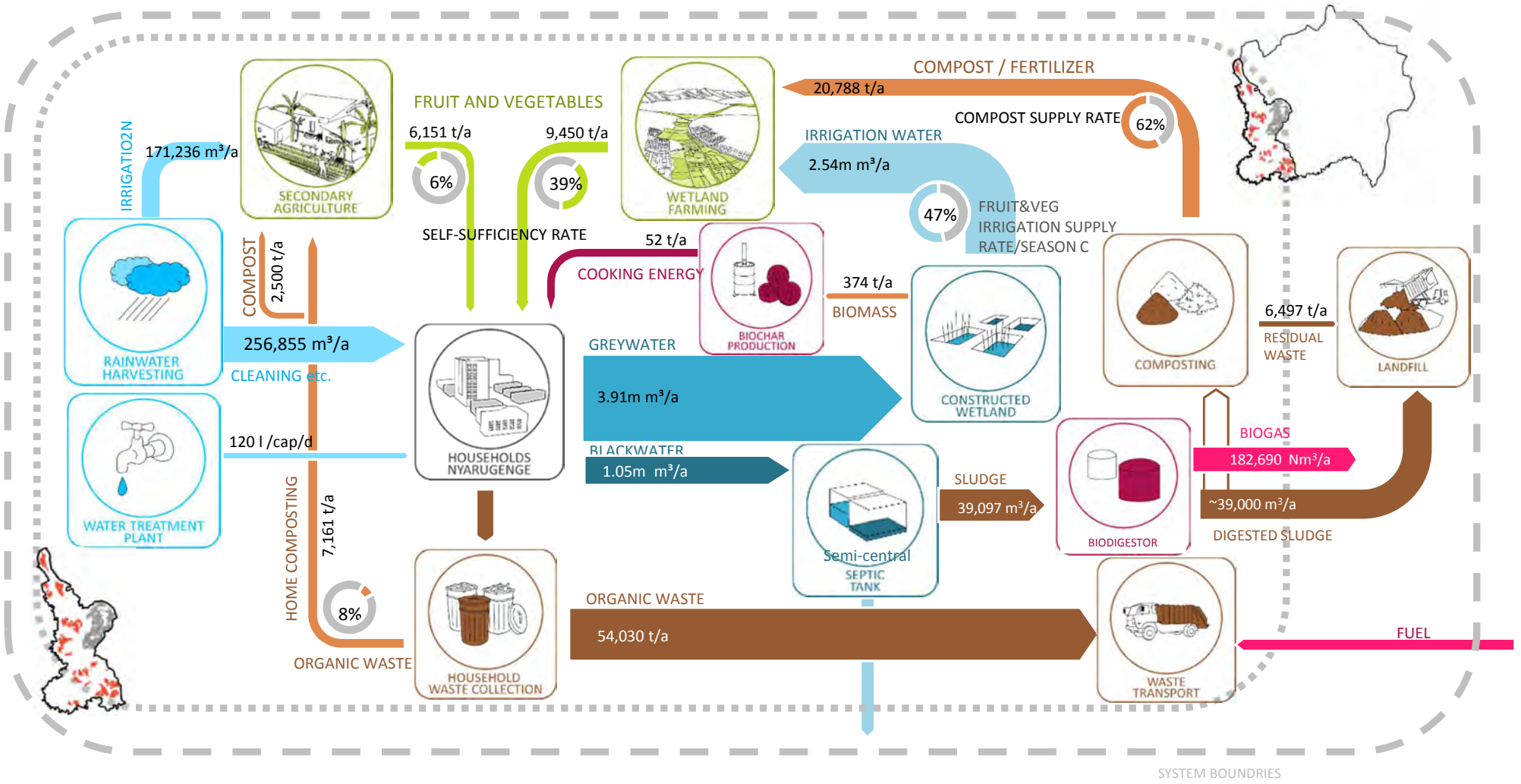
WATER - WASTE WATER – SOLID WASTE – ENERGY – URBAN AGRICULTURE



SCENARIO SIMULATION

TRANS-SECTORAL SCENARIO – PROCESS CHAIN 1

WATER - WASTEWATER - ENERGY – URBAN AGRICULTURE

RESULTS

- Generated treated greywater covers 47% of irrigation demand of fruits and vegetables in wetland farming of Nyarugenge during season C.
- Treatment of blackwater in decentralised WWTP improves sanitation conditions and reduces sludge transportation costs
- Compost application (considering max. compost application rates of 13.3 t/ha/a of fresh mass) in wetland farming substitutes:
  - ✓ 151 kg/d of artificial Urea = 16%* nitrogen demand
  - ✓ 211 kg/d of artificial Phosphate = 100%* phosphate demand
  - ✓ 404 kg/d of artificial Potash = 100%* potassium demand.
- Primary agriculture fruit &vegetable production = ~42.200 t/a
- Harvested biomass of constructed wetlands can be processed into 52 t/a of charcoal (Biochar), avoiding the use of 374 t/a of wood (deforestation)
- Landfill lifespan can be extended by composting 54.000 t/a of organic waste and 17.000 t/a of sorted recyclables within Nyarugenge
- Three composting plants in Nyarugenge generate around 20,000 t/a of compost for fertilization; covering ~60% of organic fertilizer demand of fruit&vegetable wetland farming in Nyarugenge

*rough estimation

SCENARIO SIMULATION
MASTERPLAN WASTEWATER TREATMENT

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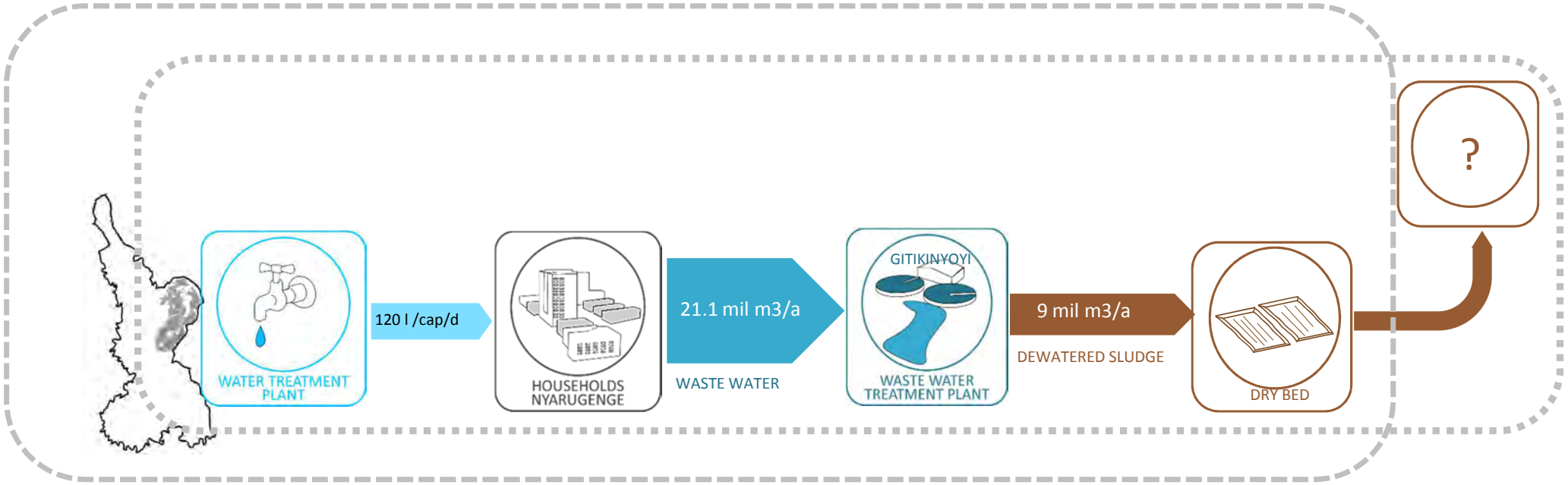
PLANNED WASTEWATER TREATMENT PLANT SERVING CBD/NEIGHBOURING SECTORS



Please note:
- volumes based on RP Simulator reference scenario results
- above process chain is not directly comparable to trans-sectoral process chain 2

SCENARIO SIMULATION

TRANS-SECTORAL PROCESS CHAIN 2

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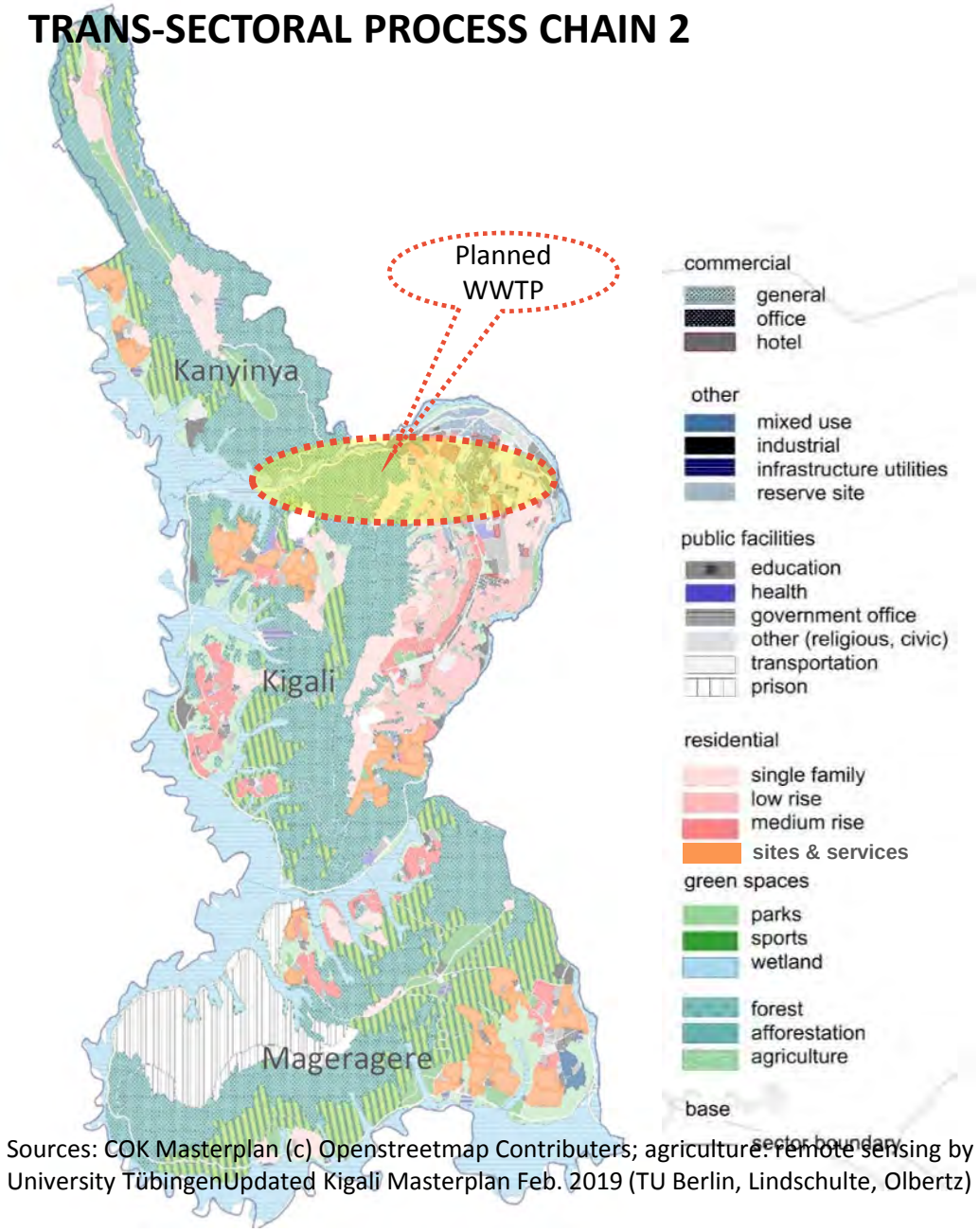
WASTEWATER – SOLID WASTE - ENERGY – URBAN AGRICULTURE



- planned Wastewater Treatment Plant (WWTP) Gitikinyoyi for serving the CBD and neighbouring sectors (66ha zoned in Kigali Master Plan 2019)
- includes site of Sewage Sludge Treatment Facility (SSTF)

Sources: COK Masterplan (c) Openstreetmap Contributers; agriculture: remote sensing by University TübingenUpdated Kigali Masterplan Feb. 2019 (TU Berlin, Lindschulte, Olbertz)

SCENARIO SIMULATION

TRANS-SECTORAL PROCESS CHAIN 2

RAPID PLANNING
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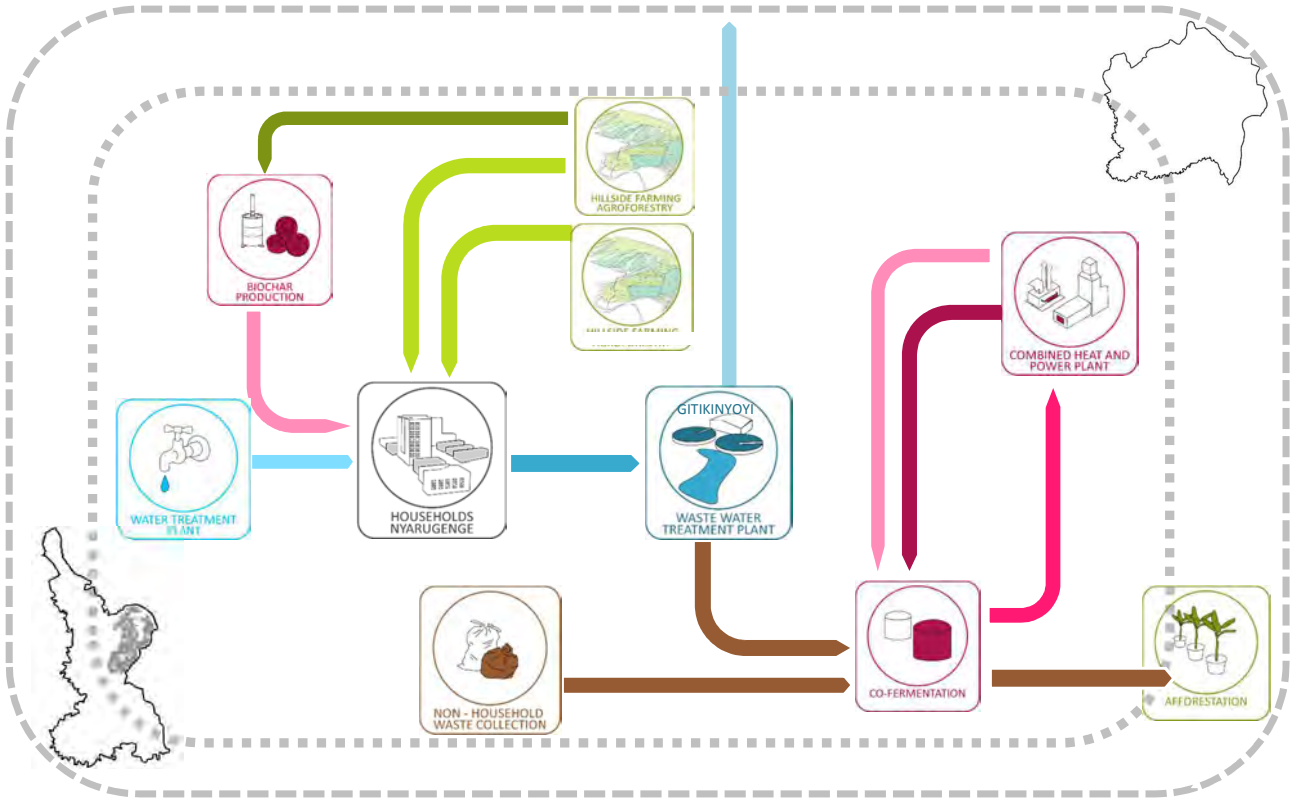
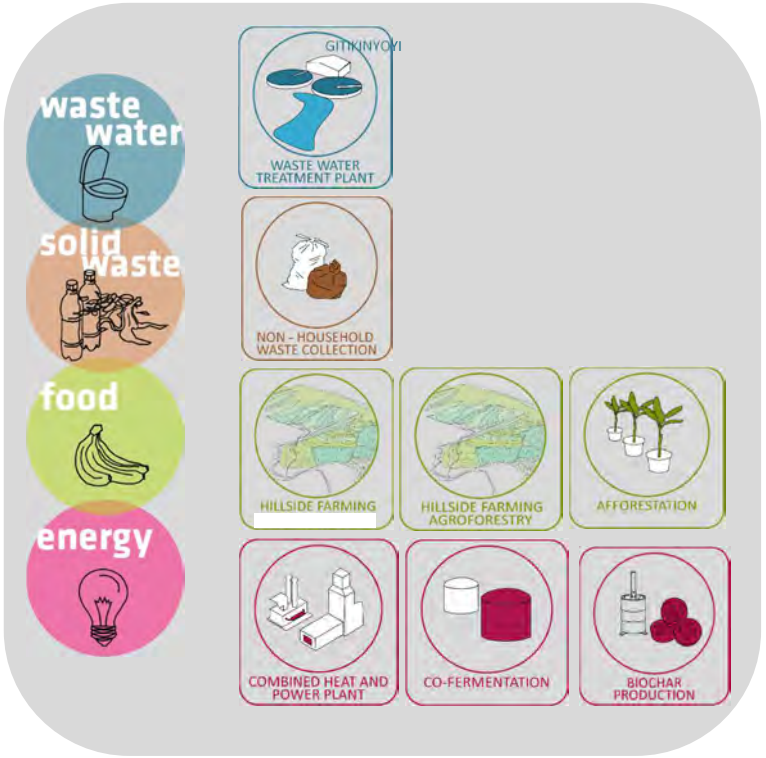
WASTE WATER - SOLID WASTE - ENERGY - URBAN AGRICULTURE



SYSTEM BOUNDARIES

SIMULATION MODULES



ENERGY AND
MATERIAL FLOWS

SCENARIO SIMULATION

TRANS-SECTORAL SCENARIO STORY LINE - PROCESS CHAIN 1

WASTEWATER – SOLID WASTE - ENERGY – URBAN AGRICULTURE

DESCRIPTION

- WWTP serving CBD and neighbouring sectors (activated sludge), with inflow rate of 90,000 m³/d, requiring space of around 40 ha. Including co-fermentation and CHP plant require approx. 44 ha
- Co-Fermentation of the WWTP sludge together with non-household organic leftovers from food processing industries and restaurants (anaerobic digestion generates biogas).
- CHP produces energy from biogas
  - ✓ electric energy for WWTP energy demand
  - ✓ heat for sludge drying
- Digested sludge used as fertilizer for afforestation and non-edible crops
- Wood from agroforestry used for charcoal production (Biochar)

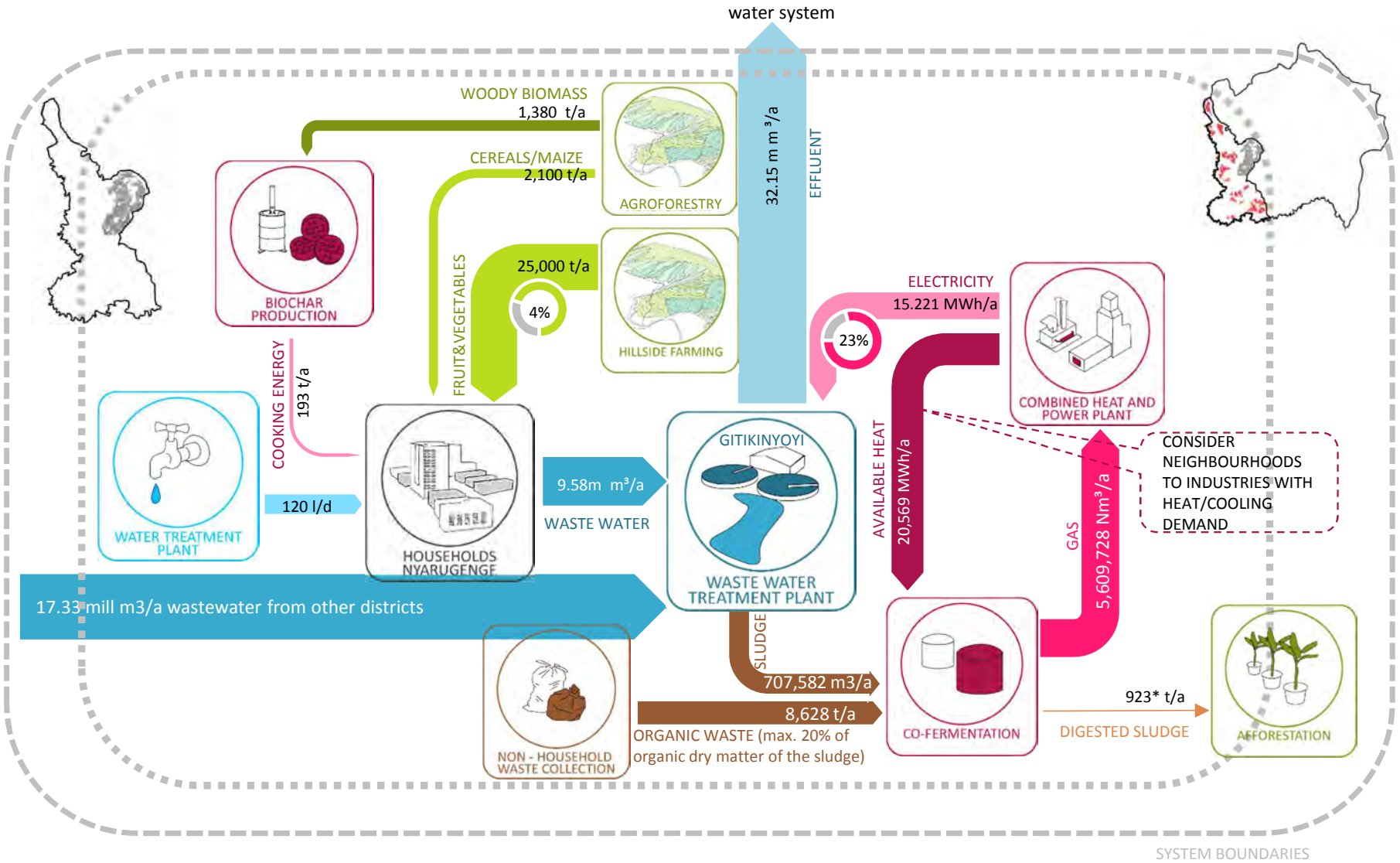
ASSUMPTIONS

- 262.577 inh. / 85.893 HH and the commercial and administration sector of Nyarugenge are connected to the sewage system, bringing wastewater to Gitikinyoyi WWTP (44% of inflow).
- Before Co-Fermentation, sludge generated by Activated Sludge Process is passed through a band filter to be thickened
  - then mixed with max. 20% of organic waste as a share of organic dry matter, e.g. food left-overs from gastronomic services and market waste
- Digested sludge from the co-fermentation process can be used on 1.268 ha (Nyarugenge) and 4.058 ha (rest of Kigali) of afforestation area for humus formation and fertilization (depending on max. application rates)

SCENARIO SIMULATION

TRANS-SECTORAL PROCESS CHAIN 2

WASTE WATER - SOLID WASTE - ENERGY - URBAN AGRICULTURE



*max. toxic heavy metal values must be adhered to

SCENARIO SIMULATION

TRANS-SECTORAL SCENARIO – PROCESS CHAIN 1

WATER - WASTEWATER - ENERGY – URBAN AGRICULTURE

RESULTS

- A wastewater treatment plant with a capacity of 90.000 m3/d serves 262.577 inhabitants (Nyarugenge), the commercial and administration sectors of Nyarugenge, as well as part of the sectors Kicukiro and Gasabo. The electric energy produced in the CHP covers 23% of the energy demand of the WWTP
- The heat produced in the CHP can be used to dry the sludge in order to reduce transportation costs or can be available for industrial processes in the proximity.
- The use of dried sludge as fertilizer for afforestation extends the landfill lifespan
- Conversion of woody biomass from agroforestry into biochar production avoids the use of 1,380 t/a of wood, e.g. from deforestation in Nyarugenge
- 923 t/a of sludge can be applied to afforestation areas in Nyarugenge (~1,200 ha) and rest of Kigali (~4,000 ha)

SCENARIO SIMULATION

SITES FOR PROPOSED FACILITIES

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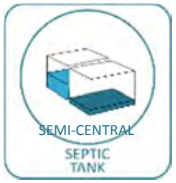
composting facility
North

sorting facility

Semi-central septic tank for one settlement



WWTP serving CBD/ neighbouring sectors

composting facility
Central

composting facility
South

Legend

- composting facility
- sorting facility
- WWTP (wastewater treatment plant)
- Semi-central septic tank plant *(serving 1 settlement)*
- biogas plant *(in proximity to semi-central septic tank plant)*

Sources: COK Masterplan (c) Openstreetmap Contributers; agriculture: remote sensing by University TübingenUpdated Kigali Masterplan Feb. 2019 (TU Berlin, Lindschulte, Olbertz)

SCENARIO SIMULATION

PROCESS CHAIN SYNOPSIS KIGALI

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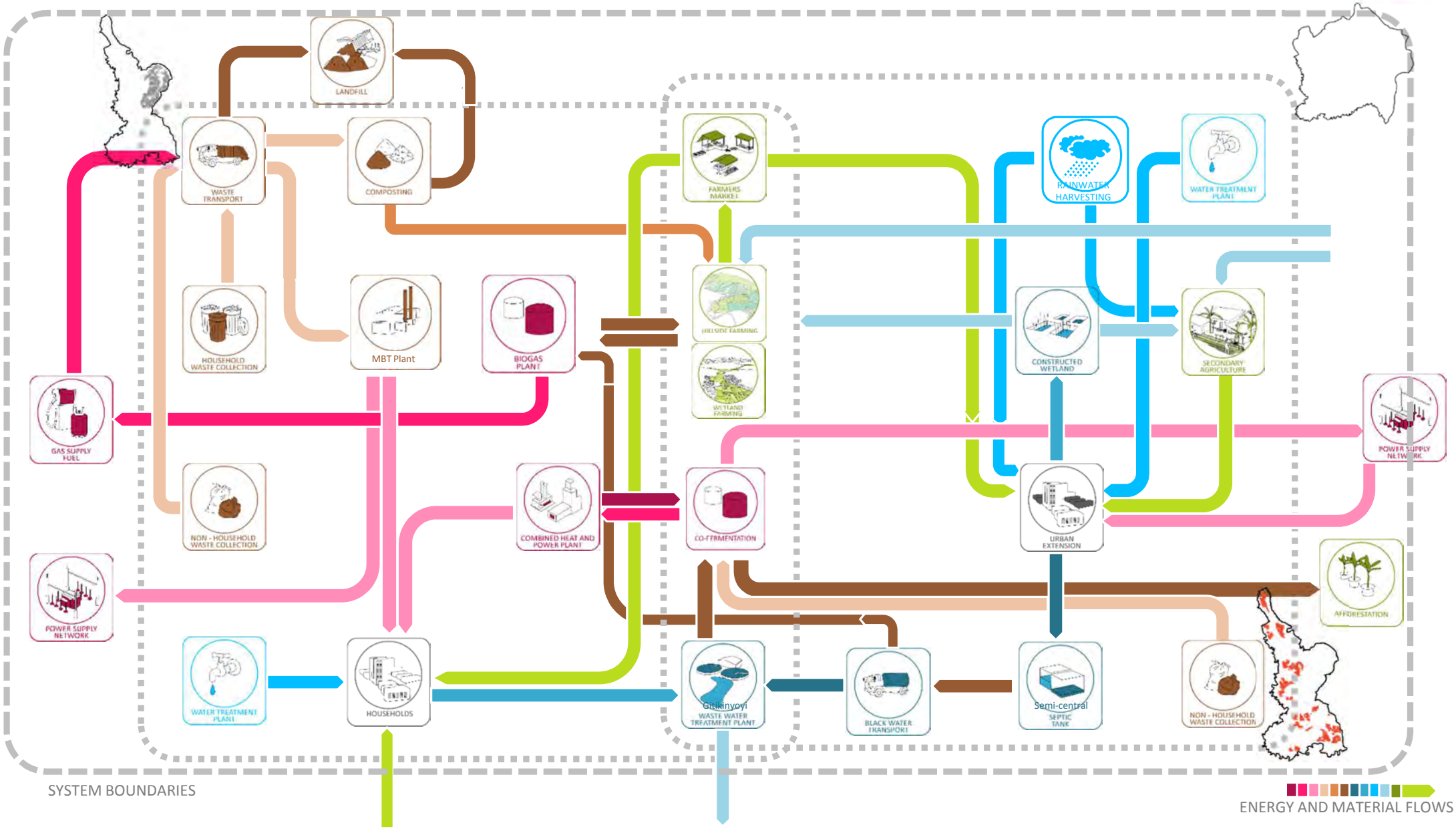


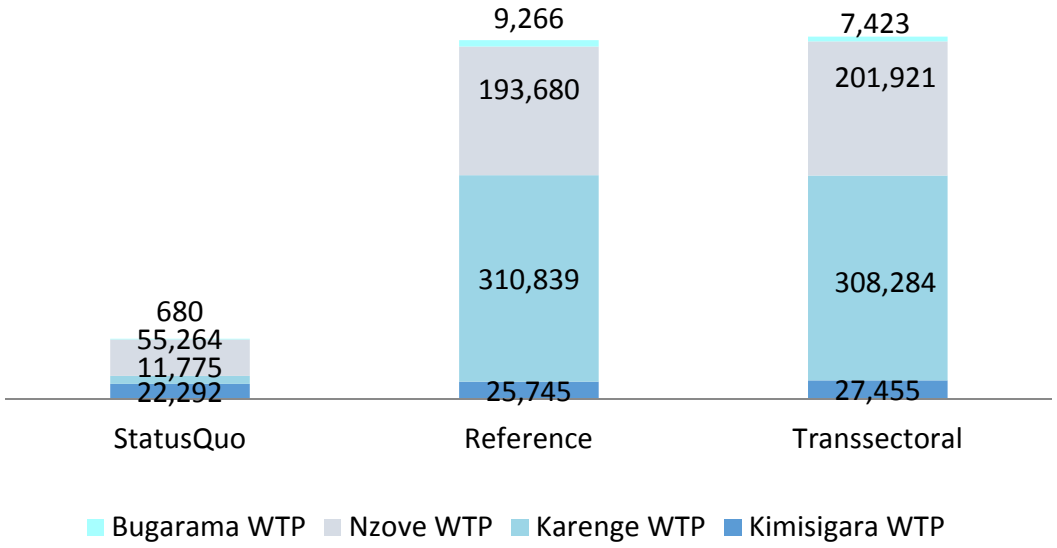
SYSTEM BOUNDARIES

ENERGY AND MATERIAL FLOWS

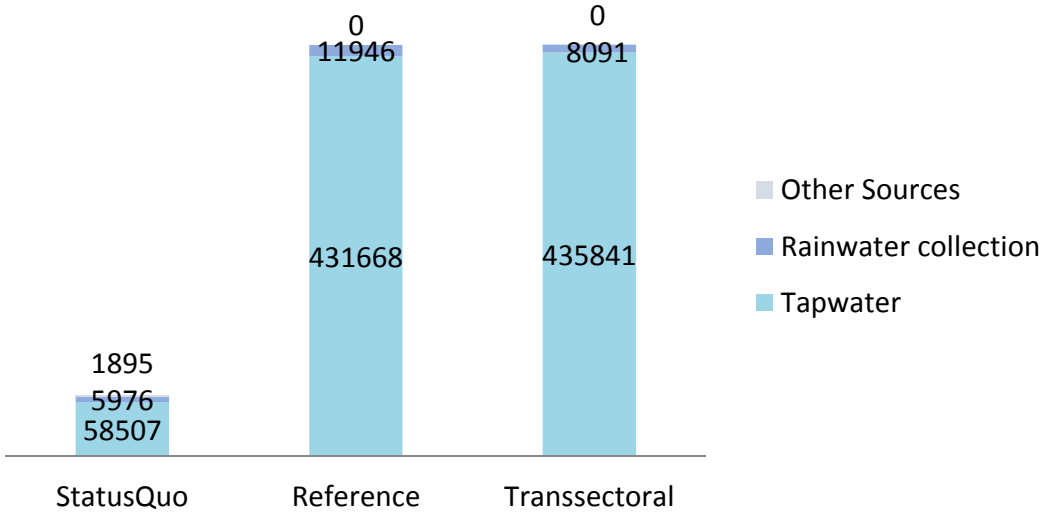
SCENARIO SIMULATION
SELECTED RESULTS - WATER SECTOR

- Fair supply of drinking water according to SDG´s (rural: 80 l/cap/d, urban 120 l/cap/d)
- Rainwater harvesting (households)

Water production in Kigali (m^3/d)



Water Consumption Kigali (m^3/d)



SCENARIO SIMULATION
SELECTED RESULTS - WASTEWASTER SECTOR

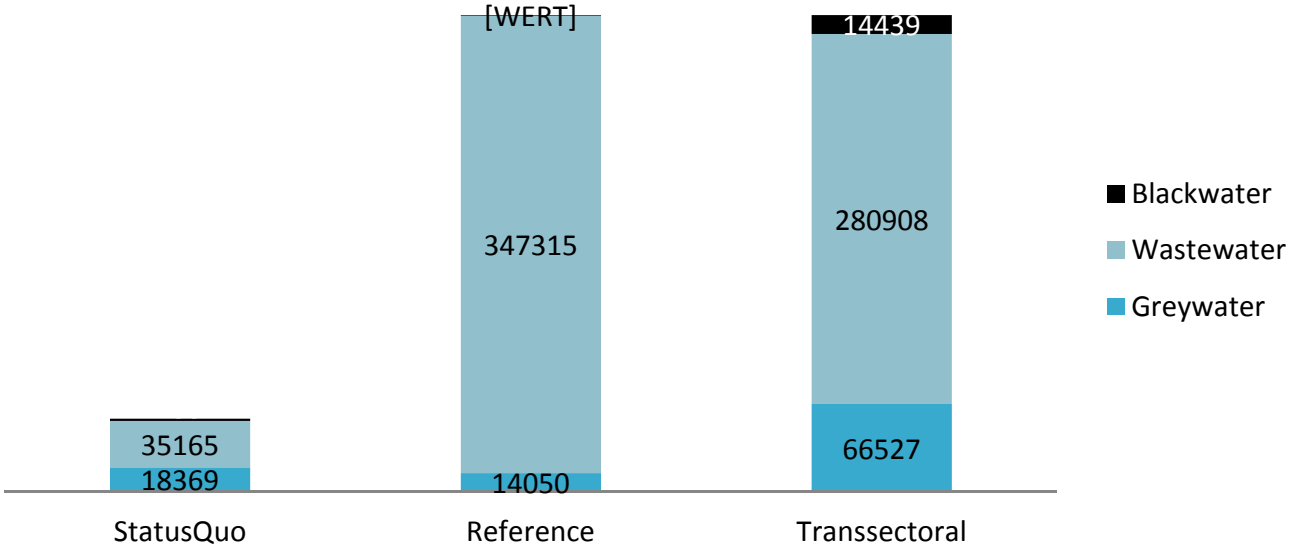
- Separation of greywater from wastewater

  → Treatment and reuse of greywater:
  - irrigation of agricultural areas

Wastewater

Urban food

Total Wastewater Generation in Kigali, m³/d



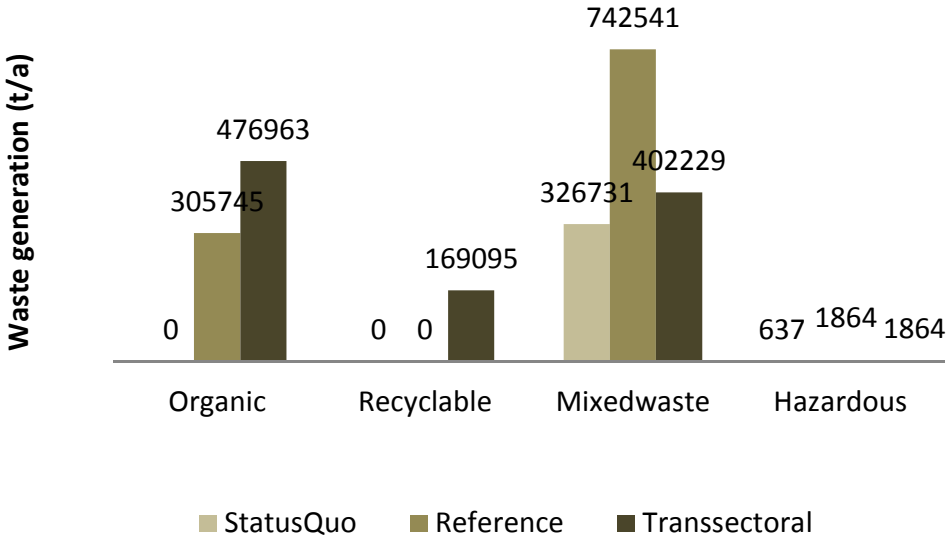
SCENARIO SIMULATION
SELECTED RESULTS - WASTE SECTOR

- Less inflow to landfill
- Production of energy
- Production of fertilizer

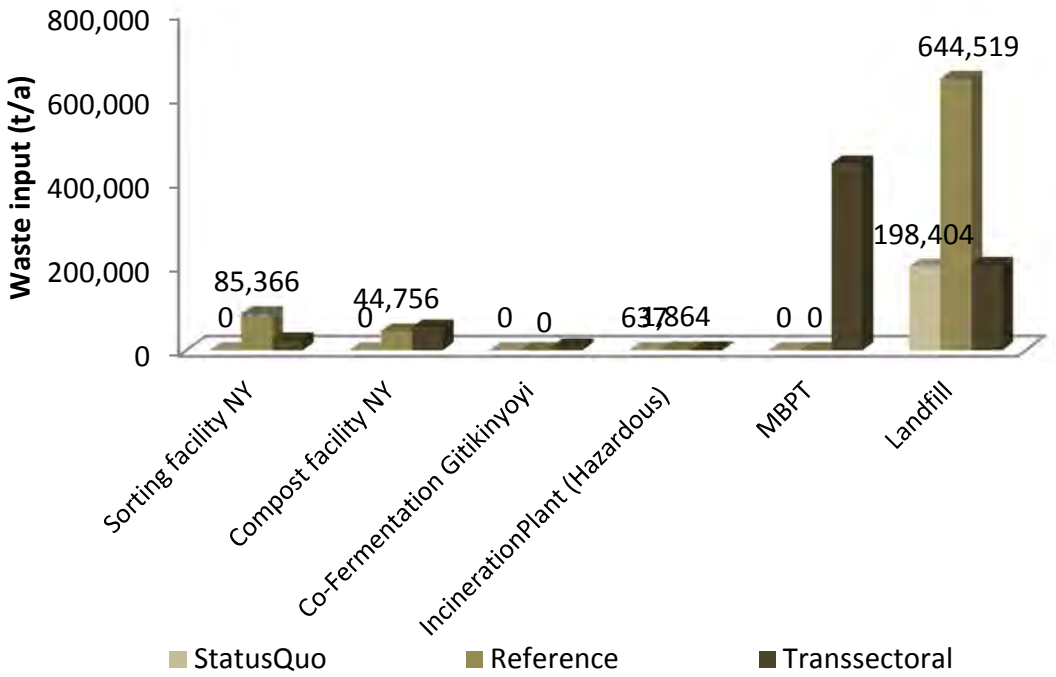
Energy

Urban food

Waste generation in Kigali



Waste treatment and disposal in Kigali

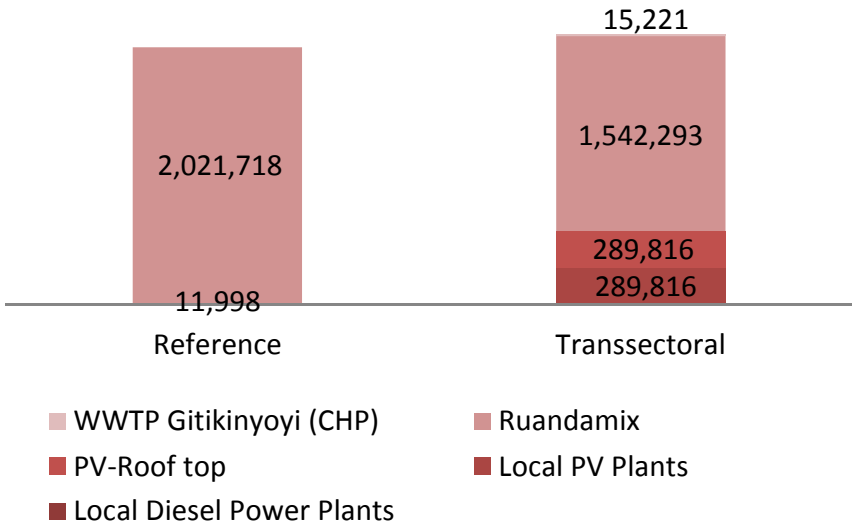


SCENARIO SIMULATION
SELECTED RESULTS - ENERGY SECTOR

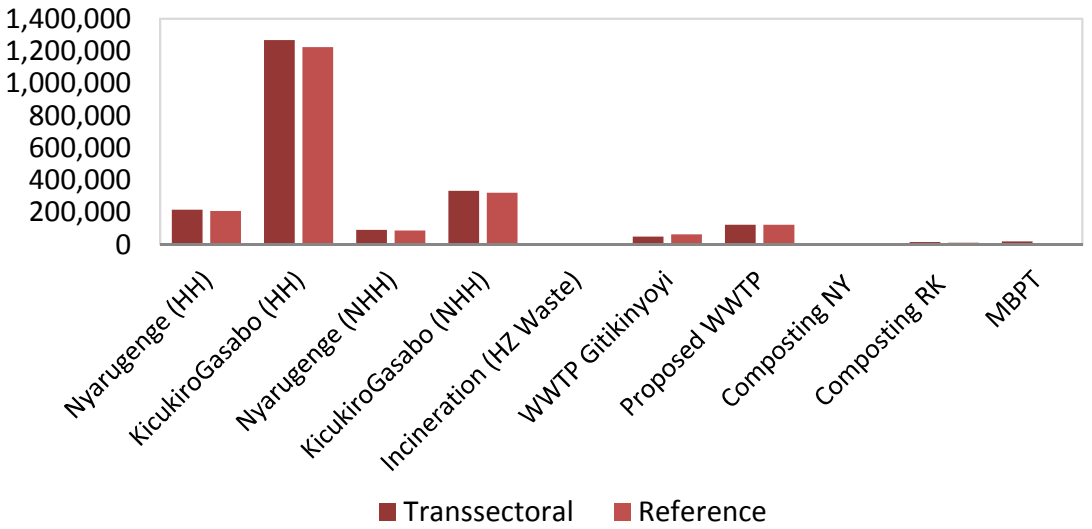
- Electricity produced by solid waste treatment
- Reduction of GHG emissions
- Local electricity production
- Resources recovery

Solid waste

Energy generation in Kigali 2040 (MWh/a)



Electricity consumption in Kigali (MWh/a)



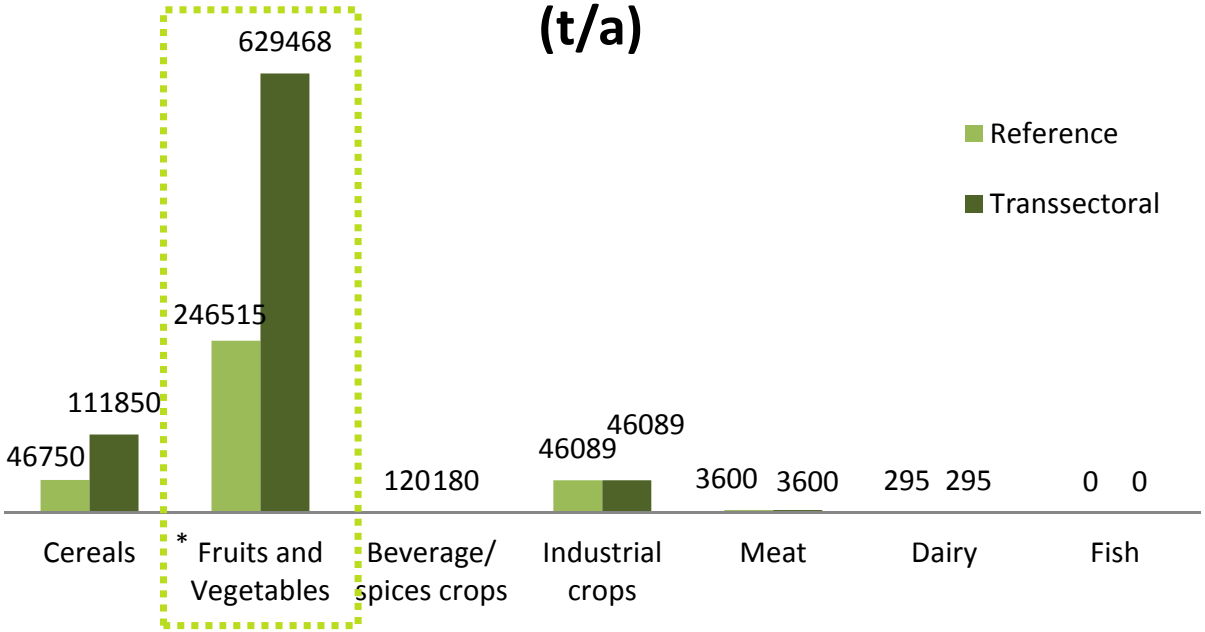
HH: Households, NHH: Non-households, HZ: Hazardous waste

SCENARIO SIMULATION
SELECTED RESULTS - FOOD SECTOR

- Sustainable use of fresh water sources
- Increasing local food production

Water

Total food production in Kigali (2040) (t/a)



>>> 89% SELF-SUFFICIENCY RATE

Assumptions:

- re-using treated greywater for irrigation to activate a third season (Season C)
- drip irrigation (fruit & vegetable production in wetlands) > assuming productivity doubles and water savings of 30%

*includes pulses

SCENARIO SIMULATION

ENVIRONMENTAL IMPACT ASSESSMENT

GREENHOUSE GAS EMISSIONS triggering CLIMATE CHANGE

Climate change […] it is ***disrupting national economies and affecting lives, costing people, communities and countries*** *[…].* ***Weather patterns are changing, sea levels are rising, weather events are becoming more extreme*** *[…].*
[…] for each ***1 degree of temperature increase, grain yields decline*** *by about* ***5 per cent****. […]*

13.2 *Integrate* ***climate change measures into national policies, strategies and planning***
13.B *Promote mechanisms for raising capacity for* ***effective climate change-related planning and management*** *[…]*

SCENARIO SIMULATION
ENVIRONMENTAL IMPACT ASSESSMENT

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GREENHOUSE GAS EMISSIONS triggering CLIMATE CHANGE

© United Nations SDGs

Intended Nationally Determined Contribution *(INDC) - Rwanda pledged to* ***reduce emissions relative to business-as-usual scenario emission levels by 2030***

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2014

Rwanda 7.59 Mt CO_2-eq
Total GHG emissions
(0.37% of world total)
World: 48,892 MtCO2eq

Rwanda 0.67 tCO2eq per capita
World: 6.73 tCO2eq per capita
25 % *from* ***Solid waste*** *and* ***Wastewater sector***
40 % *from* ***Agricultural sector***

USAID 2018, *WRI CAIT 4.0, 2017, FAOSTAT, 2018*

SCENARIO SIMULATION

ENVIRONMENTAL IMPACT ASSESSMENT

GREENHOUSE GAS EMISSIONS triggering CLIMATE CHANGE

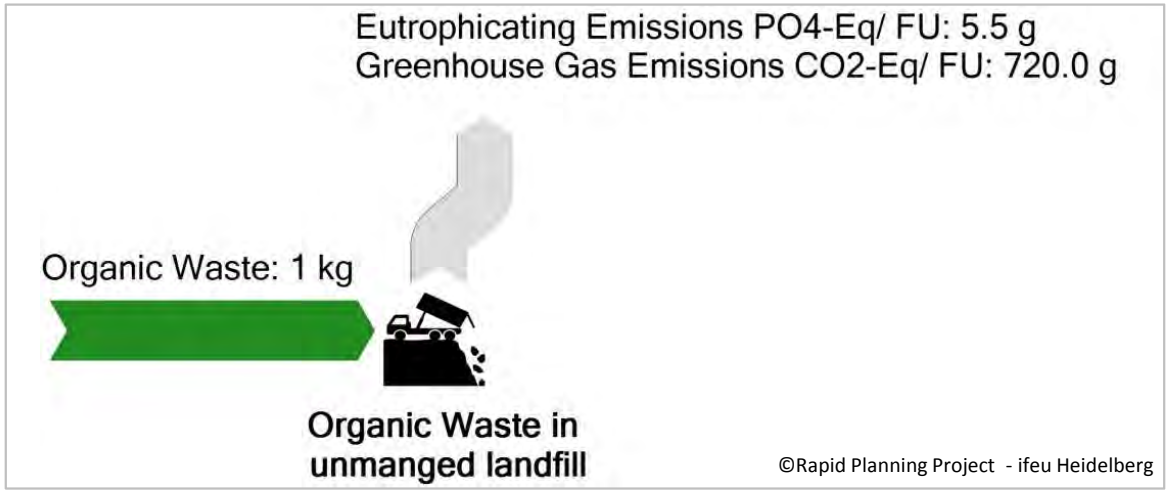
Life Cycle Impact Assessment (LCIA)					Life Cycle Inventory (LCI)	
Impact category	Unit	Geographic Scale			Greenhouse Gas CO_2-equivalents Factors*	
		Global	Regional	Local		
Climate change	kg CO_2-eq	x			CO_2 fossil	1
					CH_4 fossil	30
					CH_4 regenerative	28
					N_2O	265
					CF_4	6,630
					C_2F_6	11,100
					$CBrF_3$	6,290
					$CHClF_2$	1,810
					CCl_4	1,760
					$C_2H_3Cl_3$	160

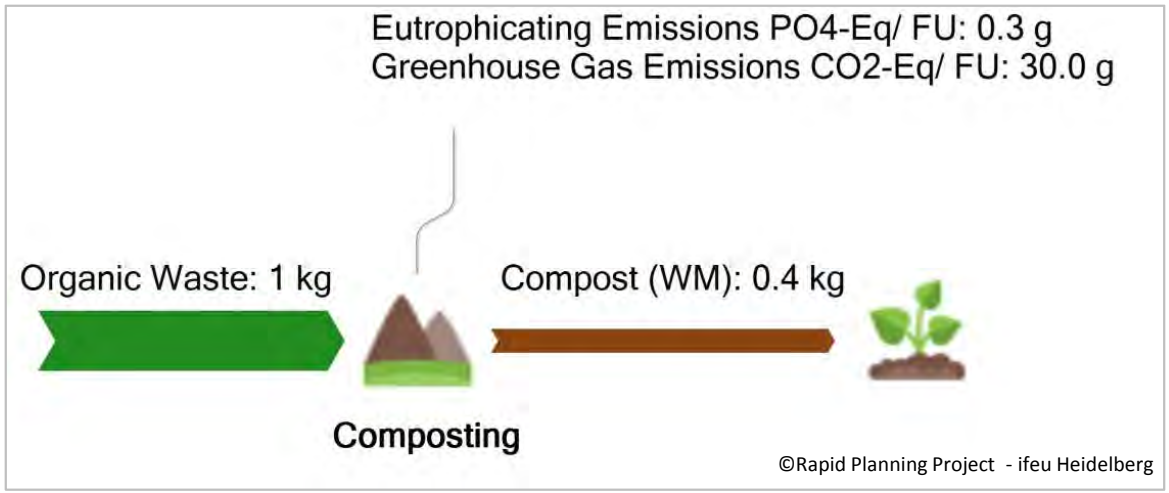
*IPCC 2013

SCENARIO SIMULATION

ENVIRONMENTAL IMPACT ASSESSMENT

PROCESS EMISSIONS EXAMPLE

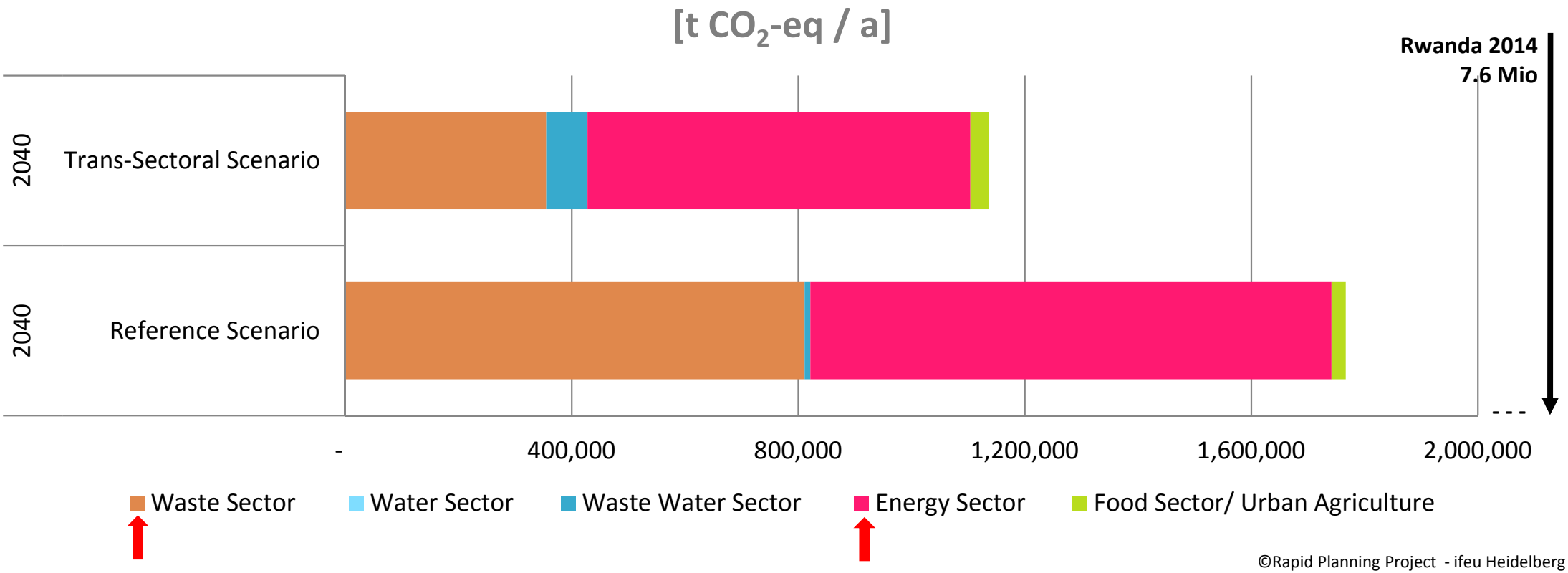




SCENARIO SIMULATION

RESULTS - ENVIRONMENTAL IMPACT ASSESSMENT

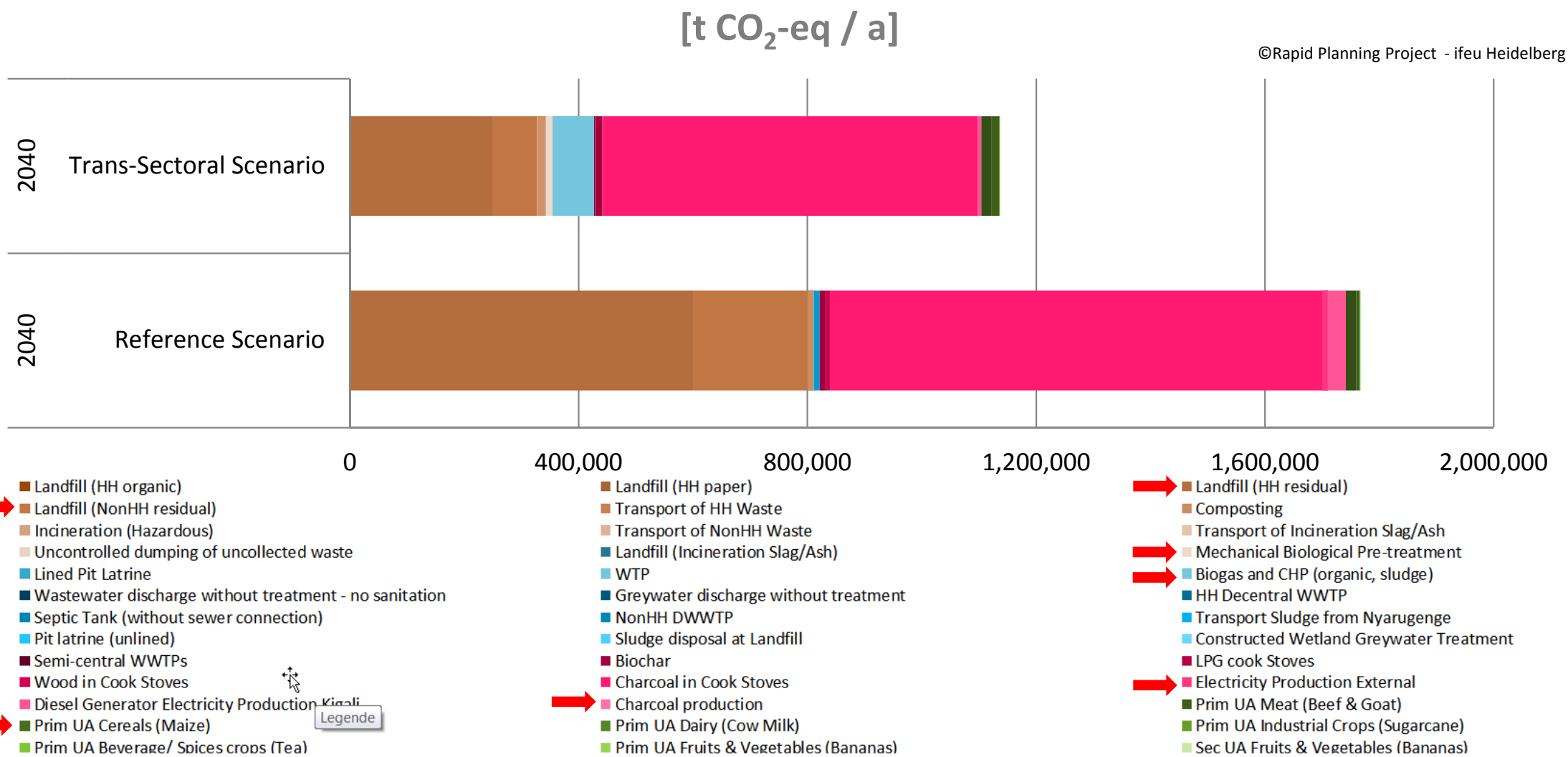
GREENHOUSE GAS EMISSIONS triggering CLIMATE CHANGE



SCENARIO SIMULATION

RESULTS - ENVIRONMENTAL IMPACT ASSESSMENT

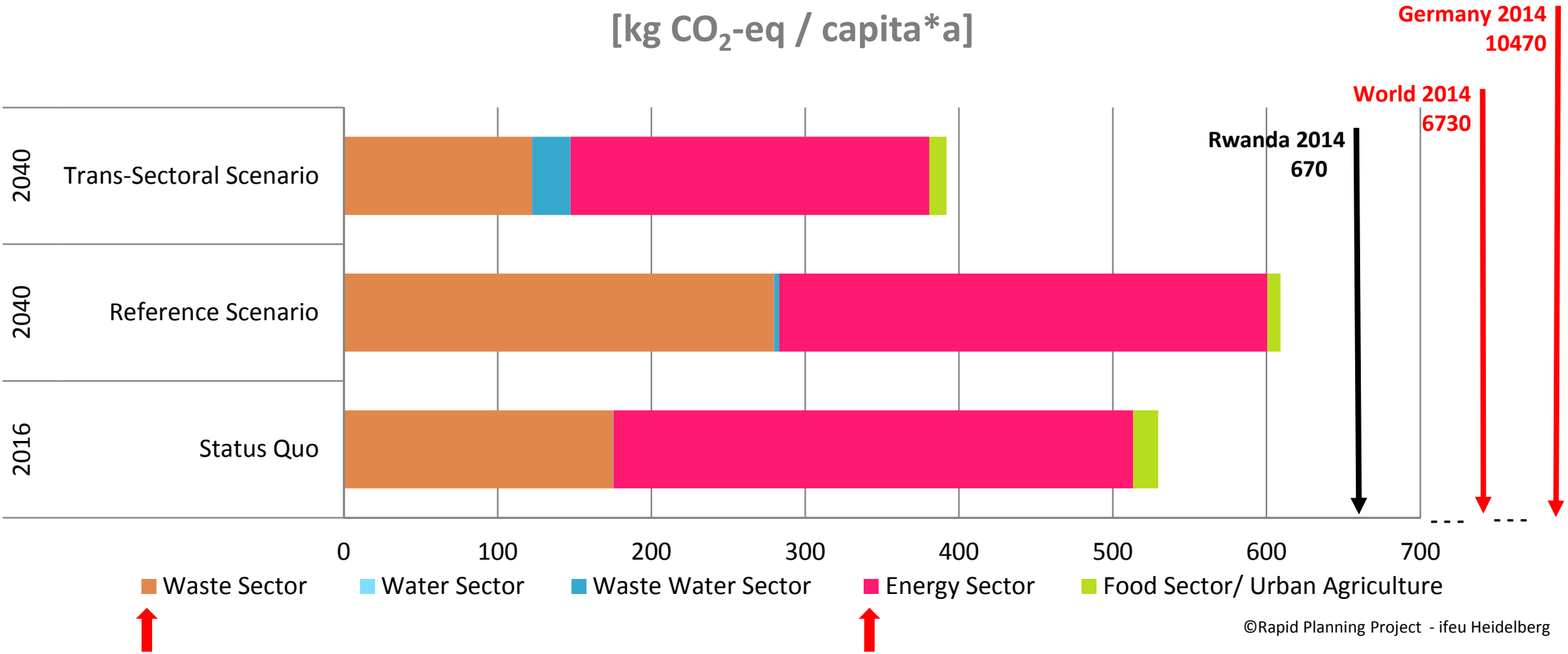
GREENHOUSE GAS EMISSIONS triggering CLIMATE CHANGE



SCENARIO SIMULATION

RESULTS - ENVIRONMENTAL IMPACT ASSESSMENT

GREENHOUSE GAS EMISSIONS triggering CLIMATE CHANGE



SCENARIO SIMULATION
ENVIRONMENTAL IMPACT ASSESSMENT

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NUTRIENT POLLUTION triggering EUTROPHICATION

*Globally, more than **80 per cent of wastewater** resulting from human activities is **discharged into rivers or sea without any pollution removal.** Coastal waters are **deteriorating due to pollution and eutrophication**. Without concerted efforts, **coastal eutrophication is expected to increase in 20 percent** […] **by 2050**.*

***6.3** By 2030, […], **halving** the proportion of **untreated wastewater** […]*
***14.1** By 2025, prevent and significantly **reduce […] nutrient pollution**.*
***15.1** By 2020, ensure the **conservation, restoration** and **sustainable use** of **terrestrial and inland freshwater ecosystems** […], in particular […] **wetlands**, […]*

SCENARIO SIMULATION RESULTS
ENVIRONMENTAL IMPACT ASSESSMENT

NUTRIENT POLLUTION triggering EUTROPHICATION

*Rwanda has committed itself to attain **100% service coverage in water supply and sanitation by 2020**.*

National Sanitation Policy Implementation Strategy
*MININFRA 2016 according overarching development goals **Vision 2020, EDPRS 2, and SDGs***

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© United Nations SDGs

2008*

Germany: 795,403 t PO4-eq 8.8 kg PO_4-eq/ capita

*EU emission inventory report 1990–2008

SCENARIO SIMULATION RESULTS

ENVIRONMENTAL IMPACT ASSESSMENT

NUTRIENT POLLUTION triggering EUTROPHICATION

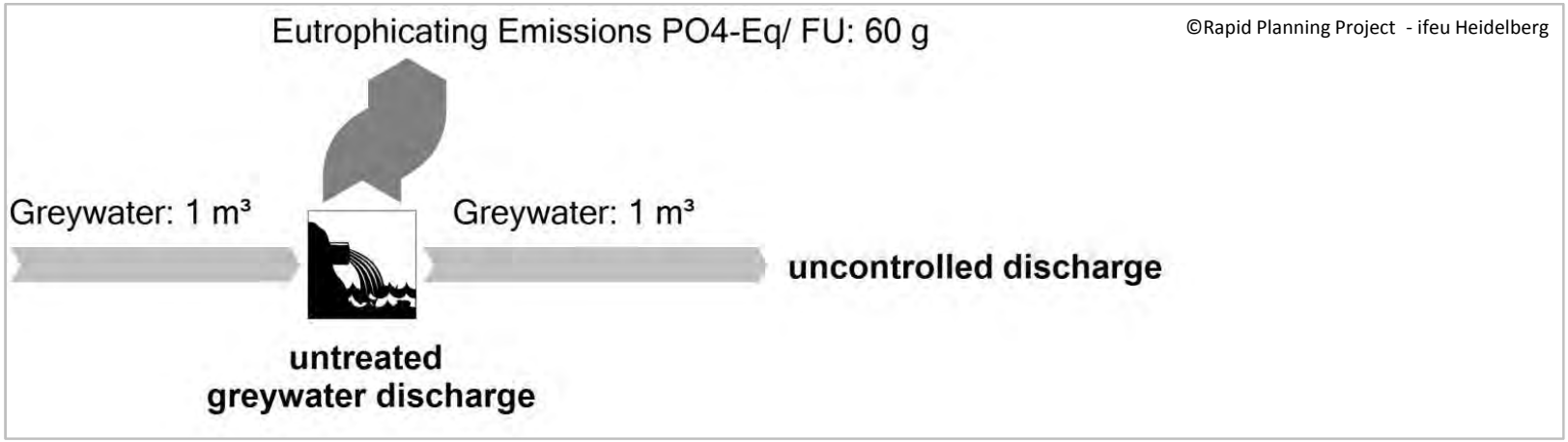
Life Cycle Impact Assessment (LCIA)					Life Cycle Inventory (LCI)	
Impact category	Unit	Geographic Scale			Nutrient Emissions PO_4-equivalents Factors*	
		Global	Regional	Local		
Eutrophication	kg PO4-eq		x	x	NO_x	0.13
					NH_3	0.35
					N_2O	0.27
					PO_4^{3-}	1
					COD	0.022
					NH_4^+	0.33
					NO_3^{2-}	0.1
					N-compounds unspec.	0.42
					P_2O_5-P	1.34
					P-compounds unspec.	3.06

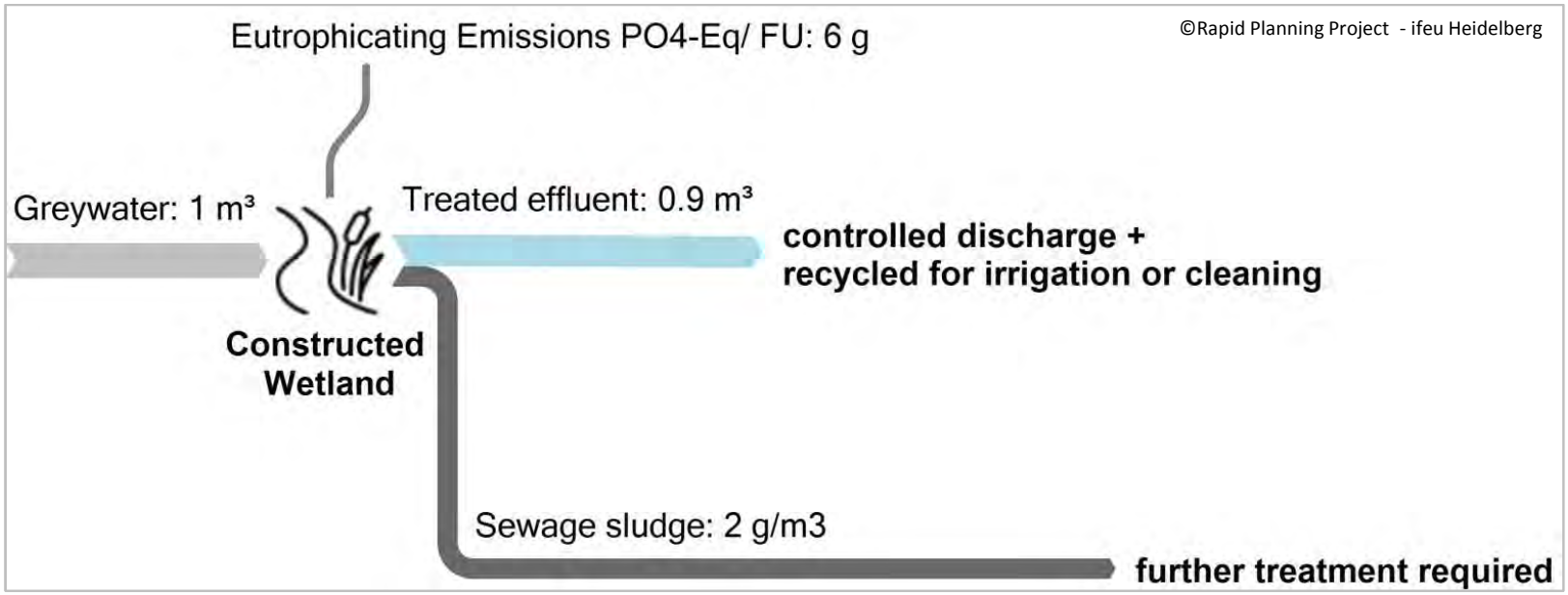
*Heijungs et al. 1992

SCENARIO SIMULATION RESULTS

ENVIRONMENTAL IMPACT ASSESSMENT

PROCESS EMISSIONS EXAMPLE

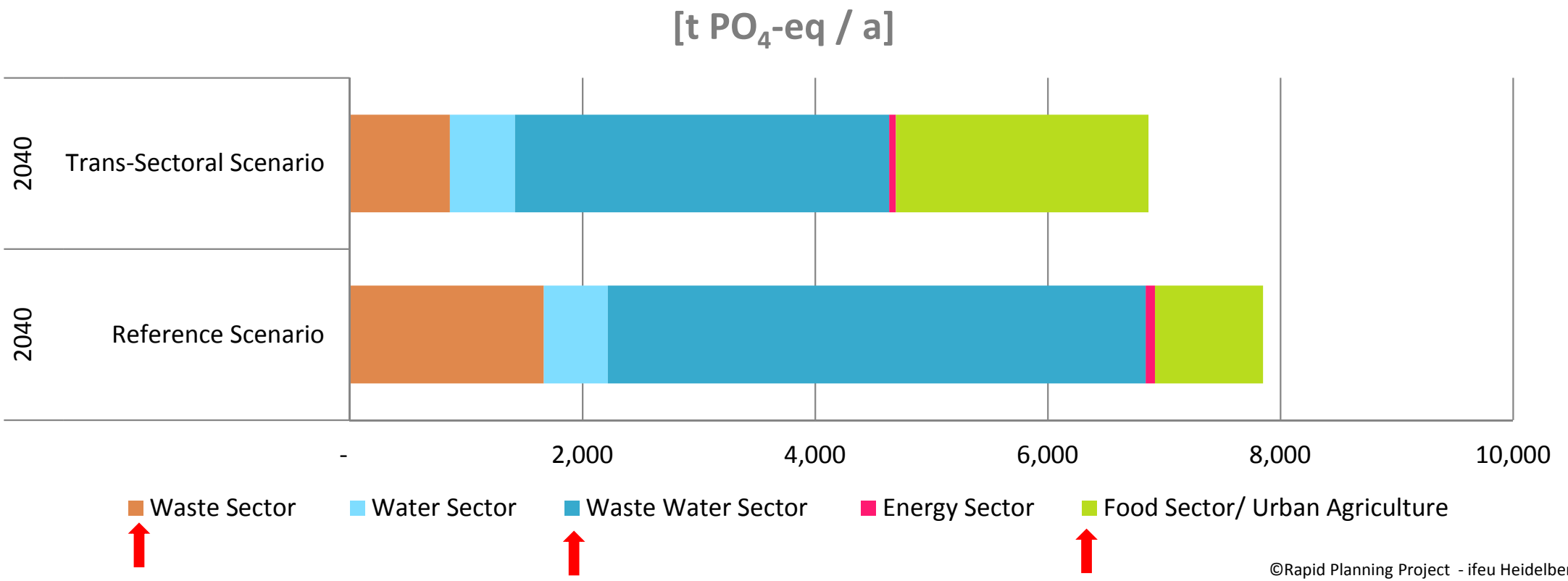




SCENARIO SIMULATION

RESULTS - ENVIRONMENTAL IMPACT ASSESSMENT

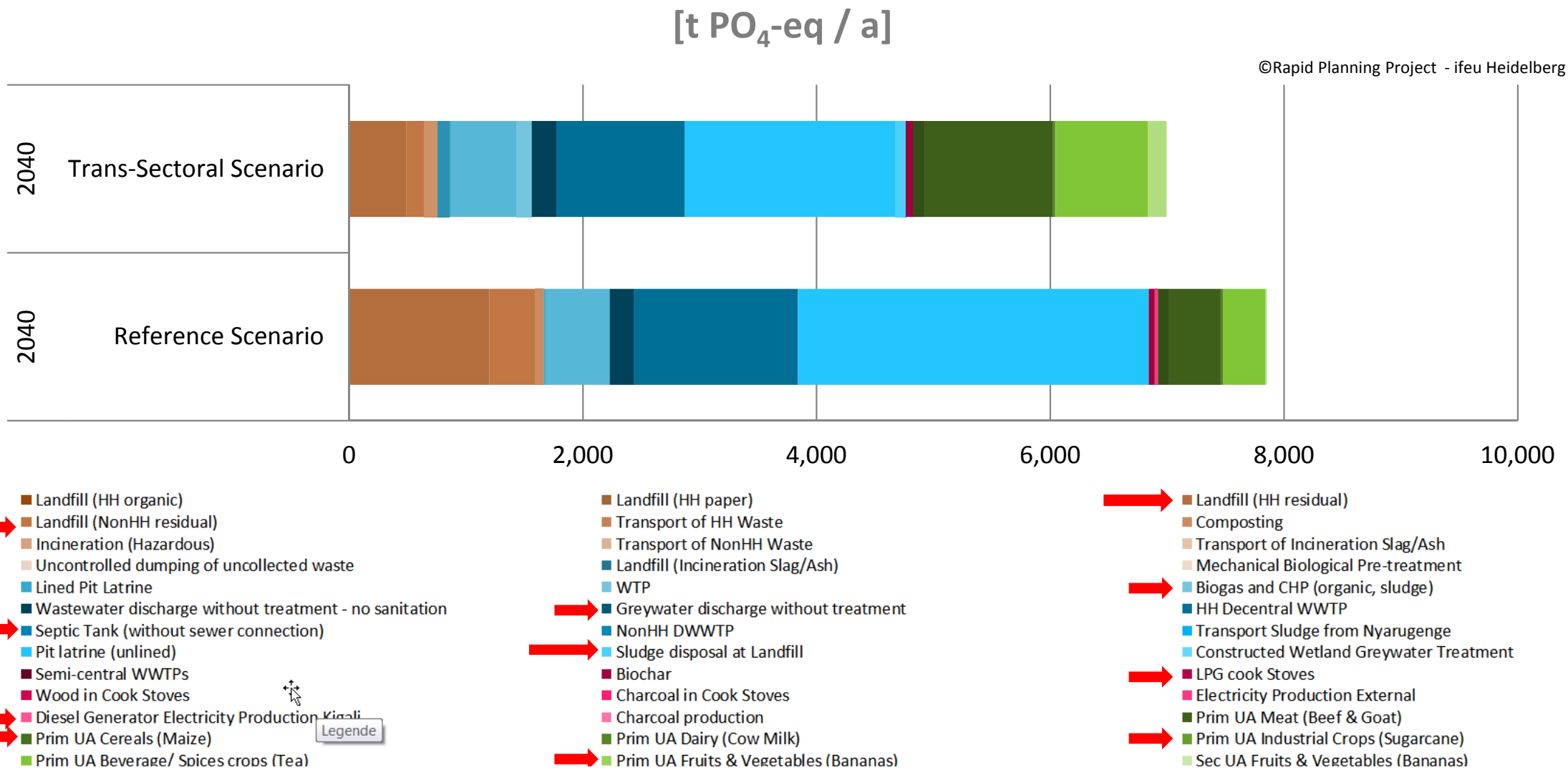
NUTRIENT POLLUTION triggering EUTROPHICATION



SCENARIO SIMULATION

RESULTS - ENVIRONMENTAL IMPACT ASSESSMENT

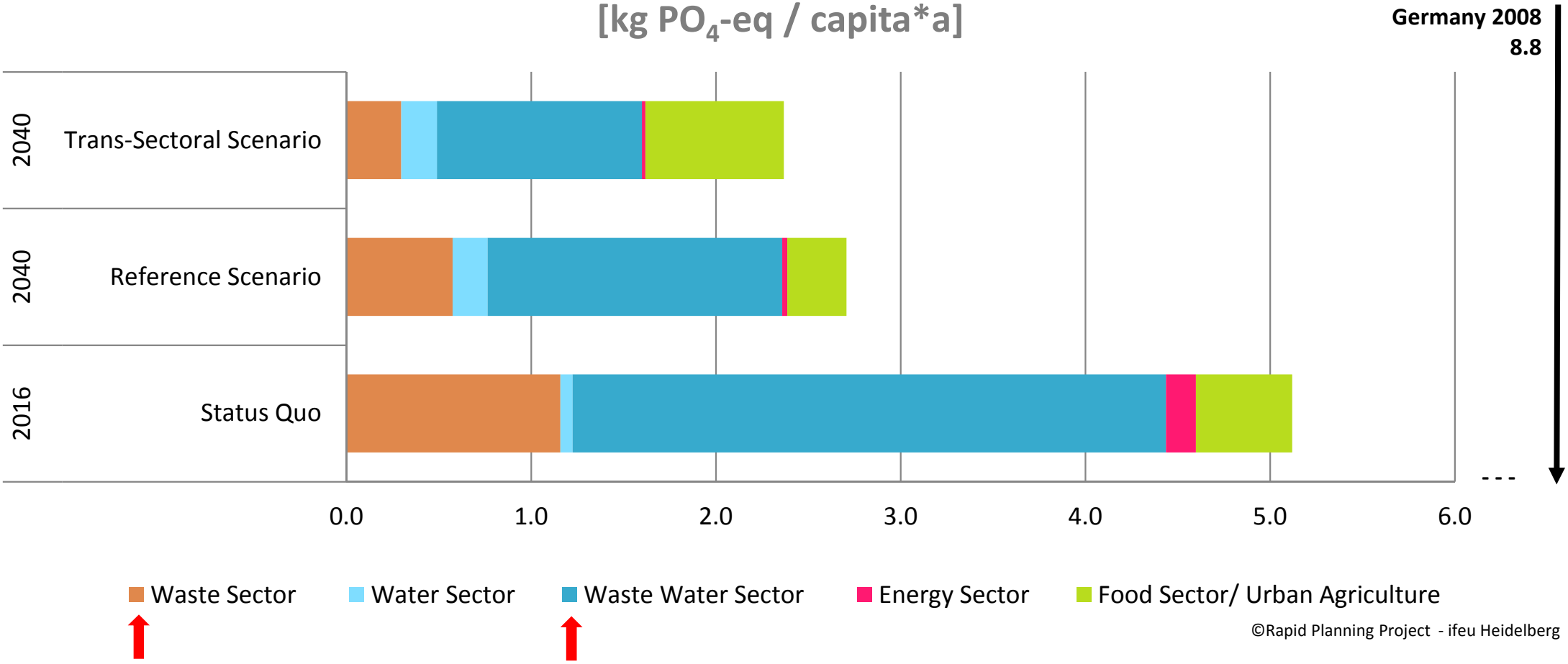
NUTRIENT POLLUTION triggering EUTROPHICATION



SCENARIO SIMULATION

RESULTS - ENVIRONMENTAL IMPACT ASSESSMENT

NUTRIENT POLLUTION triggering EUTROPHICATION



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Session 4

SHOWCASE TRANS-SECTORAL PILOTS

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ENTRY PROJECT AGATARE UPGRADING AREA

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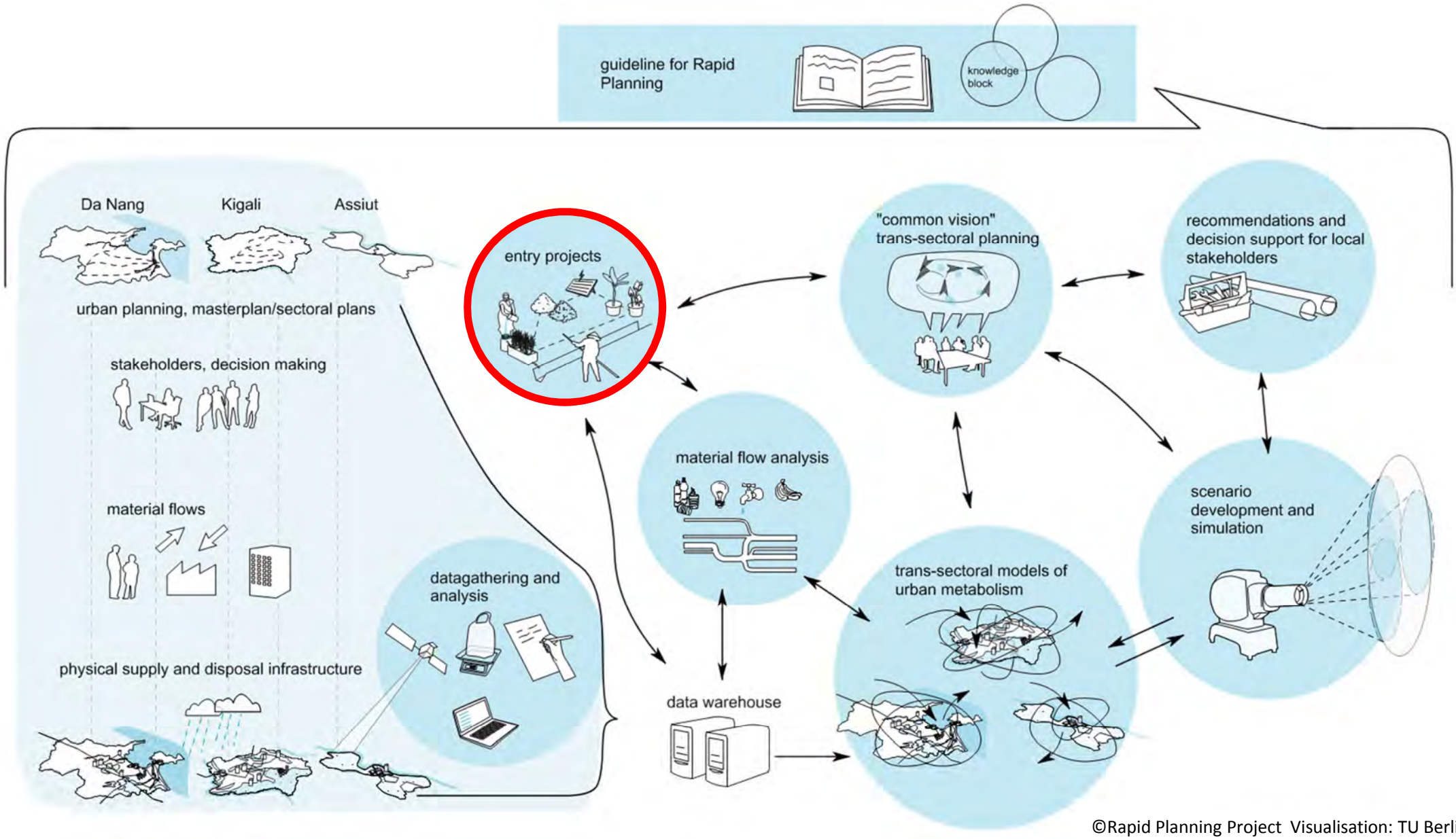

ENTRY PROJECT AGATARE UPGRADING AREA

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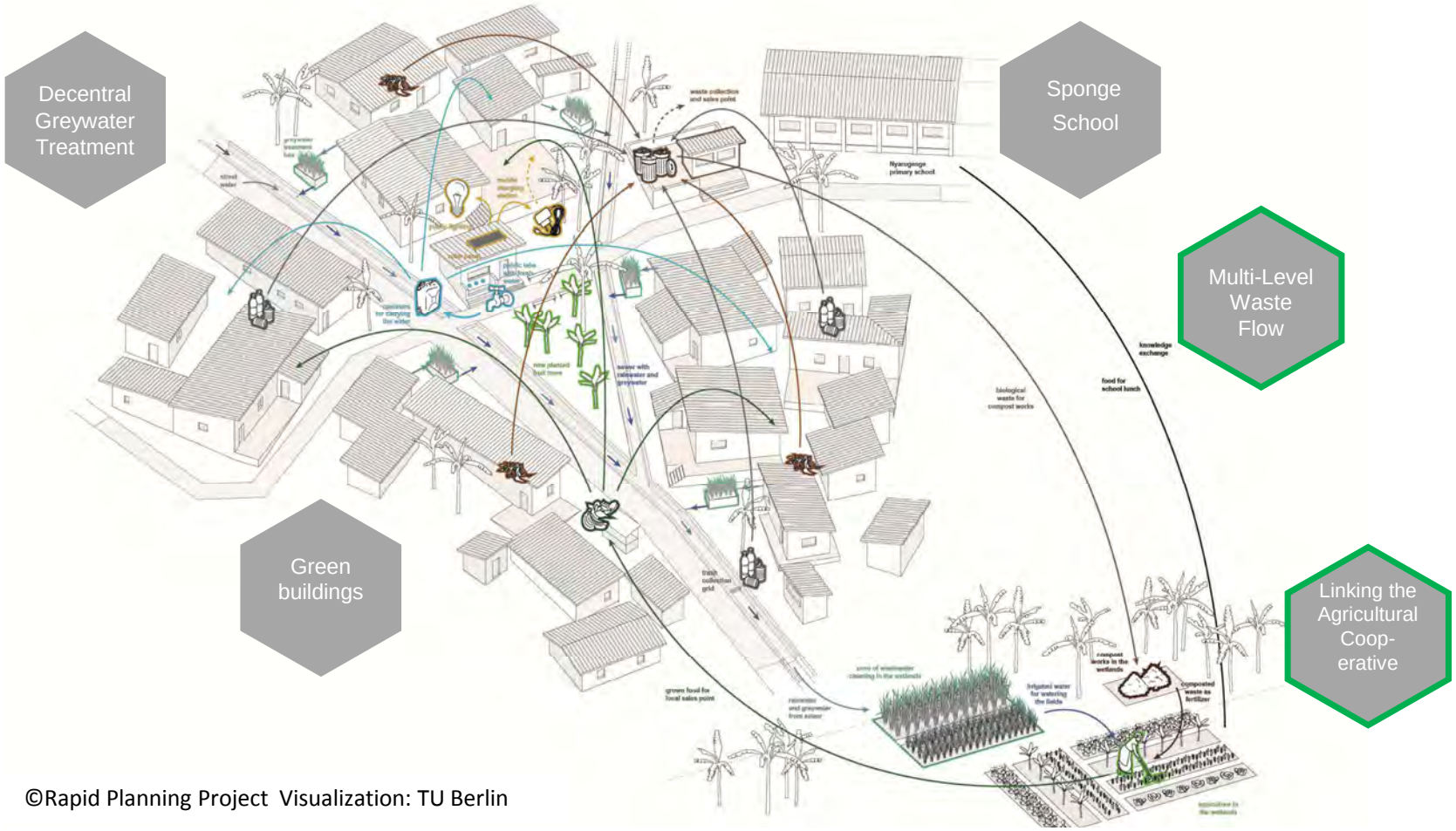
The RP Entry Project serves as a visible showcase for utilizable synergies identified by the trans-sectoral planning methodology developed within RP to upgrade informal settlements or develop new settlements. It connects spatially and substantially to the *Informal Settlement Upgrading Program* of CoK and World Bank located in Agatare/ Nyarugenge. It consists of 5 components, which spatially links the resource flows and actors through local, decentral organization:



Local Context

- Greywater, low contaminated, faecal free wastewater from body hygiene, laundry and cleaning (EN 12056-1),
- is neither treated nor recycled before discharge into the environment in the EP area.

Local Context

The lack of greywater management and storm water retention in the catchment area causes pollution, hygienic risk and flooding of the wetlands including the fields of the agricultural cooperative.

A citywide sewer connection to a central sewage treatment plant is not economic due to **low wastewater volume, willingness to pay and hilly topographic** (OPM 2017).

Goal

The *Decentral Greywater Treatment* study gathered yet unknown planning relevant data on domestic greywater (amount, properties, pathways and sinks) tested scientifically the potential of a decentralized technique to treat and recycle household greywater as an interim or hybrid technology.

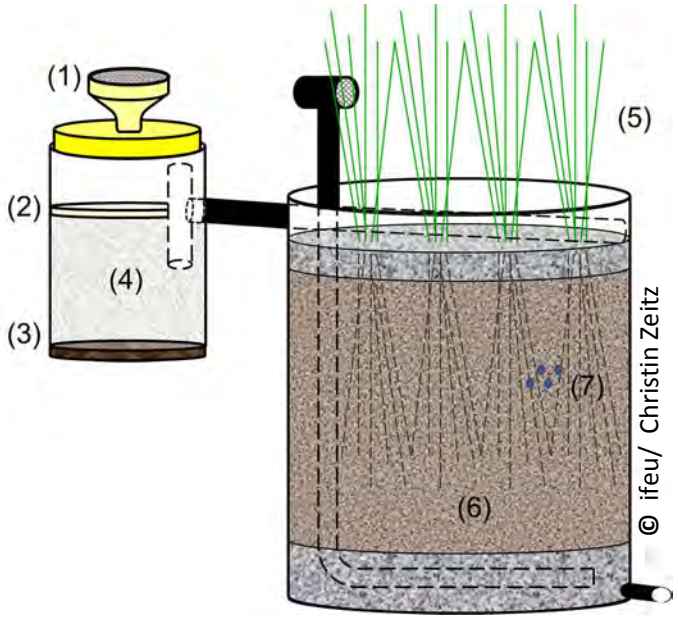
In line with the *SDG 11: Sustainable Cities and Communities and SDG 6: Clean Water and Sanitation,* the recycling of greywater is a core component in sustainable water management to upgrade slums and improve the access to basic services for all (UN 2016).

2 decentral HH Greywater Treatment Pilot Systems

1st Decentral Greywater Treatment Pilot System with kitchen garden installed in 09/16 and used ever since, expanded kitchen garden in 12/17

ENTRY PROJECT AGATARE UPGRADING AREA
GREYWATER RECYCLING RESULTS

Chemical and microbiological analyses of 2 greywater treatment pilot systems done over 6 month showed a successful reduction of all pollution indicators, **Fecal Coliforms (FC) -99.88%, Total Suspended Solids (TSS) -98%, Nitrogen (N) -85%, Phosphorous (P) -67% and Chemical Oxygen Demand (COD) -96%.** Thereby the output water quality complies with Rwandan and international discharge tolerance limits (RSB 2009; BGBl 2016) and the WHO (2000) limit of FC for reuse for irrigation.



Parameter	Limits for discharge of domestic wastewater			Gakwaya Household Analysis (range: original - corrected by error factor)						Mutangana Household Analysis (range: original - corrected by error factor)					
	REMA (WHO) 2015*	RSB 2009**	Date	In		Out		% change		In		Out		% change	
TSS mg/l	≤50	<50	07.10.16	393		3		99		507		4		99	
			11.11.16	118		4		97		748		7		99	
			13.12.16	2750		55		98		2875		108		96	
			25.01.17	279		2		99		383		4		99	
			03.03.17	307		2		99		319		22		93	
			21.04.17	370		5		99		675		2		100	
			Ø	703	-	12	-	99	-	918	-	25	-	98	-
Total Nitrogen mg/l	≤30	<30	07.10.16	18.3	- 42.7	2.3	- 5.4	87	- 87	23.1	- 54.0	2.7	- 6.4	88	- 88
			11.11.16	13.8	- 32.2	2.9	- 6.7	79	- 79	21.8	- 50.9	1.5	- 3.4	93	- 93
			13.12.16	9.8	- 22.9	1.2	- 2.8	88	- 88	10.5	- 24.5	2.3	- 5.4	78	- 78
			25.01.17	18.7	- 43.7	4.0	- 9.2	79	- 79	19.3	- 45.1	3.0	- 6.9	85	- 85
			03.03.17	11.5	- 26.8	2.04	- 4.8	82	- 82	12.3	- 28.7	1.93	- 4.5	84	- 84
			21.04.17	14.2	- 33.2	1.12	- 2.6	92	- 92	15.45	- 36.1	0.74	- 1.7	95	- 95
			Ø	14.4	- 33.6	2.3	- 5.3	85	- 85	17.1	- 39.9	2.0	- 4.7	87	- 87
Total phosphorus mg/l	≤5	<5	07.10.16	1.9	- 1.4	0.9	- 0.7	53	- 53	2.1	- 1.5	0.9	- 0.7	57	- 57
			11.11.16	2.5	- 1.8	1.1	- 0.8	54	- 54	3.0	- 2.2	1.1	- 0.8	63	- 63
			13.12.16	1.7	- 1.2	0.5	- 0.4	68	- 68	6.5	- 4.8	2.6	- 1.9	61	- 61
			25.01.17	3.6	- 2.7	0.5	- 0.4	87	- 87	9.9	- 7.4	1.0	- 0.7	90	- 90
			03.03.17	3.8	- 2.8	0.5	- 0.4	86	- 86	4.6	- 3.4	4.0	- 2.9	14	- 14
			21.04.17	5.3	- 3.9	0.6	- 0.5	88	- 88	5.6	- 4.2	1.0	- 0.7	83	- 83
			Ø	3.1	- 2.3	0.7	- 0.5	73	- 73	5.3	- 3.9	1.7	- 1.3	61	- 61
COD mg/l	≤400	<250	07.10.16	1560	- 3469	48	- 33	97	- 99	1845	- 4102	131	- 291	93	- 93
			11.11.16	673	- 1496	60	- 41	91	- 97	1530	- 3402	87	- 59	94	- 98
			13.12.16	456	- 1014	17	- 11	96	- 99	621	- 1381	46	- 31	93	- 98
			25.01.17	727	- 1616	30	- 20	96	- 99	1088	- 2418	87	- 59	92	- 98
			03.03.17	1156	2570	19	- 13	98	100	2445	5436	97	- 65	96	- 99
			21.04.17	1945	- 4325	39	- 27	98	- 99	1820	- 4047	68	- 46	96	- 99
			Ø	1086	- 2415	36	- 24	96	- 99	1558	- 3464	86	- 92	94	- 97
Fecal Coliforms Cfu/100ml	≤400	<400	07.10.16	2100	-	4	-	99.810	-	76000	-	91	-	99.880	-
			11.11.16	1800	-	6	-	99.667	-	52000	-	68	-	99.869	-
			13.12.16	4000000	-	600	-	99.985	-	8000000	-	200	-	99.998	-
			25.01.17	2000000	-	600	-	99.970	-	500000	-	600	-	99.880	-
			03.03.17	300000	-	70	-	99.977	-	2000000	-	300	-	99.985	-
			21.04.17	2000000	-	50	-	99.998	-	4000000	-	400	-	99.990	-
			Ø	1383983	-	222	-	99.901	-	2438000	-	277	-	99.934	-

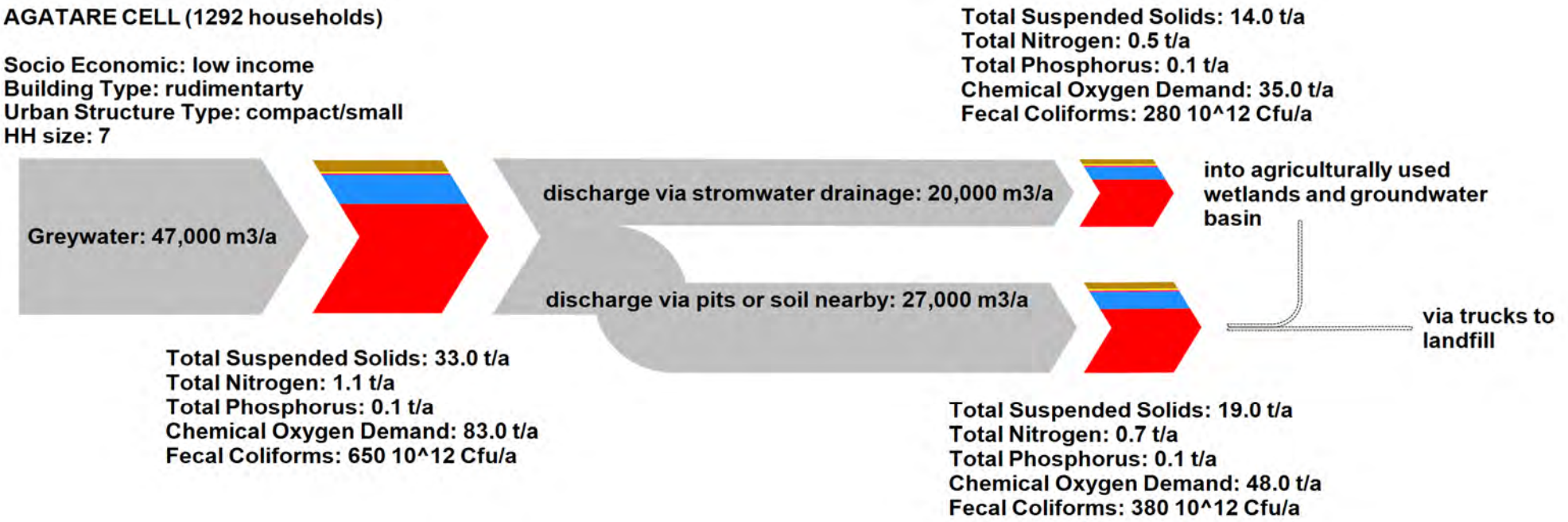
Color code: below limit | below limit - but over halfe of the limit | over limit | compared to RSB 2009

*REMA (WHO) - 2015 - Integrated study of wastewater treatment systems in Rwanda

**RSB RS 110:2009 Water Quality – Tolerance limits of discharged domestic wastewater

ENTRY PROJECT AGATARE UPGRADING AREA
GREYWATER RECYCLING RESULTS

The data from the pilot systems plus the discharge flow measurements and samplings enabled the **mass flow analysis and environmental impact assessment for Agatare**: **annually approx. 20,000 m^3 greywater (40% of total generated greywater) containing ca. 35 t COD, 280*10^12 Cfu FC, 14 t TSS, 0.5 t N and 0.1 t P are discharged via drainages into the agriculturally used wetlands.**



Local Context

Inadequate storm water management and bare soils at Biryogo Primary School (BPS) cause **erosion and flooding**, leaving little organic carbon in the lateritic soils and triggering **dust** generation.

ENTRY PROJECT AGATARE UPGRADING AREA
EROSION CONTROL

The **Sponge School** component is to demonstrate its potential to tackle erosion and increase resilience to extreme weather with the affordable vegetative bio-engineering techniques and upcycling.
… to demonstrate the *Sponge City* approach as alternative to the predominant management of erosion and storm water by impermeable sealing and rapid drain via cement-based structures (World Future Council 2016).

Worldwide **25 to 40 billion t topsoil** get lost due to erosion annually (FAO 2015).

ENTRY PROJECT AGATARE UPGRADING AREA
EROSION CONTROL RESULTS

The concept combines **Vetiver grass system** for erosion control slows, spreads, infiltrates and stores rainwater.

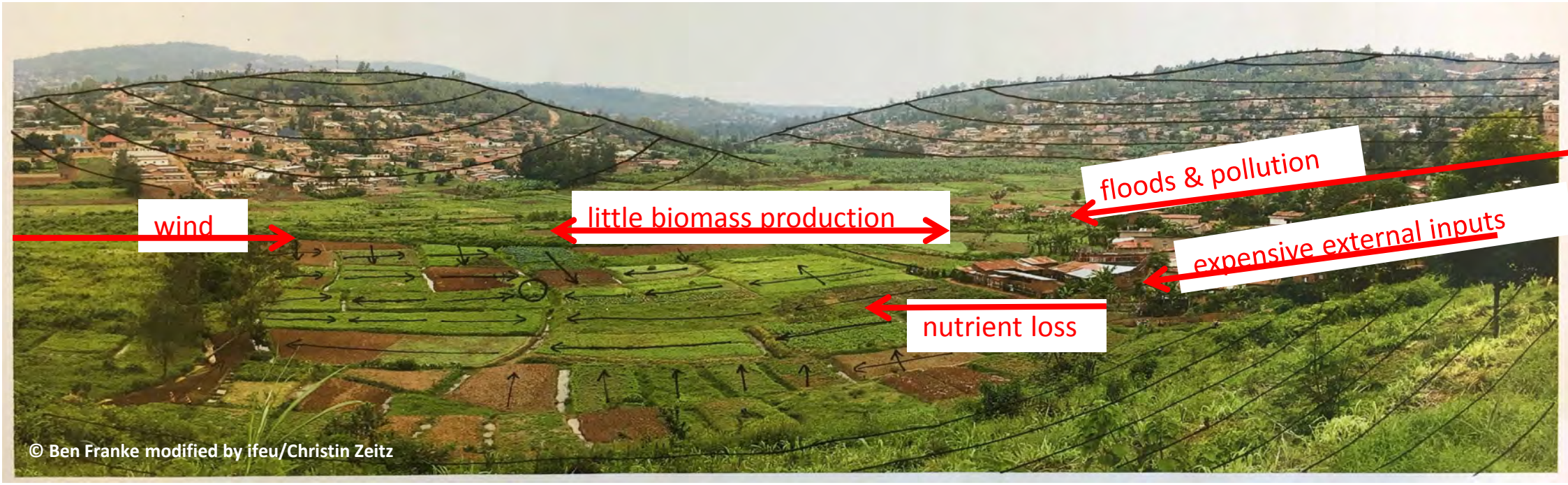
Vetiver grass system trapped and saved up already up to 25 cm of soil from erosion
(03/16- 12/17)

Vetiver – From Erosion Control to Product

In cooperation with **CoK Agaseke Promotion Project**, the RP concept ***Vetiver – From Erosion Control to Product*** valorizes Vetiver leafs by creating a local handicraft value chain and thereby adds economic interest to environmental conservation.

ENTRY PROJECT AGATARE UPGRADING AREA
COMPOSTING & IRRIGATION

Local Context



The lack of greywater management and storm water retention as well as waste dumping in the catchment area cause pollution and flooding of the wetlands including the fields of the agricultural cooperative in Rwampara wetlands. In addition, the lack of fertilizer, little biomass production and inefficient irrigation limits productivity.

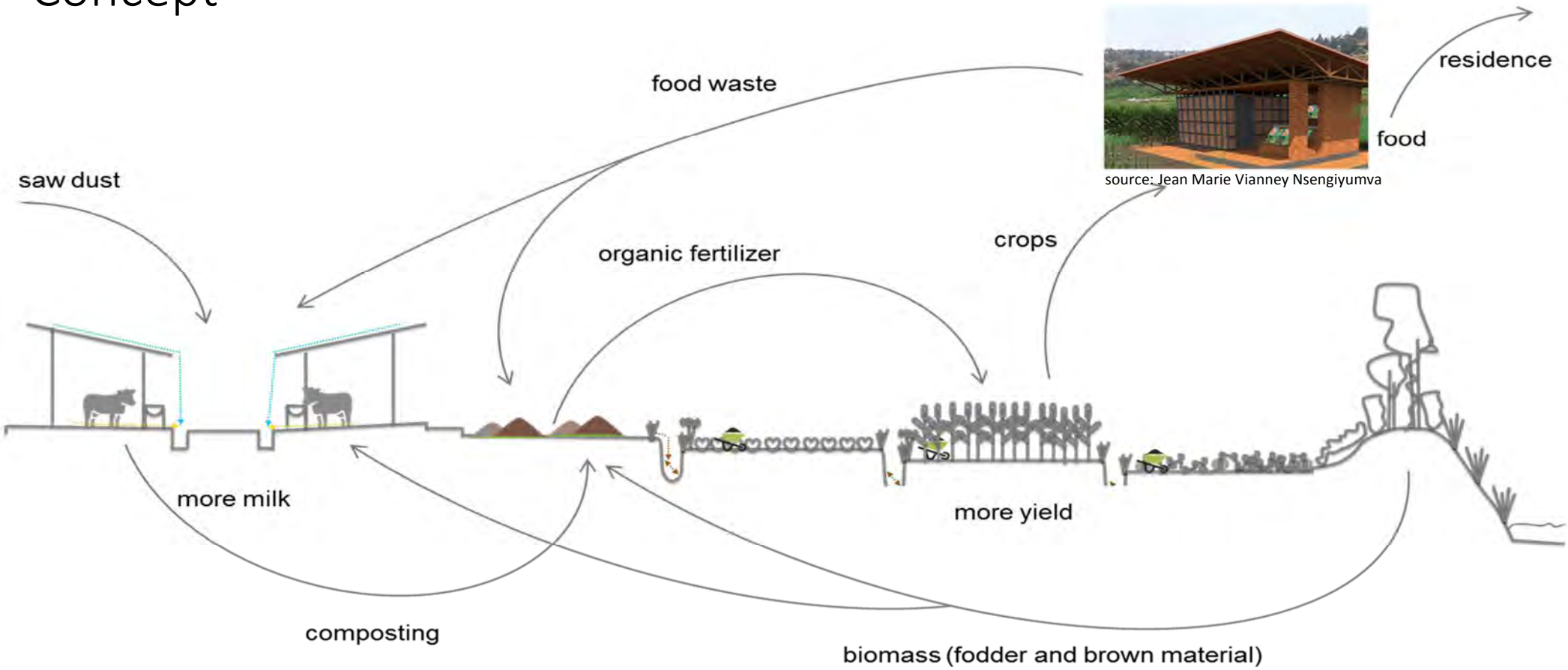
ENTRY PROJECT AGATARE UPGRADING AREA
COMPOSTING & IRRIGATION

Goal

Improve irrigation and create a nutrient loop through composting for minimal need of external inputs to produce fresh food for Kigali.

ENTRY PROJECT AGATARE UPGRADING AREA
COMPOSTING & IRRIGATION

Concept



source: Jean Marie Vianney Nsengiyumva

Nutrient Cycle: Livestock – Compost – Farming
Efficient Irrigation
Diversity and high value crops

ENTRY PROJECT AGATARE UPGRADING AREA
COMPOSTING & IRRIGATION RESULTS

GOOD QUALITY COMPOST AS ORGANIC FERTILIZER SUBSTITUTED THE NEED TO BUY COMPOST FROM EXTERNAL SOURCES

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QUALITY CRITERIA	PARAMETER	ANALYSIS RESULTS	TOLERANCE LIMITS* and REFERENCE VALUES*°	UNIT	ANALYSIS COSTS (€)
HYGIENE	Salmonella spp.*	negative in 50g sample	negative in 50g fresh compost		26
	Fecal Coliforms (E.Coli)	< 10	-	MPN°°/g	32
	Gastro-enteric worm eggs	negative	-		9
	Maw worm eggs (*Ascaris lumbricoides*)	negative	-		
	Tape worm eggs (*Eucestoda*)	negative	-		
	Capillaria Worm eggs (*Haemonchus contortus*)	negative	-		
POLLUTANT CONTENT*	As	15.4	40	mg/kg DM	29
	Pb	37	150	mg/kg DM	13
	Cd	0.12	1.5 or 50mg/kg P_2O_2	mg/kg DM	13
	Cr, $Cr^{(VI)}$	72	-, 2	mg/kg DM	13
	Ni	13	80	mg/kg DM	13
	Hg	0.07	1**°°	mg/kg DM	23
	Tl	0.2	1	mg/kg DM	29
COMPOST QUALITY	Total N	8.7	9	kg/t DM	135
	N as (NH4-N + NO3-N)	1.18		kg/t DM	
	P2O5	7	4.5	kg/t DM	
	K2O	13.9	7.7	kg/t DM	
	MgO	4.6	0.498% in DM equal 4.89 kg/t DM	kg/t DM	
	Na	2.6	0.2% in DM equal 2 kg/t DM	kg/t DM	
	S	1.3	0.3% in DM equal 3 kg/t DM	kg/t DM	
	Alkaline Substances as CaO	41.5	27	kg/t DM	
	Cu	31	100-70+°°	mg/kg DM	
	Zn	177	400-300+°°	mg/kg DM	
	Organic Matter	22.9	min. 15% (weight) in DM	% in DM	
	Dry Mass	72.5	max. 45% (weight) water content	% DM from WM	
	C/N Ratio	15	less or equal 25 ++	in DM	
	Volume weight	0.676	0.54+++	kg/l DM	8
IMPURITIES*	>2mm	0.07	max. 0.5% (weight)	% in DM	5
thereof	Glass	0		% in DM	5
	Hardplastic	0		% in DM	10
	Plastic foil	0.07		% in DM	
	others	0		% in DM	5
Stones	>10mm	0.34	max.0.5 % (weight)	% in DM	5
TOTAL incl. 19% VAT					**443.87**

ENTRY PROJECT AGATARE UPGRADING AREA
COMPOSTING & IRRIGATION RESULTS

REDUCED ENVIRONMENTAL EMISSIONS, COSTS, TIME FOR IRRIGATION WITH SOLAR PUMP
WATER SAVINGS THOUGH MULCHING + SUBSOIL IRRIGATION

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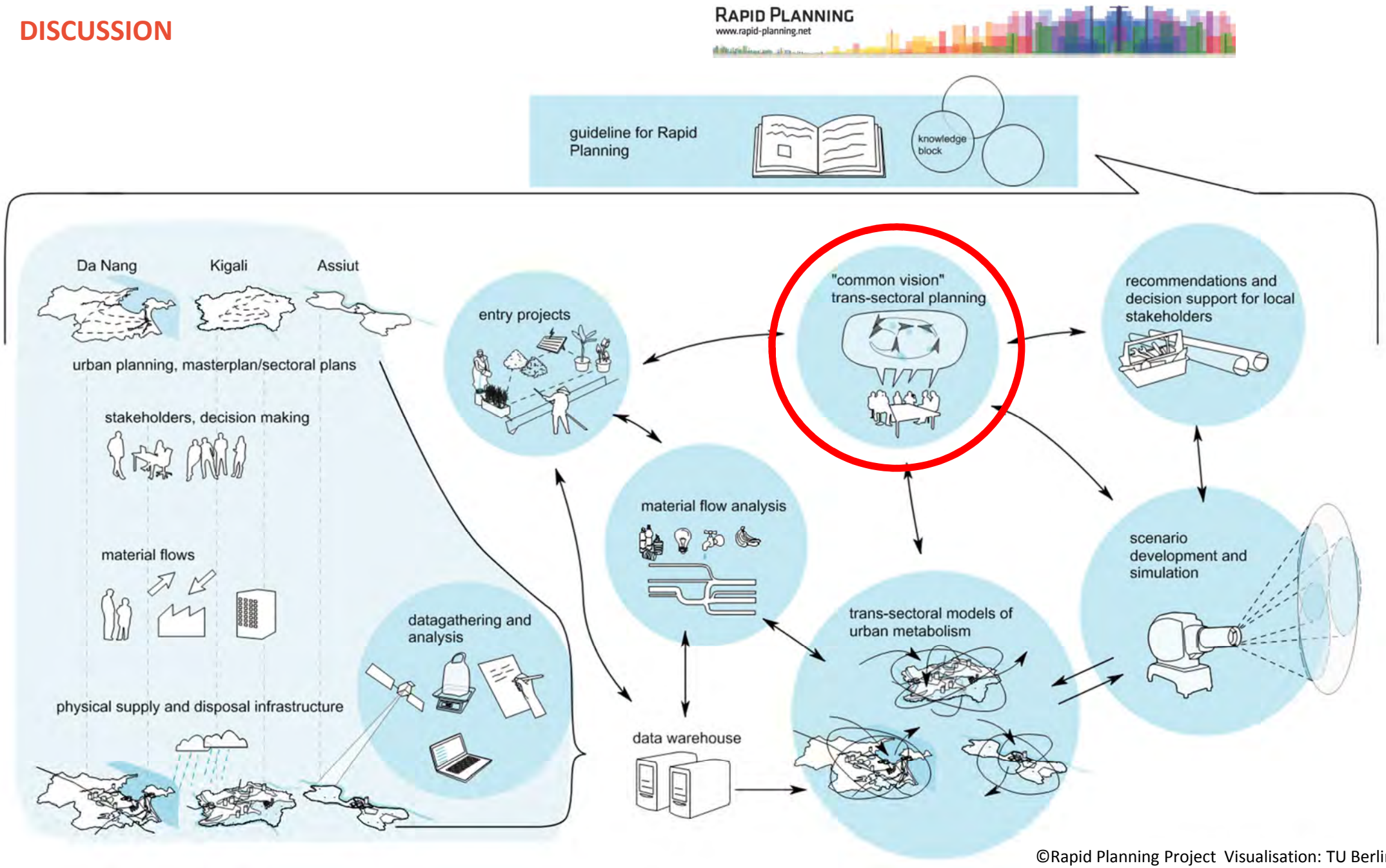
Discussion

INTEGRATE INTO URBAN PLANNING

Uni Frankfurt • all participants

DISCUSSION



DISCUSSION INPUT
INTEGRATION INTO URBAN PLANNING

IMPORTANT TOPICS to DISCUSS

1.

*How to integrate the results of the **ENTRY PROJECT IN THE AGATARE UPGRADING AREA** with its practically improved trans-sectoral elements related to greywater recycling, composting and erosion control - combined with opportunities for on- and off-'farm' income generation - into the urban planning framework?*

2.

*How to integrate the results and recommendations of the **TRANS-SECTORAL SCENARIO SIMULATION PROCESS** with its variety of trans-sectorally calculated process chains into the urban planning framework?*

DISCUSSION INPUT
INTEGRATION INTO URBAN PLANNING

1. INTEGRATION OF THE RESULTS OF THE AGATARE ENTRY PROJECT IN THE UPGRADING AREA INTO THE URBAN PLANNING FRAMEWORK?

Framework: **Green and Integrated Development Model Villages Approach**. This national roll-out programme developed by Rwandan Housing Authority (RHA) up-scales selected sustainable infrastructure solutions that support practices for integrated food, water and energy self-sufficiency in the pilot "Green Village" approach developed by Rwanda Environment Management Authority (REMA) under UNDP-UNEP Poverty and Environment Initiative (PEI) programme and is getting implemented on district-level .

?

Discussion: *Opportunities and constraints for the integration of the results of the ENTRY PROJECT related to greywater recycling, composting and erosion control.*

DISCUSSION INPUT
INTEGRATION INTO URBAN PLANNING

2. INTEGRATION OF THE RESULTS OF THE AND RECOMMENDATIONS OF THE TRANS-SECTORAL SCENARIO SIMULATION PROCESS INTO THE URBAN PLANNING FRAMEWORK?

Framework: **Master and Land-use Planning with Zoning Regulations.**

Integration Needs: **Integration of Trans-sectoral Facilities and Activities**

?

Main focus on following topics and related facilities and activities:

- Solid waste sorting facility
- Composting facilities
- Sewage sludge treatment facility
- Application of compost and treated sludge for agriculture and forestry
- Constructed Wetlands in the wetland's buffer zone

Discussion: *Opportunities and constraints for the integration of the results and recommendations of the proposed Trans-sectoral Facilities and Activities.*

DISCUSSION INPUT - BUILDING CAPACITIES FOR TRANS-SECTORAL URBAN PLANNING

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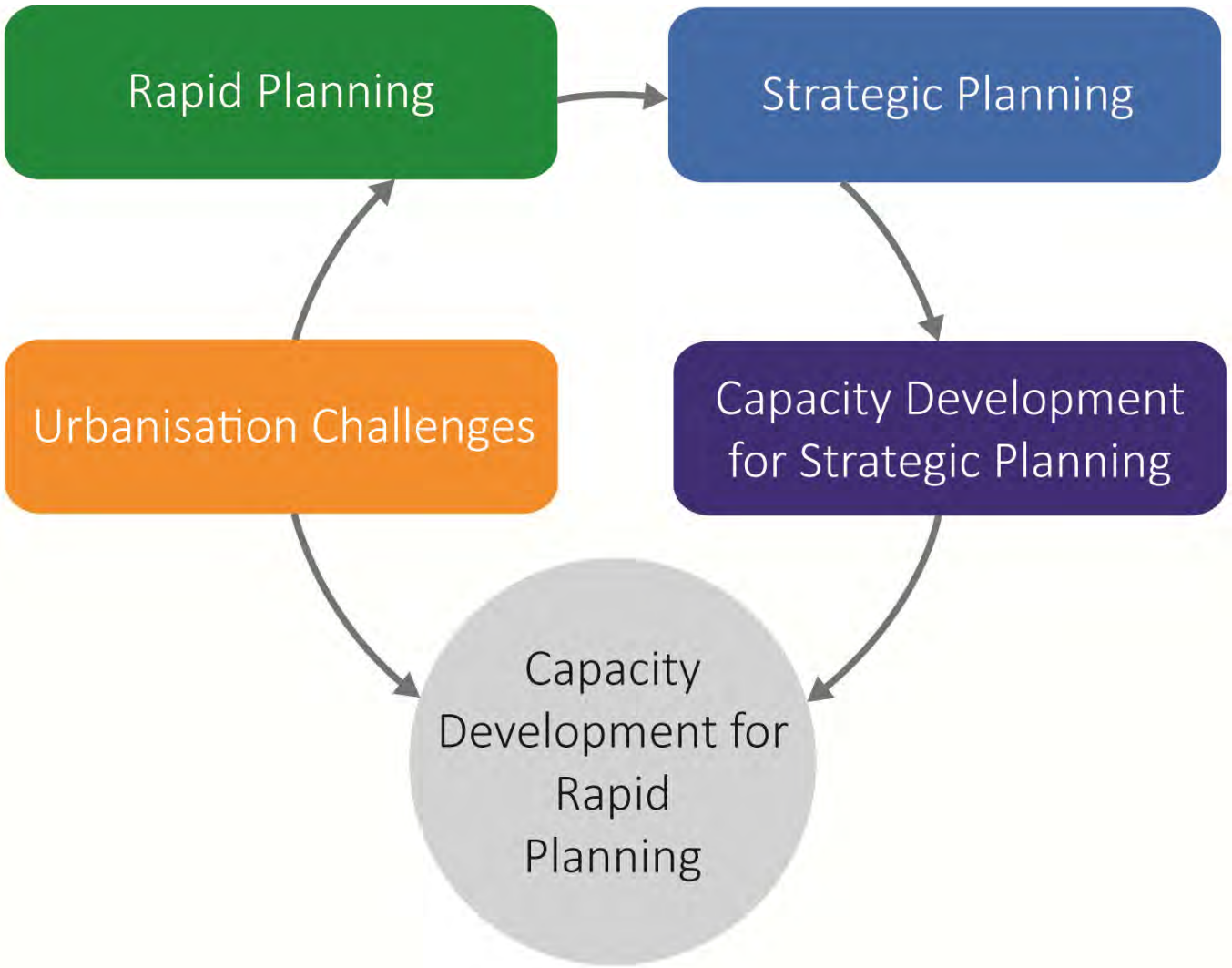
Methodology



DISCUSSION INPUT - BUILDING CAPACITIES FOR TRANS-SECTORAL URBAN PLANNING

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The Rapid Planning Premises

Urbanisation Challenges	Rapid Planning
Centralised Planning	Integrated Infrastructure Development
Time-consuming Data Processsing	Systematic Data Generation
Sectoral Interpretation of Data	Integrated Data Visualisation
Fragmented Understanding of the City	Sectoral Urban Analysis
Lack of Inter-deparetmental Collaboration	Integrated Urban Analysis
Unattainable Development Models	Realistic Development Goals
Silo Planning	Collaborative Trans-sectoral Approach
Technological Stagnation	Synergetic Potentials
Short-term Infrastucture Interventions	Integrated Infrastructure Planning

DISCUSSION INPUT - BUILDING CAPACITIES FOR TRANS-SECTORAL URBAN PLANNING

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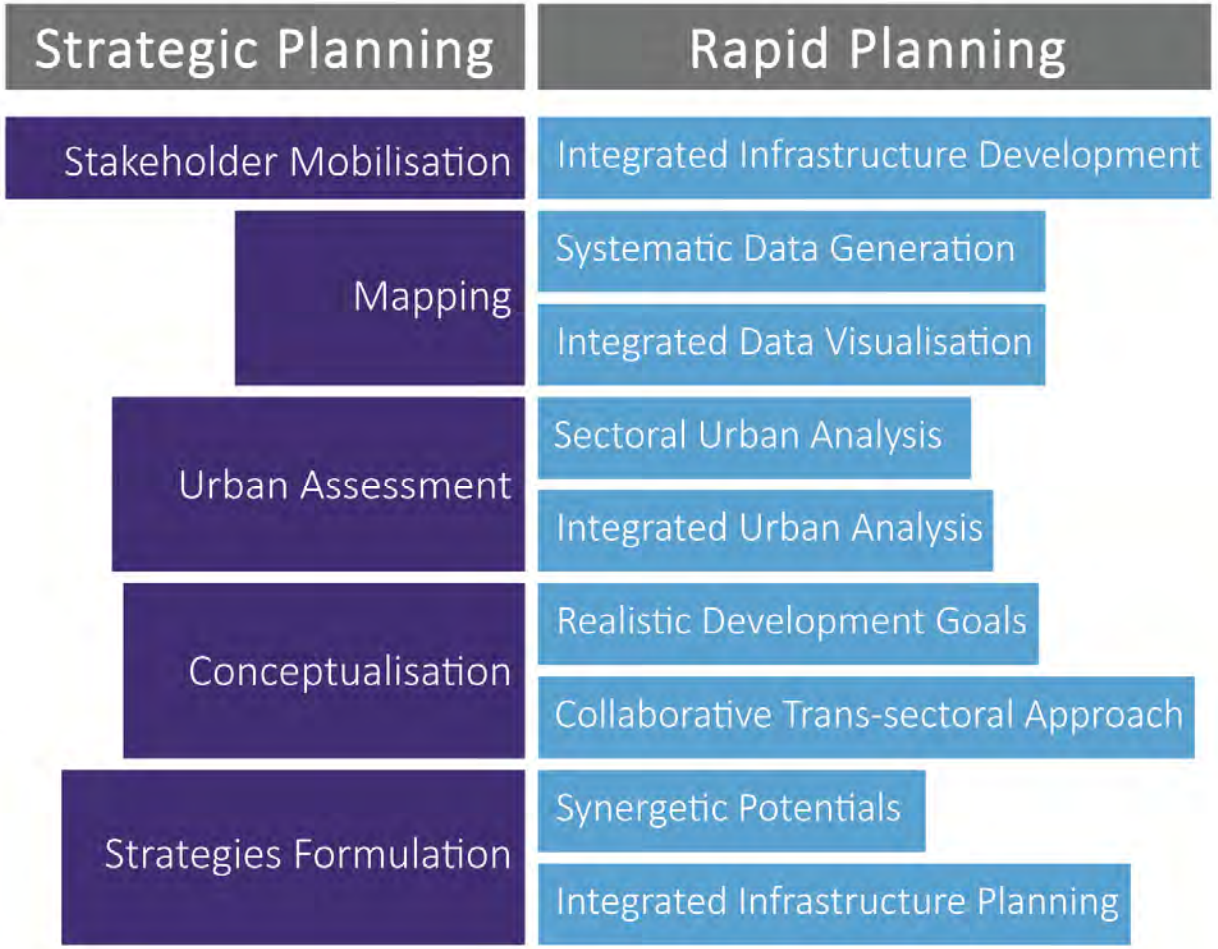
RP as a Strategic Planning Process



DISCUSSION INPUT - BUILDING CAPACITIES FOR TRANS-SECTORAL URBAN PLANNING

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Strategic Planning Process

Strategic Planning	Objectives of Strategic Planning
Stakeholder Mobilisation	Diversity of stakeholders
Mapping	Data collection, processing and visualisation
Urban Assessment	Spatial analysis of the built environment
Conceptualisation	Definition of a vision, medium and short-term objectives
Strategies Formulation	Prioritisation of projects

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Capacity Development Considerations for a Strategic Planning Process

DISCUSSION INPUT - BUILDING CAPACITIES FOR TRANS-SECTORAL URBAN PLANNING

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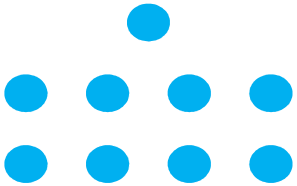
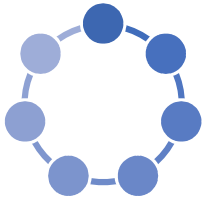
What is Capacity Development?



Capacity Building



Capacity Development

Create abilities and skills

Overlooks existing capacities, social structures and institutions

Acknowledge and enhance existing capacities

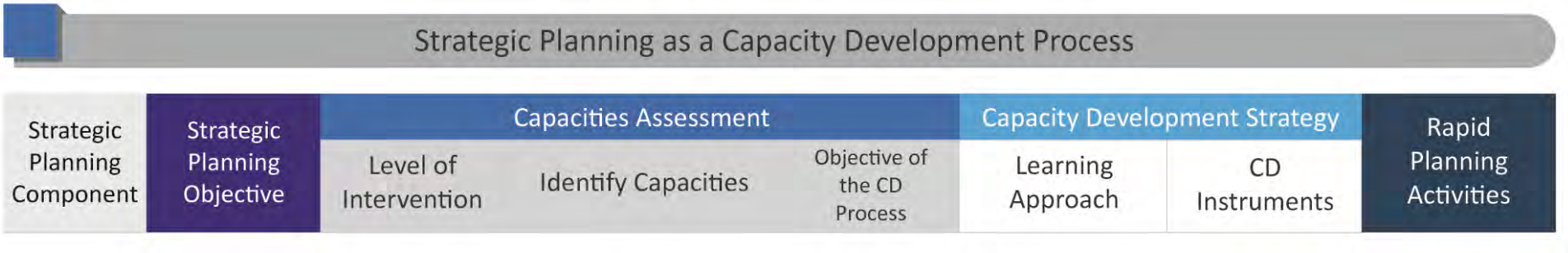
Identify and create needed capacities

Strengthen local institutions

What is Capacity Development?

Necessary Knowledge + *Skills & Know-How* + *Instruments & Technologies*

Capacity Development Concepts



Capacities Assessment	Level of Intervention	Society, institution and individual
	Identify Capacities	Existing and desired capacities in each intervention level
	Objectives of CD	Expected results and indicators to measure the CD process
CD Strategy	Learning Approach	Capacity development strategies
	Instruments	Learning methods to achieve the CD objectives

Capacity Development for RP

Phase 1: Stakeholder Mobilisation

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Strategic Planning as a Capacity Development Process

Strategic Planning Component	Strategic Planning Objective	Capacities Assessment			Capacity Development Strategy		Rapid Planning Activities
		Level of Intervention	Identify Capacities	Objective of the CD Process	Learning Approach	CD Instruments	
Stakeholder Mobilisation	Promote good governance through participatory practices	**Individual:** municipal officers, communities	Individual capacities for communication and promotion of participatory practices	Foster influential participation of diverse stakeholders in planning procedures	Communication	Meetings with diverse stakeholders	Definition, information and sensitization of all relevant stakeholders
		Institutional: Municipal Departments and public stakeholders	Inter-departmental communication and information sharing procedures		Knowledge Management	Documentation of participatory practices by municipal stakeholders	
		Environment: Decision makers, private companies and community representatives	Information sharing and communication among vertical management	Institutionalisation of a flexible framework for participation	Leadership Development	Definition of a participation strategy and establishment of communication channels among stakeholders	
			Participation processes for the involvement of stakeholders external to the municipality		Partnerships and Networks		

Capacity Development for RP

Phase 2: Mapping

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Strategic Planning as a Capacity Development Process

Strategic Planning Component	Strategic Planning Objective	Capacities Assessment			Capacity Development Strategy		Rapid Planning Activities
		Level of Intervention	Identify Capacities	Objective of the CD Process	Learning Approach	CD Instruments	
Mapping	Holistic understanding of the condition, challenges and potentials of urban development in the city	**Individual:** municipal or external technicians and experts in data processing and statistical analysis	Individual skills for data collection	Institutionalisation of systematic data collection and processing methods for integrated urban development	Customised Training	Training and Recruiting	(Building) Categorisation of building typologies, spatial units, urban structures
			Individual capacities for data digitalisation and processing		Knowledge Management	Establishment of a statistical analysis	
			Individual skills for usage of geographical information software			Definition of data-sharing procedures among municipal departments	Remote sensing
		Institutional: technological setting for information sharing	Institutional capacities and technological infrastructure for statistical analysis, categorisation and spatial modelling		Organisational Strengthening		Surveys for socio-economic and sector specific infrastructure data collection
			Inter-departmental framework for information and data sharing			Investment in technical infrastructure	
						Consultancy	Data aggregation and generation of specific planning values
		Environment: experts and relevant stakeholders in urban development	Medium to advanced understanding of rapid urbanisation processes, patterns, and challenges and existing development plans	Interpretation and visualisation of comprehensive urban data	Communication	Multi-sectoral communication	Baseline Scenario
			Participation strategy for the inclusion of external stakeholders		Partnerships and Networks	Partnerships with the Civil and Private sector	Reference Scenario
			Visualisation of urban issues				Trans-sectoral Scenario

Capacity Development for RP

Phase 3: Urban Analysis

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Strategic Planning as a Capacity Development Process

Strategic Planning Component	Strategic Planning Objective	Capacities Assessment			Capacity Development Strategy		Rapid Planning Activities
		Level of Intervention	Identify Capacities	Objective of the CD Process	Learning Approach	CD Instruments	
Urban Assessment	Support and promote participatory urban planning and informed decision-making	**Institutional:** Experts from municipal departments	Medium to advanced knowledge of existing municipal development plans	Generation of a participatory urban analysis process for the holistic understanding of the urban condition, development needs and challenges	Communication	Establish inter-departmental collaboration and communication	Urban metabolism assessment
							Environmental impact assessment
		Environment: representati-ves of communities, private sector and external relevant stakeholders	Medium to advanced understanding of rapid urbanisation processes, patterns, and challenges		Knowledge Management	Recruiting	Appraisal of spatial distribution and current condition of existing infrastructure
					Exposure	Consultancy	
					Organisational Strengthening	Define a participation strategy for urban assessment for relevant stakeholders	Appraisal of spatial distribution of future infrastructure needs

Capacity Development for RP

Phase 4: Conceptualisation

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Strategic Planning as a Capacity Development Process

Strategic Planning Component	Strategic Planning Objective	Capacities Assessment			Capacity Development Strategy		Rapid Planning Activities
		Level of Intervention	Identify Capacities	Objective of the CD Process	Learning Approach	CD Instruments	
Conceptualisation	Promote and institutionalise integrated urban planning processes	**Institutional:** Experts from municipal departments	Medium to advanced understanding of rapid urbanisation processes, patterns, and challenges	Institutionalisation participatory urban planning and informed	Communication	Informative and interactive discussions and workshops with the stakeholders	Definition of applicable sustainable infrastructure development technologies
			Expert knowledge about sustainable practices for urban development		Knowledge Management	Establish general development objectives for urban development	Identify trans-sectoral synergies
		Environment: representatives of communities, private sector and external relevant stakeholders	Local knowledge about urbanisation issues		Organisational Strengthening	Establish Inter-departmental collaboration and communication strategy	Definition of the Rapid Planning trans-sectoral development scenario
			Skills for promoting participatory urban planning processes			Definition of an integrated urban development vision	

Capacity Development for RP

Phase 5: Strategies Formulation

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Strategic Planning as a Capacity Development Process

Strategic Planning Component	Strategic Planning Objective	Capacities Assessment			Capacity Development Strategy		Rapid Planning Activities
		Level of Intervention	Identify Capacities	Objective of the CD Process	Learning Approach	CD Instruments	
Strategies	Create an institutional culture of integrated informed decision-making for urban development	**Institutional:** Experts from municipal departments	Expert knowledge about Integrated urban development	Improve the process of good governance through participatory planning processes	Communication	Establish an institutional framework for collaborative planning	Considerations for change management
			Institutional capacities for supporting participatory planning processes		Knowledge Management	Multi-stakeholder workshops	Lessons learned for integrated and participatory planning processes
	Promote vertical and horizontal decentralisati-on processes	**Environment:** representati-ves of communities, private sector and external relevant stakeholders	Framework for participation and communication between municipal departments, communities, private sector and decision makers		Partnerships and Networks	Establish policies for the institutionali-sation of participatory planning and integrated urban development	Capacity developments materials for different target groups
					Organisational Strengthening		

The Strategic Planning Process

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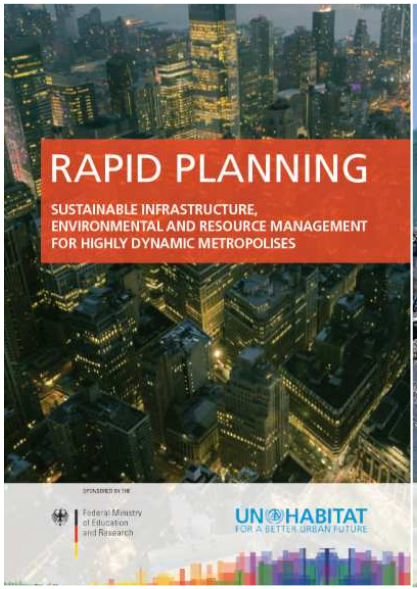
Capacity Development Materials

RP Deliverables
Brochures
Articles



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THE RAPID PLANNING PROJECT
TEAM

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