RAPID PLANNING

SUSTAINABLE INFRASTRUCTURE, ENVIRONMENTAL AND RESOURCE MANAGEMENT FOR HIGHLY DYNAMIC METROPOLISES

SESSION 1: DATA AND INFORMATION GATHERING

2017/09/12 – MID TERM CONFERENCE – NAIROBI

DATA GATHERING AS PART OF THE RP METHODOLOGY

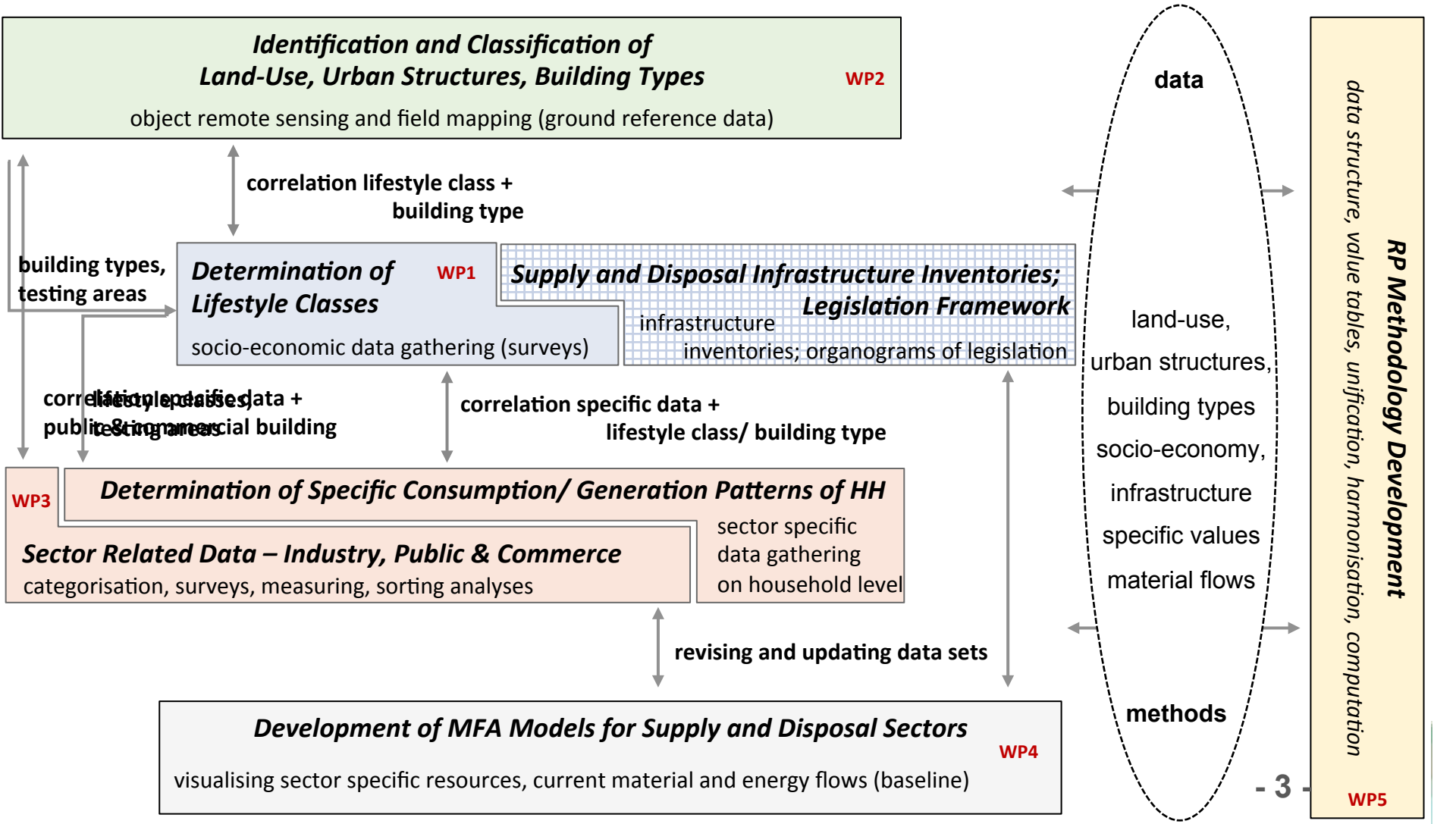
- *Data and information on land-use, urban structures, building types*
  - object remote sensing and field mapping (ground reference data)

- *Socio-economic, infrastructure, legislation/ regulation data and information*
  - data gathering within household surveys by means of questionnaires, technical inventories on supply and disposal infrastructure, organograms of legislation structures

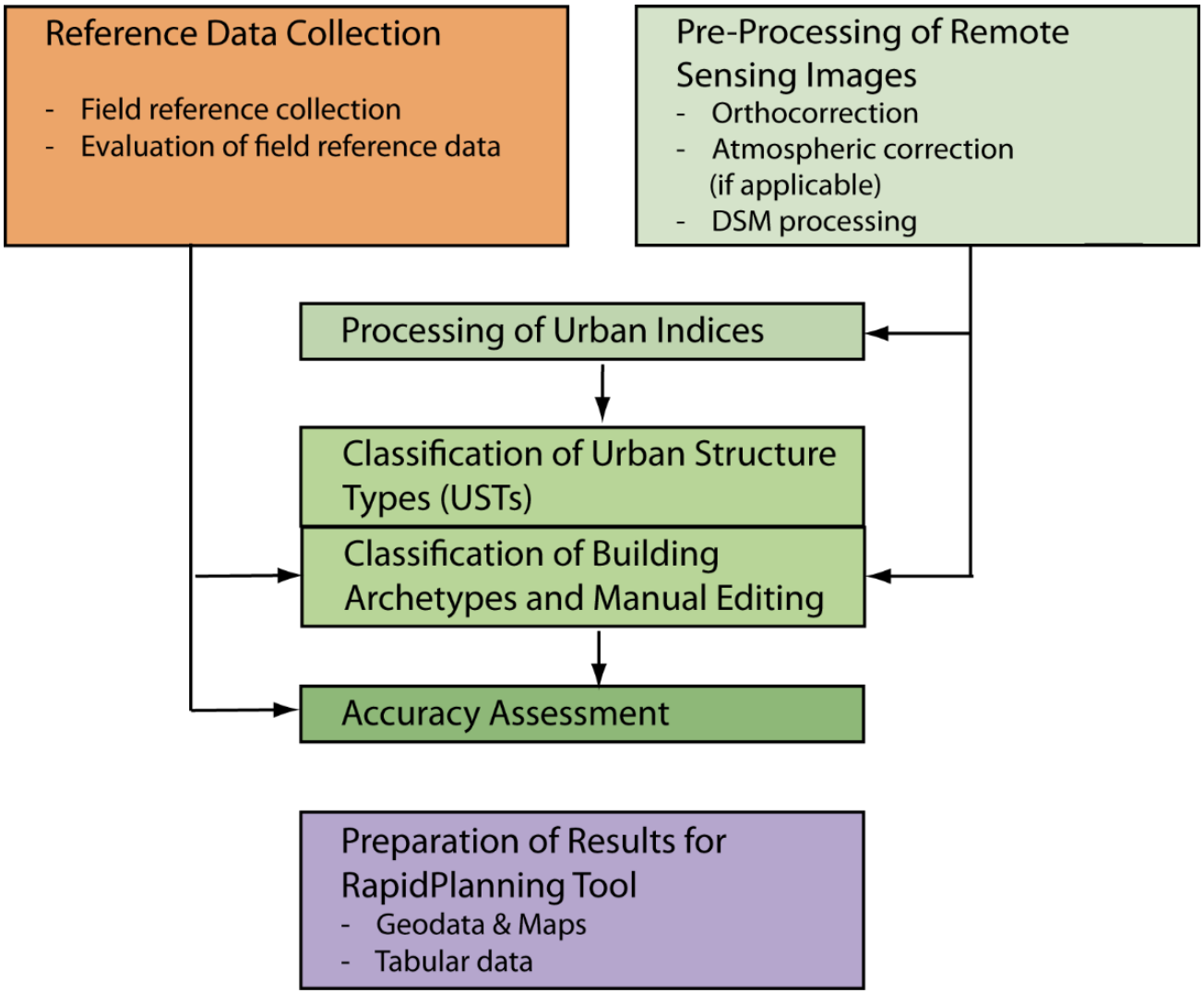
- *Sector specific data on energy/ water/ food/ waste/ wastewater*
  - sector specific data gathering on household, industry, public & commercial level and for urban agriculture/ food by means of surveys, measuring, sorting analyses etc.

- *Data and information on material and energy flows*
  - comprehensive analyses of material and energy flows by means of Material Flow Analyses (MFA)

DATA GENERATION PROCESS OVERVIEW



REMOTE SENSING ANALYSIS


Reference Data Collection
- Field reference collection
- Evaluation of field reference data
Pre-Processing of Remote Sensing Images
- Orthocorrection
- Atmospheric correction (if applicable)
- DSM processing
Processing of Urban Indices
Classification of Urban Structure Types (USTs)
Classification of Building Archetypes and Manual Editing
Accuracy Assessment
Preparation of Results for RapidPlanning Tool
- Geodata & Maps
- Tabular data

REFERENCE DATA COLLECTION

Building Reference Data Collection

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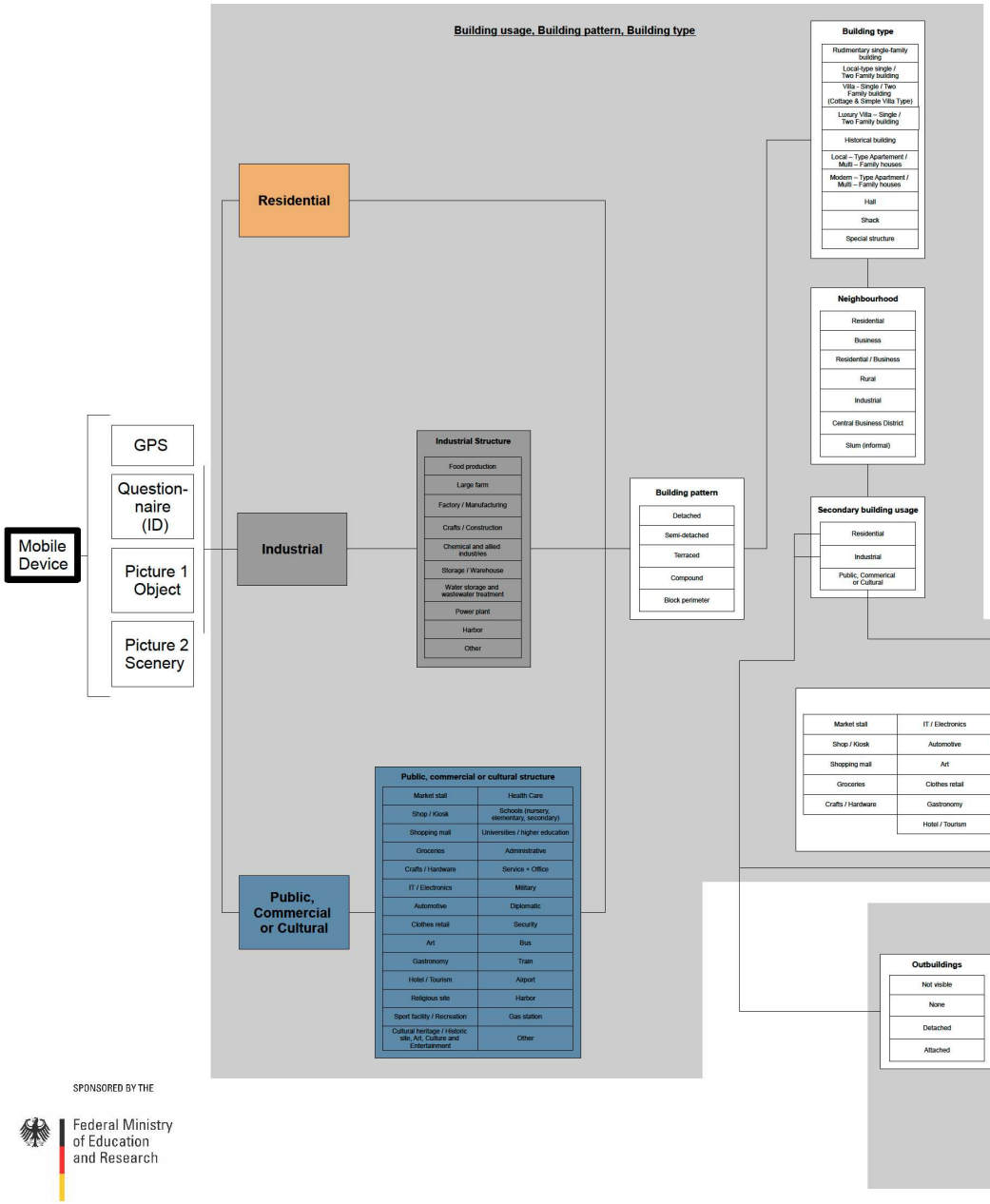

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Reference Data Collection

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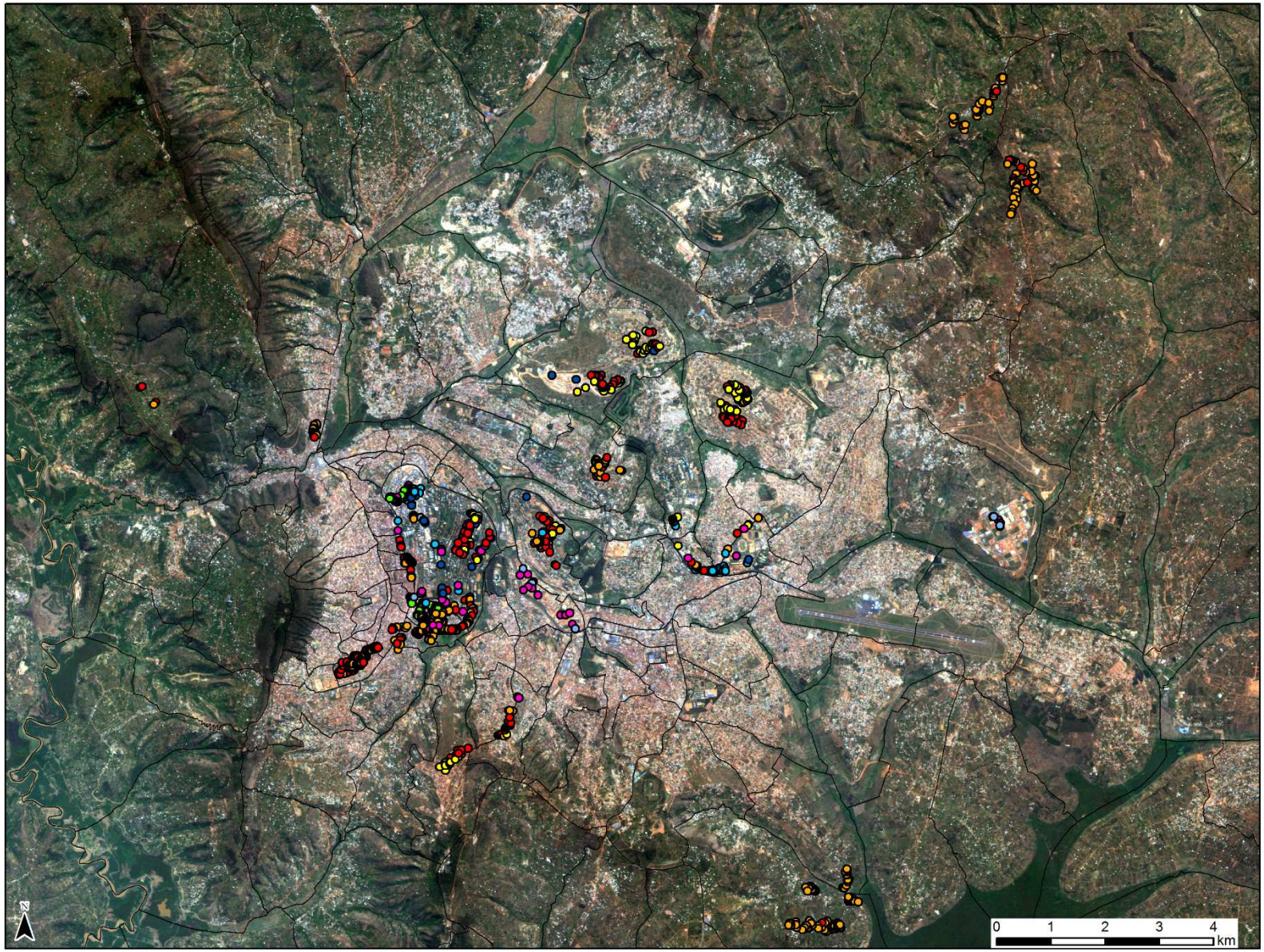
RAPID PLANNING
www.rapid-planning.net



- Rudimentary, Basic or Unplanned Building
- Local-Type Building
- Bungalow-Type Building
- Villa-Type Building
- Local Apartment-Type Building
- Modern Apartment-Type Building
- Hall
- Special Structure
- Outbuildings / Shack
- Cell Boundary

1074 building reference points collected during field work 11/2014, 06/2015 and 11/2015.

The boundaries are provided by the National Institute of Statistics Rwanda. The underlying satellite image is a RapidEye scene (2015-07-14). The RapidEye data has been contributed on behalf of the German Aerospace Center (DLR) through funding of the German Ministry of Economy and Energy.

Map compiled by: Felix Bachofer
Version: 2017-01-20

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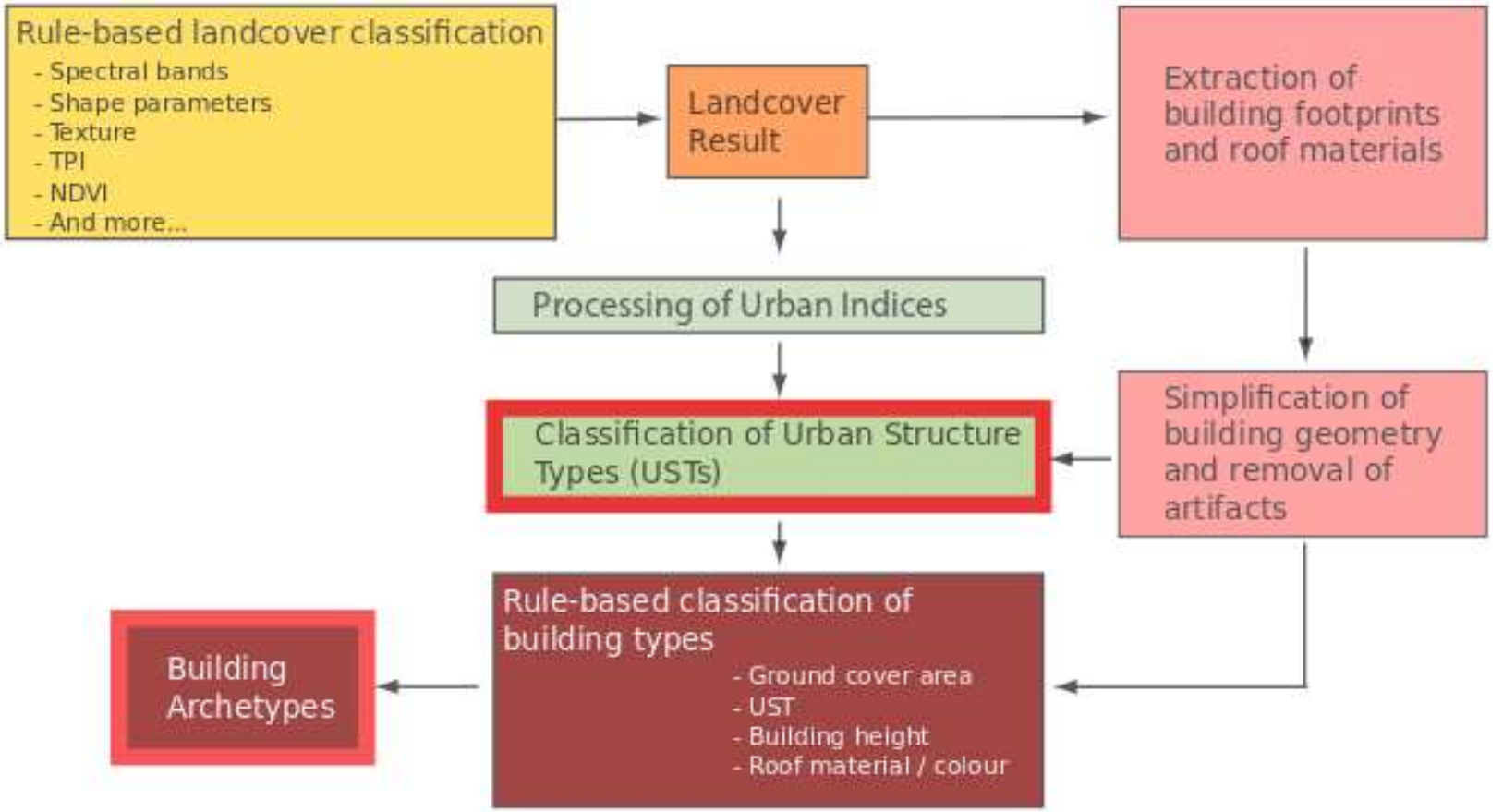
IDENTIFICATION OF URBAN MORPHOLOGY


Rule-based landcover classification
- Spectral bands
- Shape parameters
- Texture
- TPI
- NDVI
- And more...
Landcover Result
Extraction of building footprints and roof materials
Processing of Urban Indices
Classification of Urban Structure Types (USTs)
Simplification of building geometry and removal of artifacts
Rule-based classification of building types
- Ground cover area
- UST
- Building height
- Roof material / colour
Building Archetypes

URBAN STRUCTURE TYPES

Classification parameters: building density, floor-area index, green index….

KMEANS
Unsupervised
clustering

SVM
Supervised
classification

Rule-based
classification

Parameters
Block 1: p1, p2, p3…. -> class3
Block 2: p1, p2, p3…. -> class6
Block 3: p1, p2, p3…. -> class2

Training data
Block 1 = class 4
Block 2 = class 7
Block 3 = class 1

Test data
Block 1: p1, p2, p3….
Block 2: p1, p2, p3….
Block 3: p1, p2, p3….

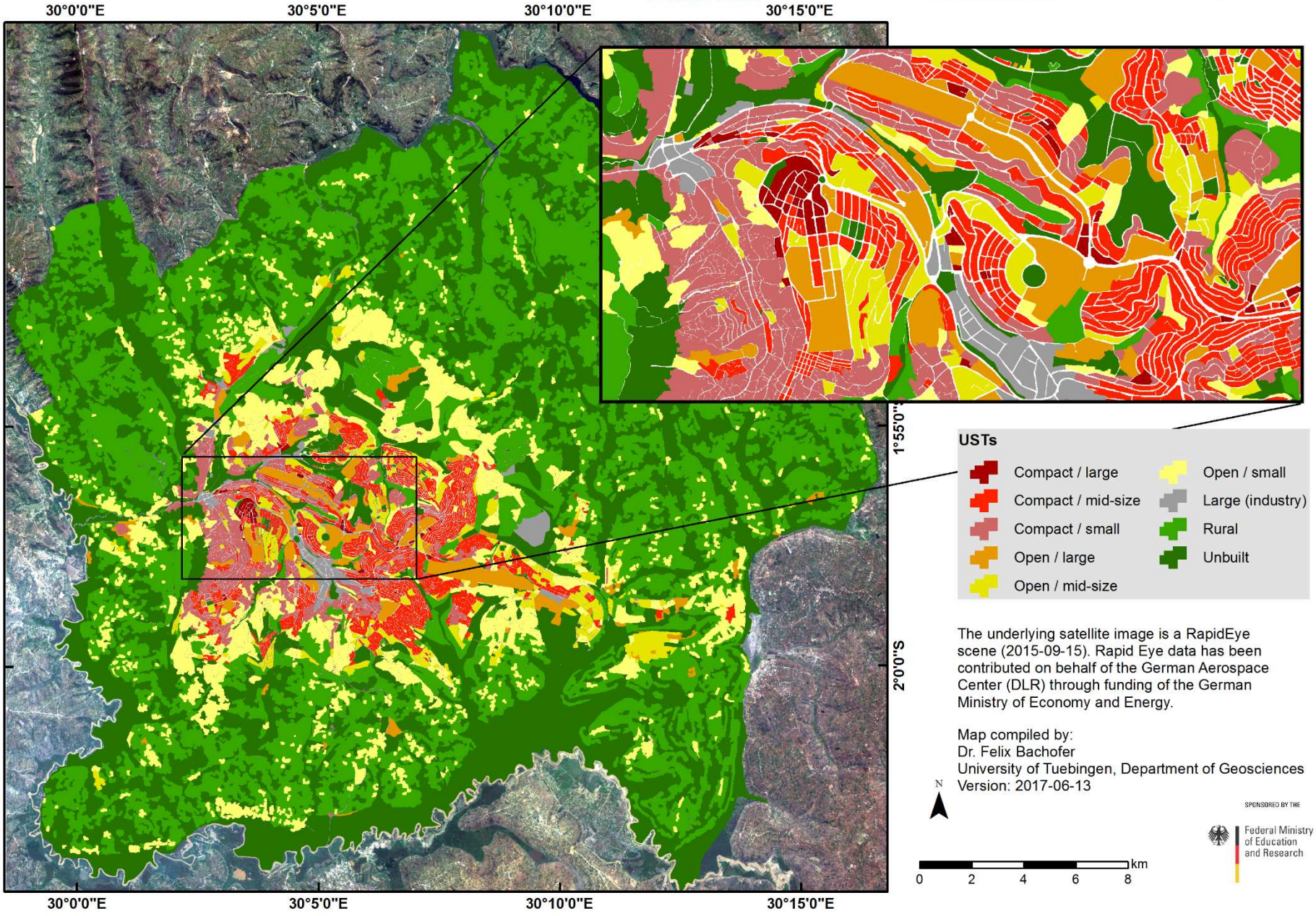
Green index > 0.5
AND
Density <= 0.4
……

USTs classification result

Optional

Expert based refinement of USTs results

Urban Structure Types Kigali



The underlying satellite image is a RapidEye scene (2015-09-15). Rapid Eye data has been contributed on behalf of the German Aerospace Center (DLR) through funding of the German Ministry of Economy and Energy.

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University of Tuebingen, Department of Geosciences
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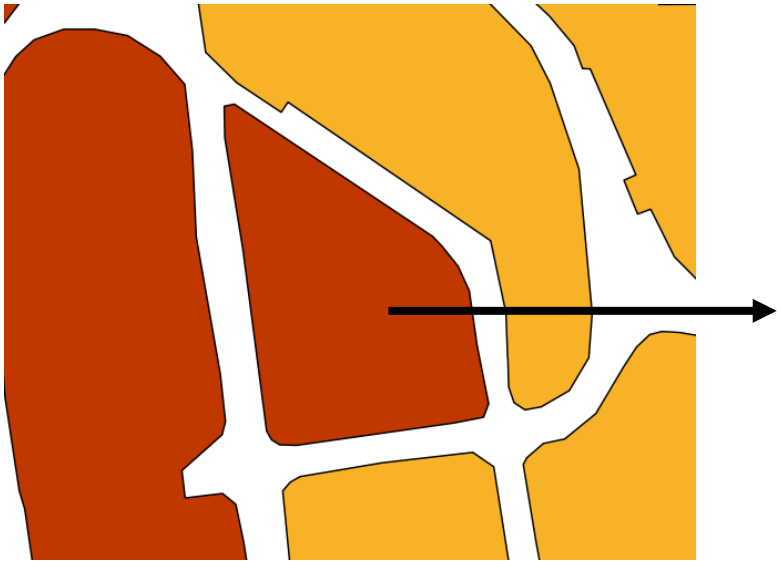
BUILDING BLOCKS



After an additional processing step the data is supplemented by:

The number of buildings of each identified building type

UST: Urban structure type

Mean plot size derived from cadastral data.

Number of buildings per block

Total built-up area per block

Mean building size per block

Ground Space Index (GSI): Share of built-up area in relation to block area

Number of buildings per block area

Mean distance of all building of a building block in relation to building density

Standard deviation of mean distance of all building of a building block in relation to building density

Accessibility, measured by the mean distance to the closest road network

Mean of the **mean distance of all buildings to its' four closest neighbouring buildings**

"**Average Nearest Neighbour**" in relation to block area. The Nearest Neighbor Index is expressed as the ratio of the Observed Mean Distance to the Expected Mean Distance.

Zone (Commercial Center / Urban /Rural)

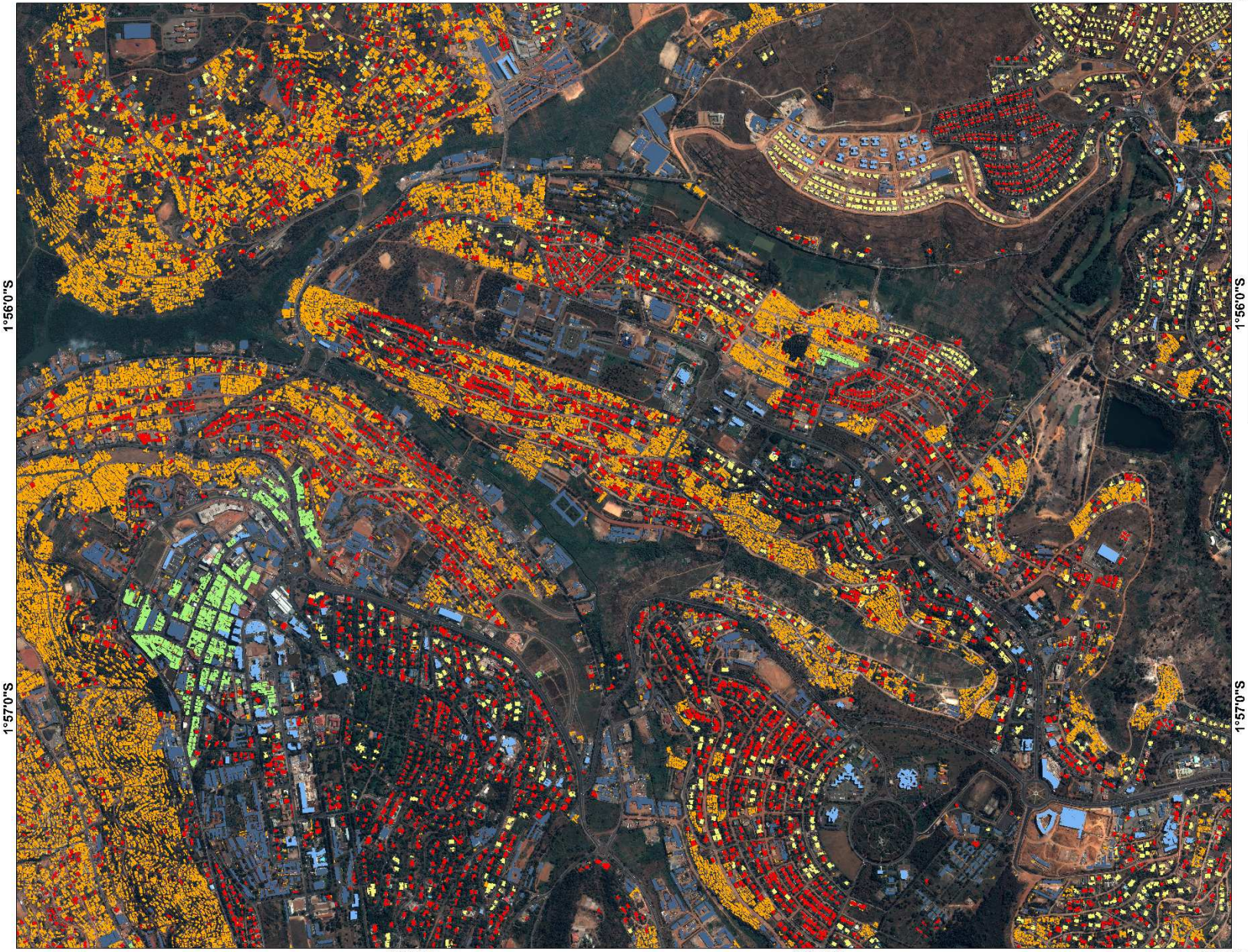
Mean slope of building centroids per block

Total vegetated area

Share of agricultural used area

Green Coverage Ratio (GCR): Share of vegetated area

BUILDING TYPE DELINEATION



Building Types Kigali

Building Types

- Rudimentary-, Basic or Unplanned Building
- Local-Type Building
- Bungalow-Type Building
- Villa-Type Building
- Local - Type Apartment
- Modern - Type Apartment
- Hall
- Shack / Outbuilding
- Special Structure

The pie charts represent the share of the number of buildings for each building types in a building block.

The size of the pie charts depends on the total number of buildings per block (log).

The Pléiades image covers the central and densely built-up part of the City of Kigali.

190,774 built-up structures were identified and classified to 9 building archetype classes with an overall accuracy of 91 %.

A RapidEye image was used to identify buildings in the sparsely built and mostly rural areas of Kigali. 92,937 were identified with an overall accuracy of 83.6 %.

An overall number of 283,711 built-up structures were identified by the combined methodology

The underlying satellite image is a Pléiades scene (2015-08-09).

Map compiled by:
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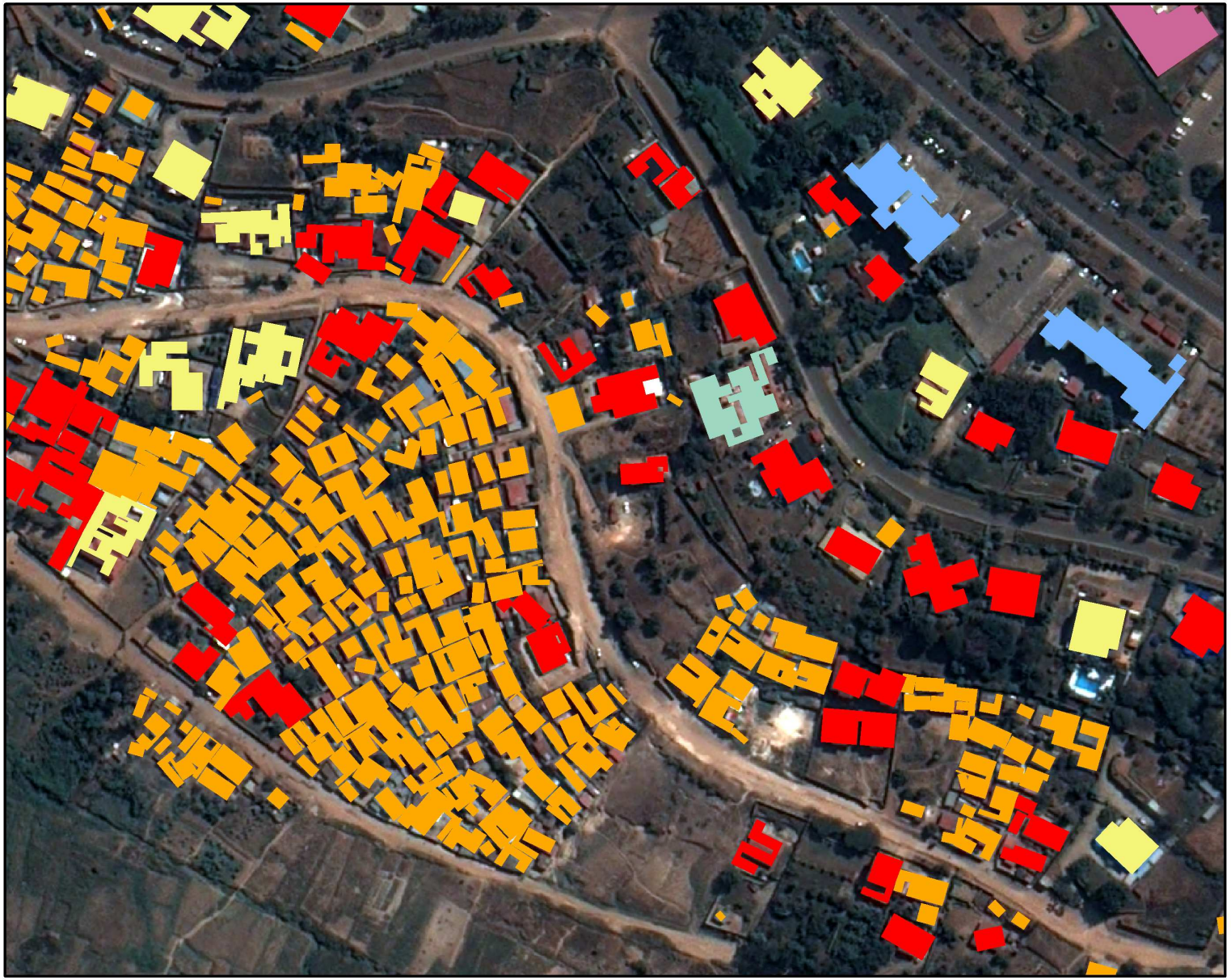
University of Tuebingen
Department of Geosciences
Version: 2017-07-10

N

0 250 500 750 m

Building Types Kigali



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The underlying satellite image is a Pléiades scene (2015-08-09).

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Department of Geosciences
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N

0 25 50 75 100 m

Building type
Area of building footprint
UST: Urban structure type
Zone (Commercial Center / Urban /Rural)
Structure: Indicates if the building is detached, attached, grouped or clustered.

Class Name	Number of buildings	Percentage	Total area (m²)	Mean area (m²)
RapidEye covered area "Rudimentary"	92,937	100 %	5,600,397	60.3
Rudimentary / Unplanned	152,955	80.19 %	11,065,142	72,3
Local-Type	1,165	0.61 %	333,536	286,3
Bungalow-Type	24,812	13.00 %	5,051,583	203.6
Villa-Type	5,681	2.98 %	1,545,743	272.1
Local Apartment-Type	858	0.45 %	461,350	537.7
Modern Apartment-Type	225	0.12 %	198,513	882.3
Hall	4,742	2.48 %	2,530,147	533.5
Outbuilding	160	0.08 %	5,717	35.7
Special	176	0.09 %	53,740	305.3
SUM Pleiades	190,774	100 %	21,245,471	
Total SUM	283,711		26,845,868	

OUTLOOK REMOTE SENSING

SOCIO-ECONOMIC HOUSEHOLD SURVEY

APPROACH AND METHODOLOGICAL IMPLEMENTATION

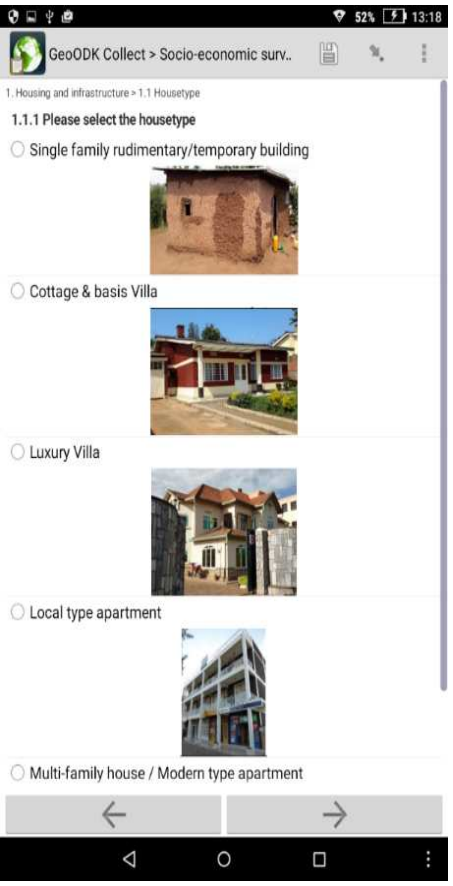
- **Development of a meta questionnaire for socio-economic household surveys**
  - Adaptation of the questionnaire to the regional context by considering local knowledge from Kigali
- **On-site check of the preselected test areas (homogeneous building type)**
  - First rough socio-economic estimation of the test area considering local knowledge
- **Conduction of survey in the test areas**
  - Tablet computer based survey, different blocks of questions
  - GPS data and pictures of every surveyed building (later correction and identification possible)
- **Analyses of the gathered survey data**
  - Quality check
  - Selection of usable reliable data for analyses (specific household information, specific items, devices and features, expenditures)
- **Derivation of lifestyle classes (LC)**
  - Development of special evaluation procedure
- **Linking LC to building types (BT)**
  - Linkage of building type and urban structure type to integrate location parameters
  - Estimation of additional location parameters for further specification of building types

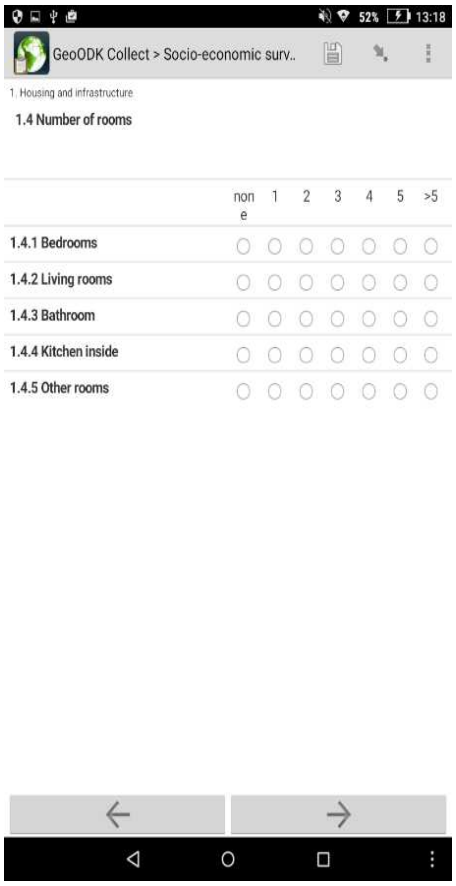
STRUCTURE AND CONTENT OF THE QUESTIONNAIRE:

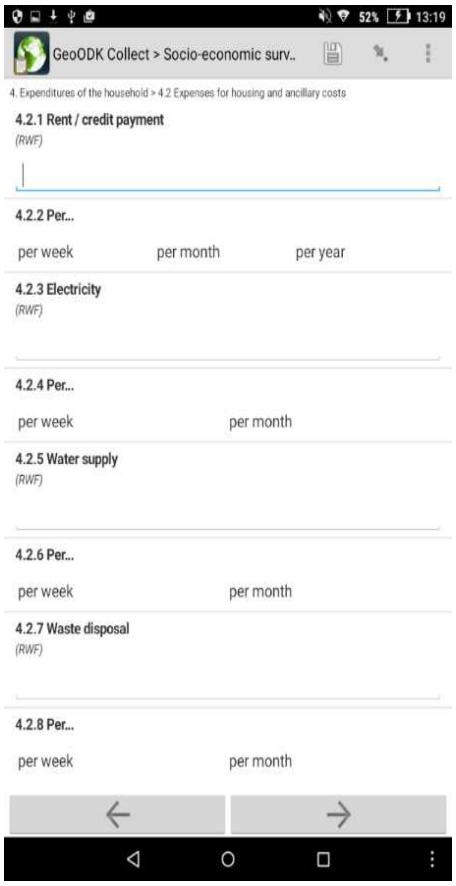
- **Housing and infrastructure**
  - Questions about: number of floors, number of households, number of units, number of different uses, overall size of the plot, footprint of the house, access to the structure, property of the house or flat, overall size of the flat, number of different rooms, private water tab, kind of toilet, sewage disposal
- **Specific information on the household**
  - Questions about: number and age of family members, working family members, Ubudehe category and total financial resources
- **Specific items, devices and features of the household**
  - Questions about: TV, flat screen, satellite dish, notebook, cell phone, household appliances (refrigerator, dishwasher, washing machine and further), air conditioning, motorcycle, car, bank account and further
- **Expenditures of the household**
  - Questions about: total expenditures, food and beverages, mobility, leisure, rent, electricity, water supply, waste disposal, charcoal, firewood, education / school, college / university, health insurances, further insurances, support for relatives and further
- **Food and buying habits**
  - Question about: frequency of street food, local restaurants, fast food, resort restaurant, frequency of eating meat, beer and further, distance to local market, supermarket, from farm and further
- **Earnings of the household**
  - Questions about: highest degree, profession, number of current jobs, characteristics of main job, total income of all jobs, rental income, support from relatives
- **Assessment given by the interviewer**
  - Personal estimation about socio economic classes, quality of the surrounding of the house, quality of the answers

EXTRACT FROM THE DIGITAL QUESTIONNAIRE FOR KIGALI

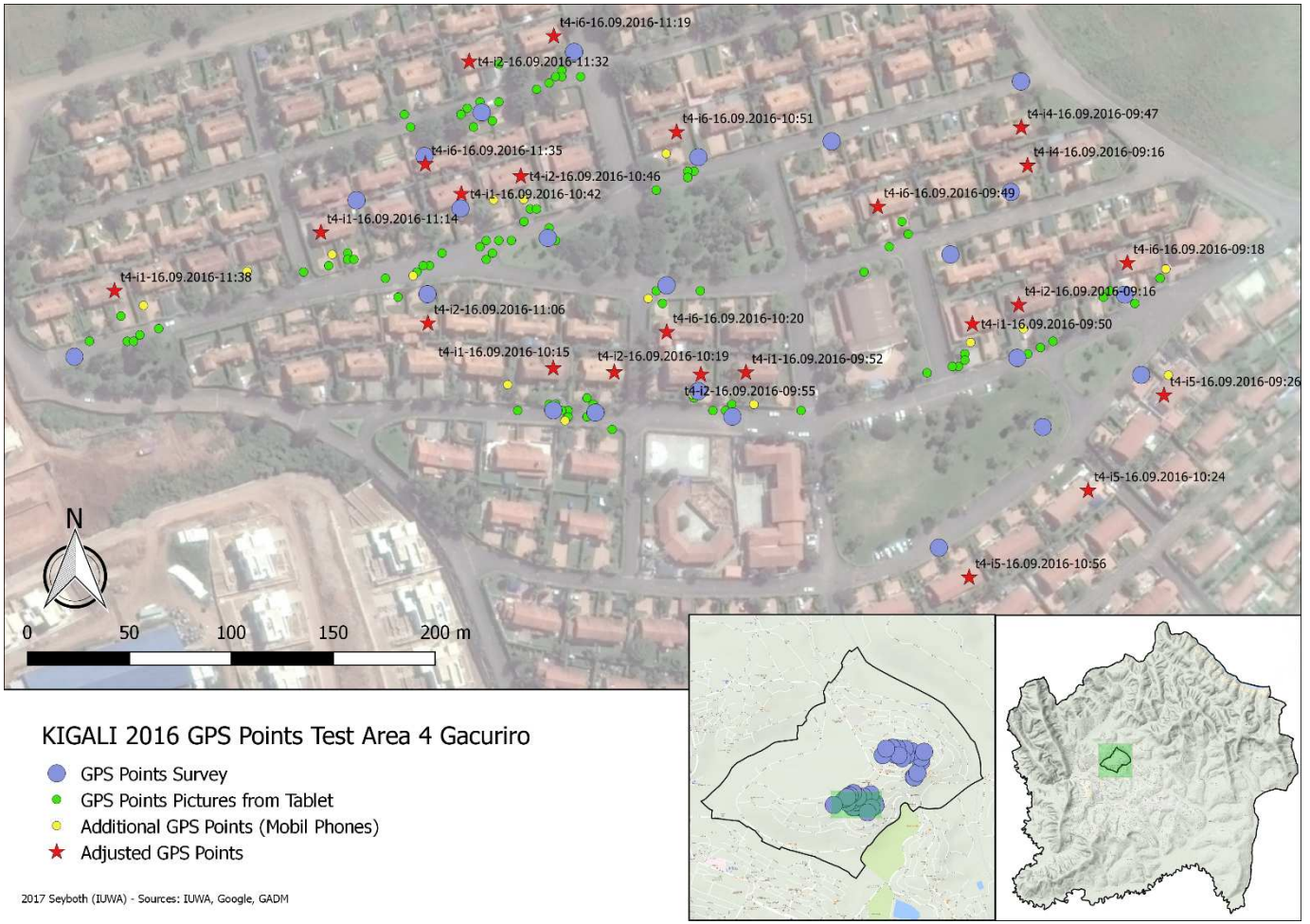
(Android Tablet with GeoODK)



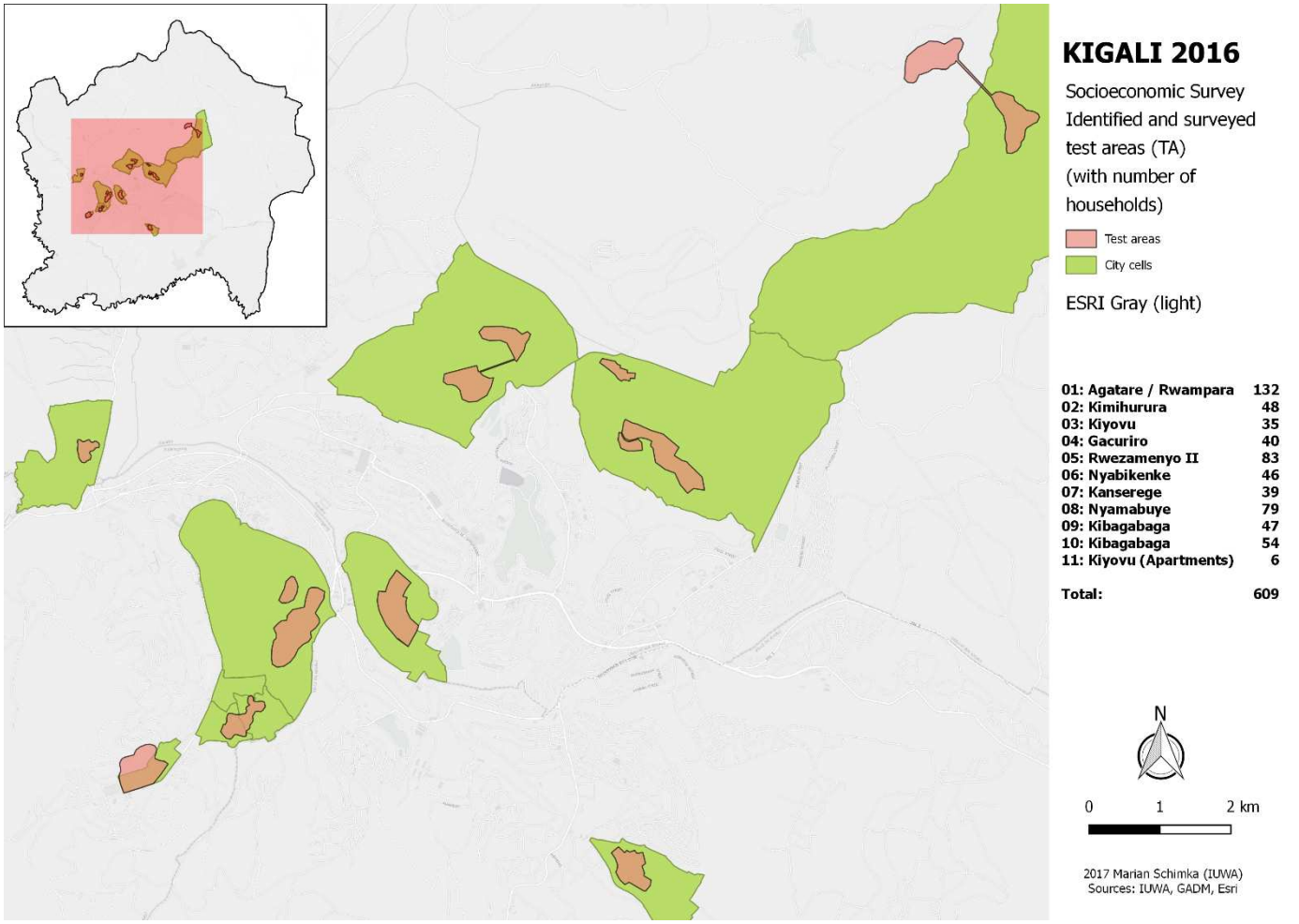




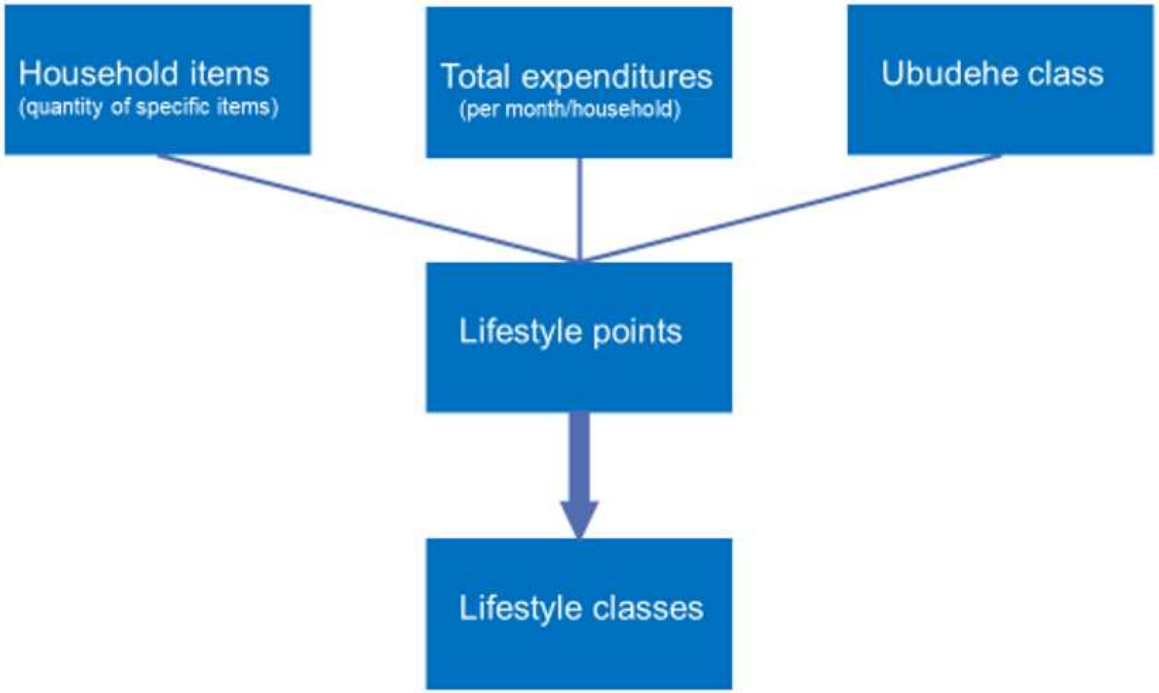
ADJUSTMENT OF GPS DATA POINTS *(Android Tablet with GeoODK)*



SURVEYED AREAS KIGALI AND NUMBER OF INTERVIEWS



METHOD FOR GENERATING LIFESTYLE CLASSES OF HOUSEHOLDS KIGALI



- Summation of the three components
  (Household items, Total expenditures, Ubudehe)
- Lifestyle points (LP) (1-4 LP x 3 components = 3–12 LP) of each test area

Household items

- 28 binar questions
- Different categories (electronic Items, household items, mobility)

⇨ 4 categories: 1. < 25 % answered with „yes“ 2. < 50 % answered with „yes“
3. < 75% answered with „yes“ 4. >= 75% answered with „yes“

Total expenditures

- Added results of 38 questions about different expenditures (food, mobility, energy, water, …)
- All data calculated per household (standardised by)

total expenditures of household/month/√number of household members /

4 categories: quartiles

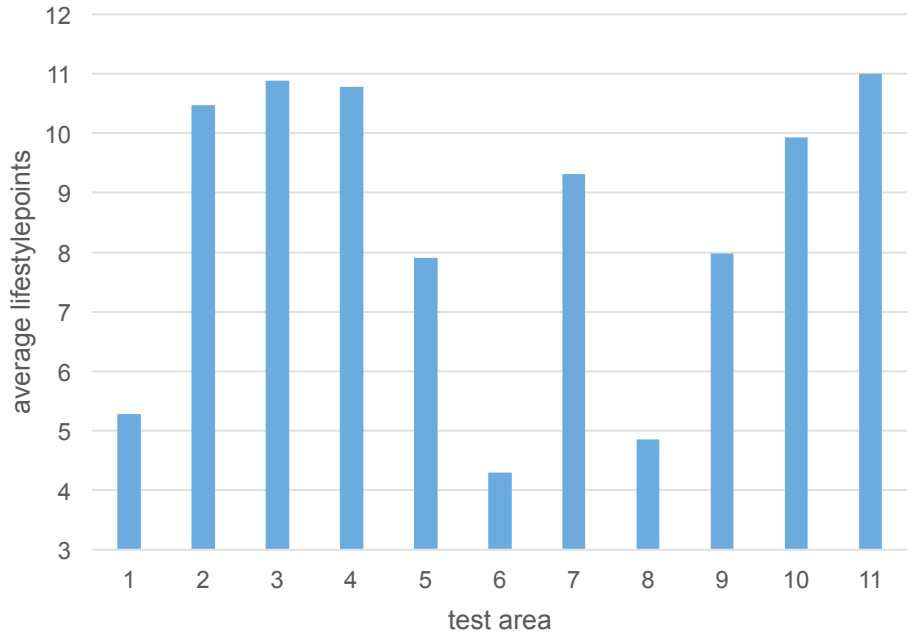
⇨

Ubudeheclass

- Classification of Rwandans based on economic status

⇨ 4 categories: one, two, three, four

NUMBER OF AVERAGE LIFESTYLE POINTS IN THE DIFFERENT TEST AREAS



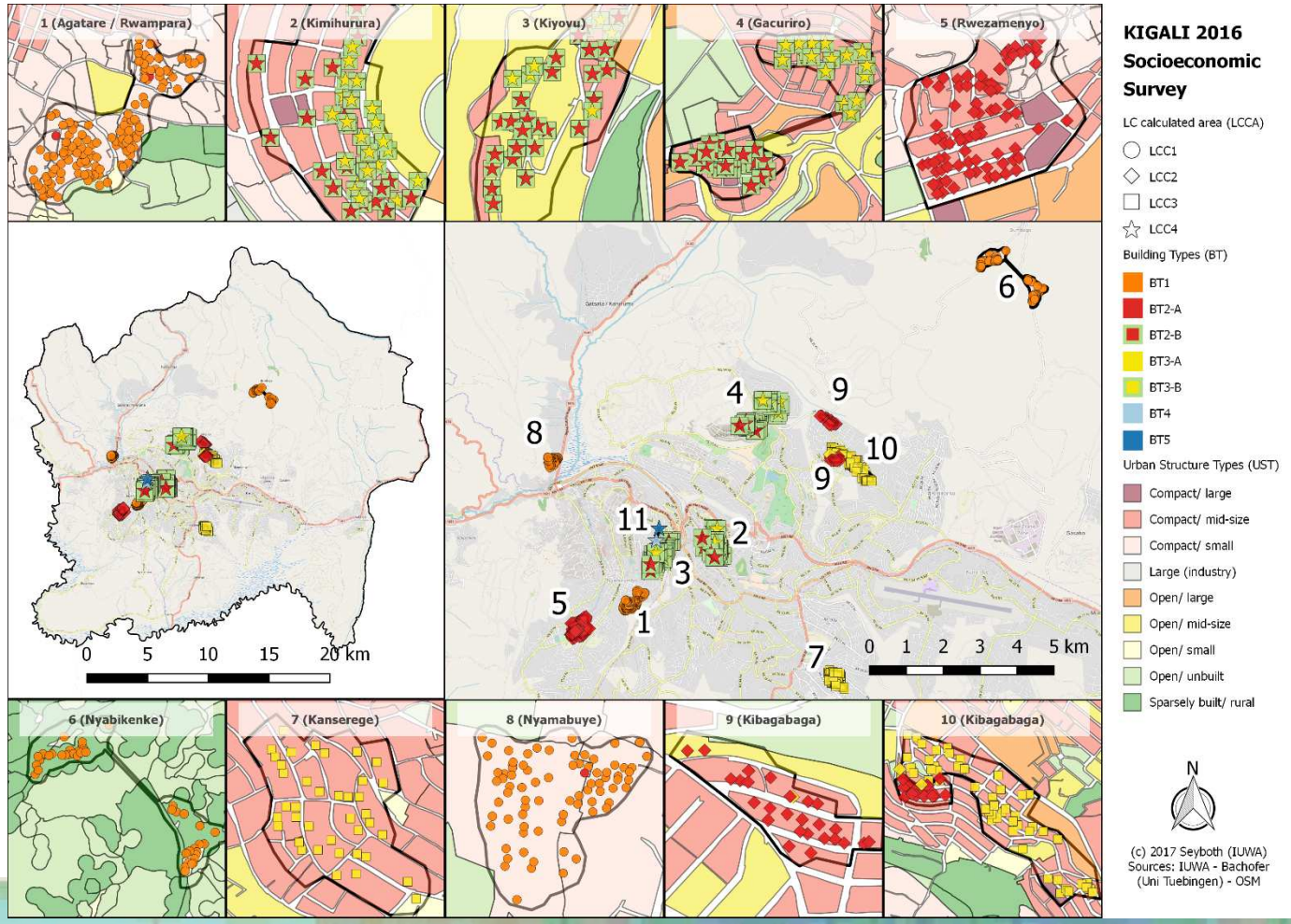
HOUSEHOLDS PER TEST-AREA WITH AVERAGE LIFESTYLE POINTS AND STANDARD DEVIATION

Area	Number of HH	Average lifestylepoints	Standard deviation
1	132	5.27	1.21
2	48	10.48	0.87
3	35	10.89	0.93
4	40	10.78	0.86
5	83	7.9	1.25
6	46	4.3	0.79
7	39	9.31	1.28
8	79	4.85	0.64
9	47	7.98	1.69
10	54	9.93	1.40
11	6	11	

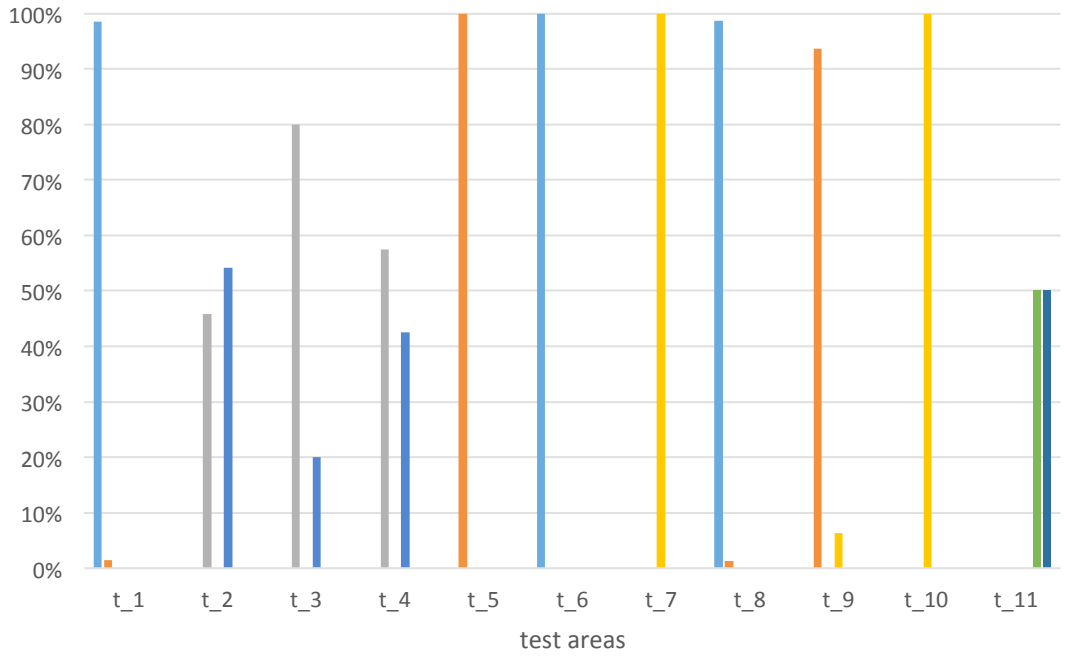
Related lifestyle class (LC) LC 1 = average LP < 6 LC 2 = average LP < 8
LC 3 = average LP < 10 LC 4 = average LP > 10

TEST AREAS WITH LIFESTYLE CLASS (LC), BUILDING TYPE (BT) AND URBAN STRUCTURE TYPE

Typical building in test area 4



ALLOCATION OF **BTs** IN TEST AREAS



Building type (BT)

BT1 --- Rudimentary/ Unplanned (BT1)

BT2 --- Bungalow-Type (BT2-A)

BT2↑ --- Bungalow-Type (BT2-B)

BT3 --- Villa-Type (BT3-A)

BT3↑ --- Villa-Type (BT3-B)

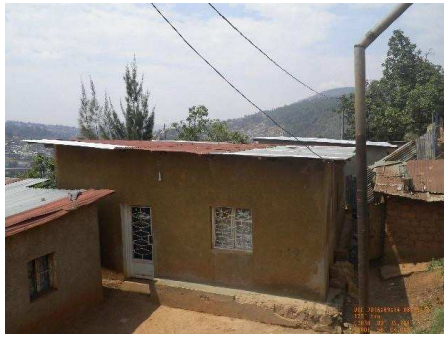
BT4 --- (Local apart.-type) (BT4)

BT5 --- (Modern apart.-type) (BT5)

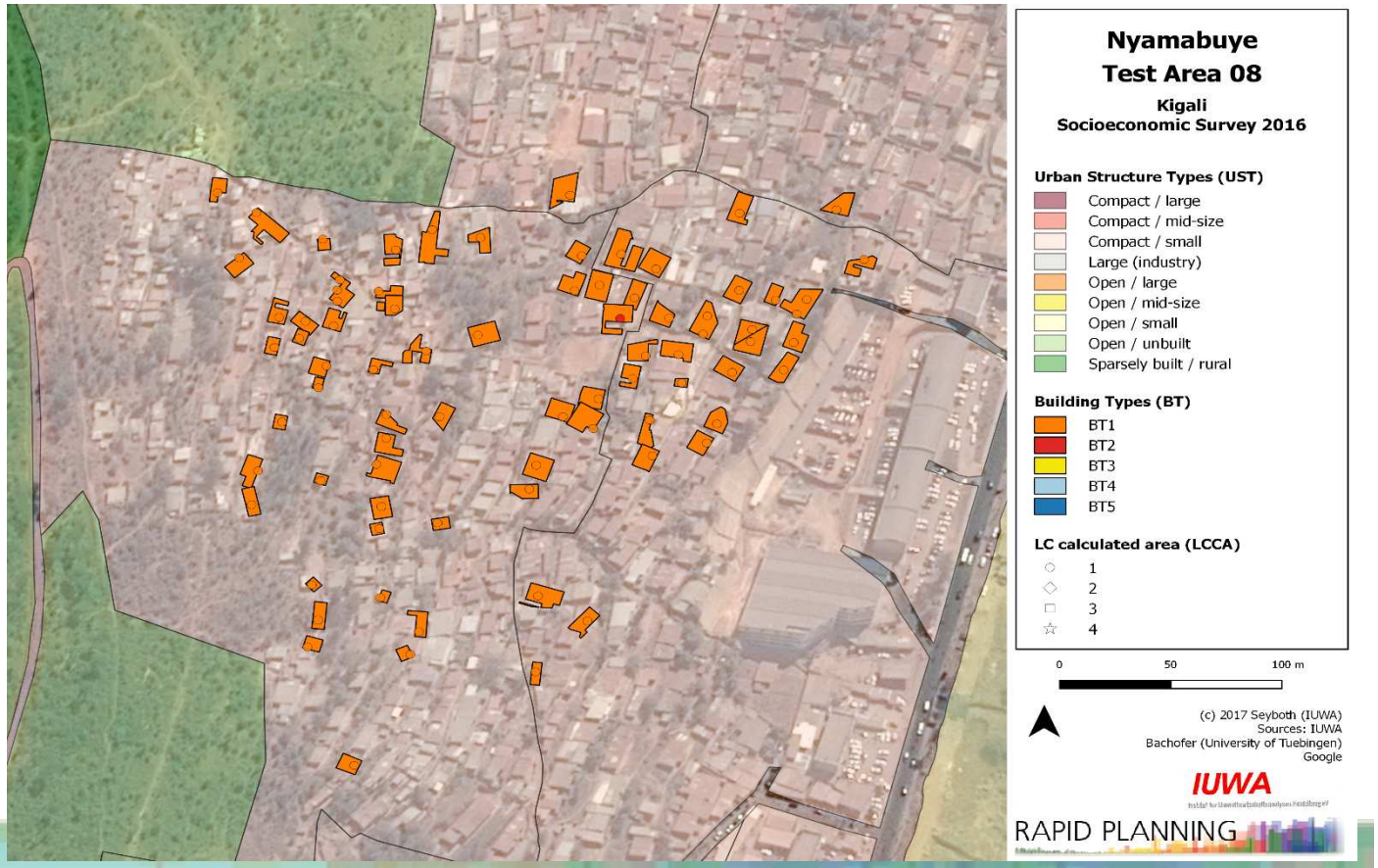
BT	Number of buildings	Percentage
Rudimentary	152,955	80.19%
Bungalow	24,812	13.00%
Villa	5,681	2.98%
Local apart.	858	0.45%
Modern apart.	225	0.12%

RP: USTs and Building Types – Remote Sensing Workflow –Deliverables 2.7 & 2.8 – Case City: Kigali 2017/06 Felix Bachofer

INTERSECTION OF LIFESTYLE CLASS (LC) FROM HOUSEHOLDS IN KIGALI WITH BUILDING TYPES AND URBAN STRUCTURE TYPES

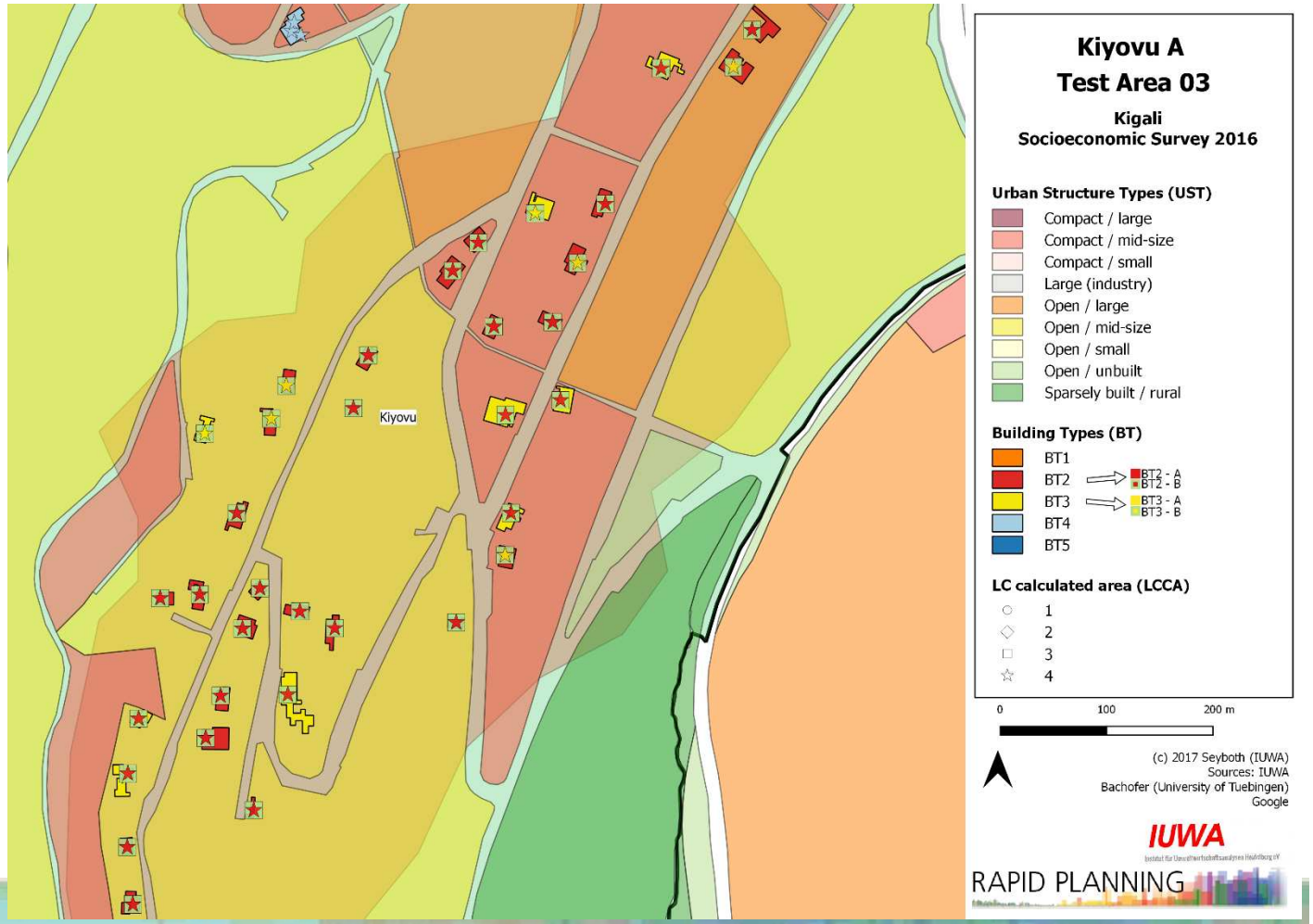


Typical building in test area 8

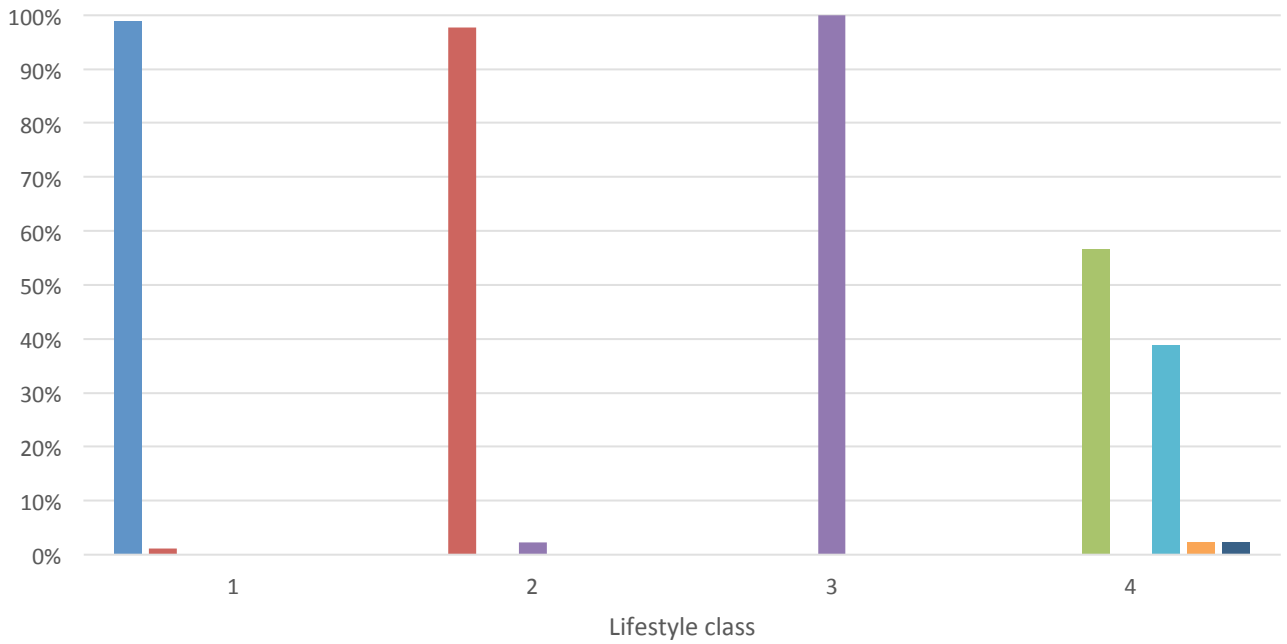


INTERSECTION OF LIFESTYLE CLASS (LC) WITH BUILDING TYPES AND URBAN STRUCTURE TYPES

Typical building in test area 3



ALLOCATION OF **BTs** TO **LCs** LINKED WITH URBAN STRUCTURE TYPES AND FURTHER LOCATION PARAMETERS (ZONE)



--- Rudimentary	254
--- Bungalow (BT2-A)	130
--- Bungalow (BT2-B)	73
--- Villa (BT3-A)	96
--- Villa (BT3-B)	50
--- (Local apart.)	(3)
--- (Modern apart.)	(3)

FURTHER SPECIFICATION OF BUILDINGS

To get a good correlation of all buildings with the life style class of their inhabitants, further specifications of buildings are necessary.

- Specification of building type (e.g. bungalow with two storey,)
  building height

- Specification by urban structure type (refinement)
  remote sensing

- Specification by location parameters
  (zones of comparable locations „economic status“ in residential areas)
  on-site by local knowledge

  Possible parameters:
  land price, safety, inner-city location, urban infrastructure....

Team Socio-Economic Data Gathering Activities
***Kigali**, Sept. 2016*

SECTOR-SPECIFIC DATA GATHERING

DATA GATHERING & ANALYSIS IN KIGALI

- Households (IER)
  - Target group: households
- Industry (IUWA)
  - Target group: manufacturing sector (>100 employees)
- Public & commerce (IUWA)
  - Target group: facilities such as shops, restaurants, schools, etc.

Goal: Develop and test various methods to gather specific data (e.g. per capita energy consumption or per employee water consumption) in the case cities to assist cities worldwide with a quick and reliable data gathering method

HOUSEHOLD SURVEY: CONCEPT

Aim: determine consumption/generation patterns for sectors energy, water, waste, waste water and food, based on household/building types

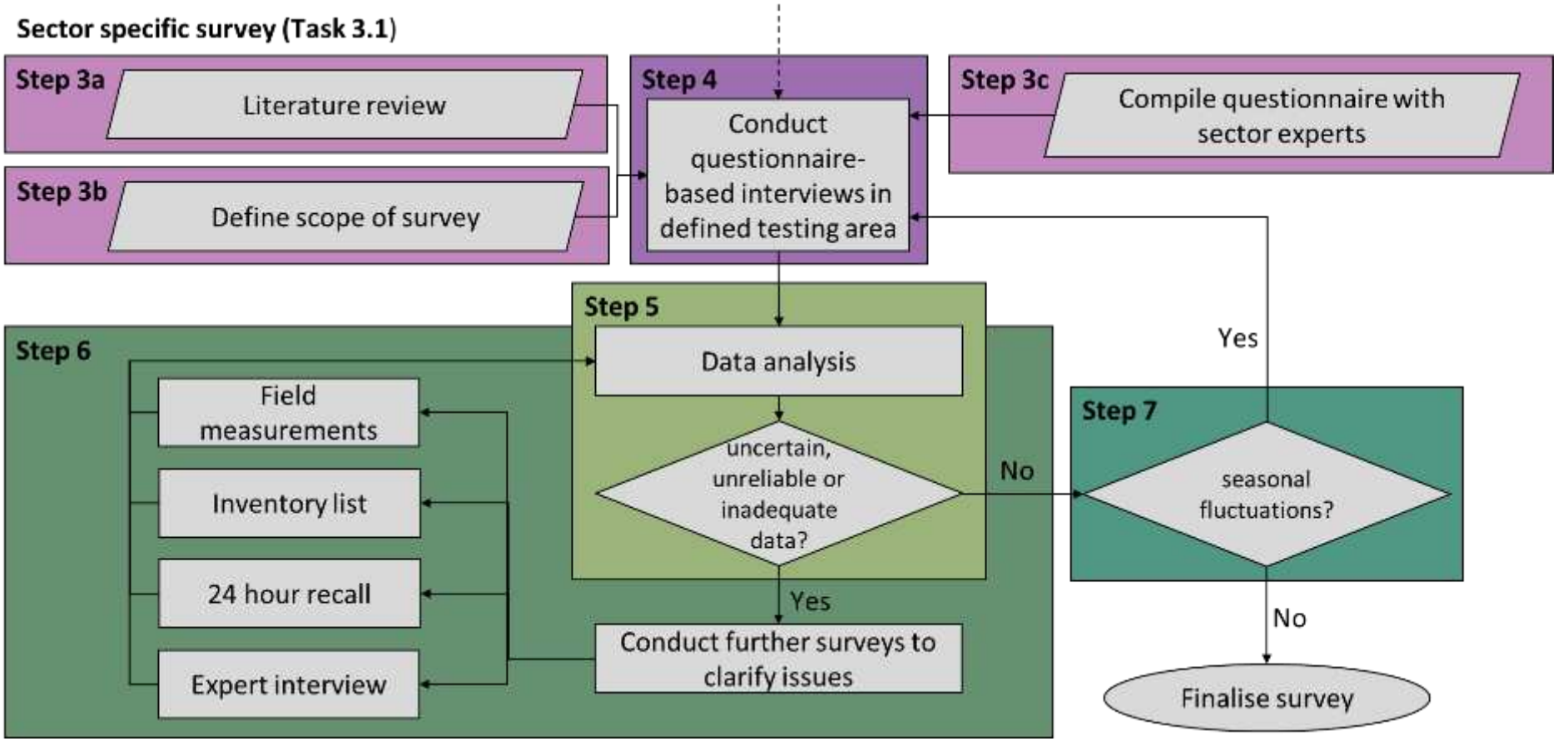
Methodology

1. Data collection by means of an interview with questionnaires (using tablets to reduce transfer mistakes, local assistants for translation) in the WP1/2 testing areas
2. Consolidation of results with field measurements, 24 h recall and expert interviews e.g. for solid waste (field measurements with COPED),
3. Letting people make a (daily) inventory list over a period of time, e.g. for food purchase

Restrictions / Challenges for questionnaires

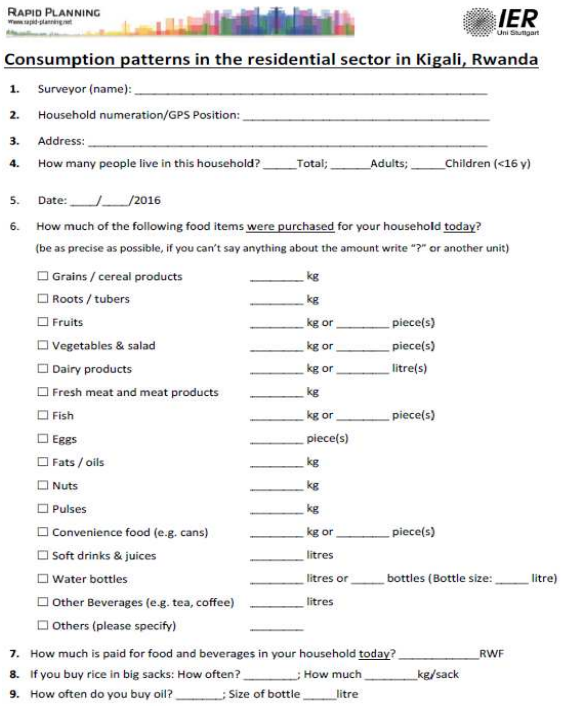
- To cover all sectors and keep it short simultaneously (interview time < 30 minutes)
- Seasonal/weekly variations must be regarded
- Proof of validity often difficult (missing electricity or water bills)
- Answers heavily depend on willingness to participate

HOUSEHOLD SURVEY: METHODOLOGY



METHODS USED IN KIGALI

- Questionnaire survey
  - 728 Households, 20 – 40minutes/household
- Food inventory survey
  - 70 households, 15 days
- Solid waste characterisation survey
  - 60 households, 4 weeks



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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

Food inventory

IMPRESSIONS OF SURVEY PREPARATION AND EXECUTION

Training session with field assistants, Kigali

Interviewee 1

Interviewee 2

Rudimentary building

Bungalow

Villa

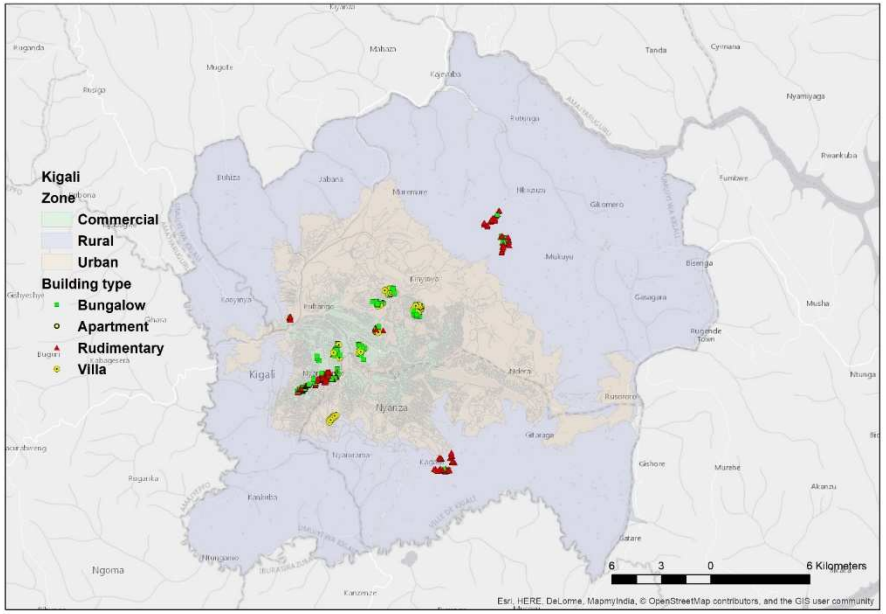
Apartment

CLASSIFICATION OF SAMPLE SIZE

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**	

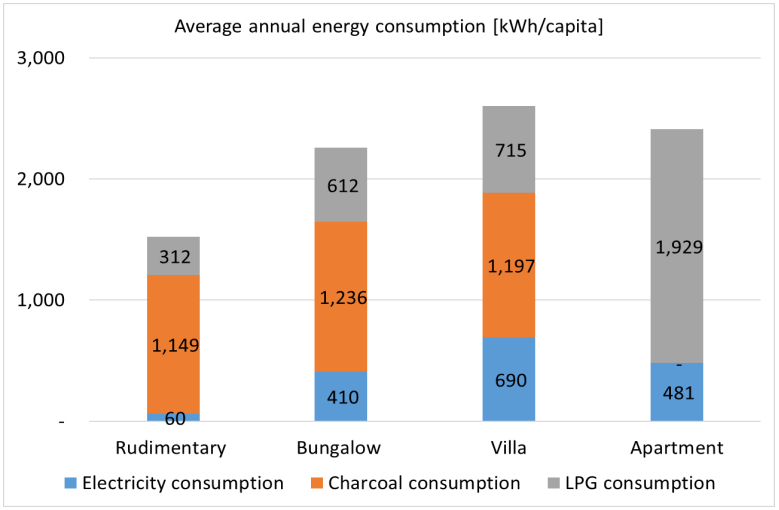
Classification of sample size

- Classification is based on WP1 and WP2 results
- In total, 728 geo-referenced households in twelve test areas

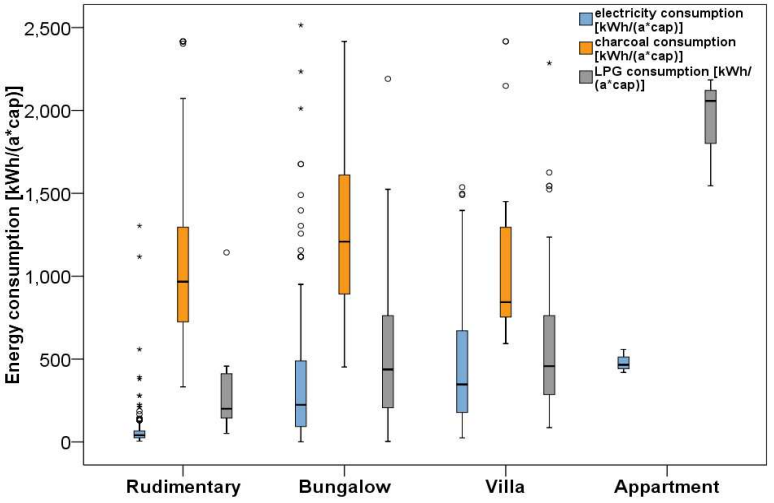


Location of surveyed households in Kigali

EXEMPLARY RESULTS: ENERGY CONSUMPTION IN BUILDING TYPES



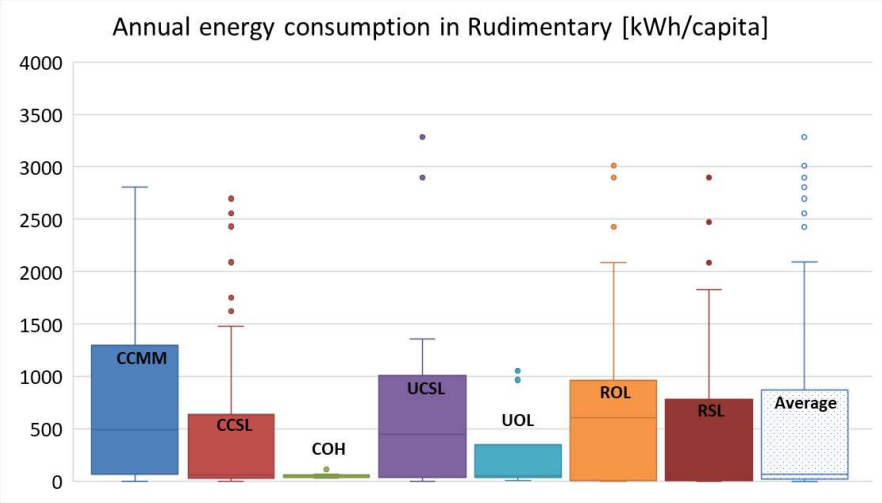
Energy consumption by building type



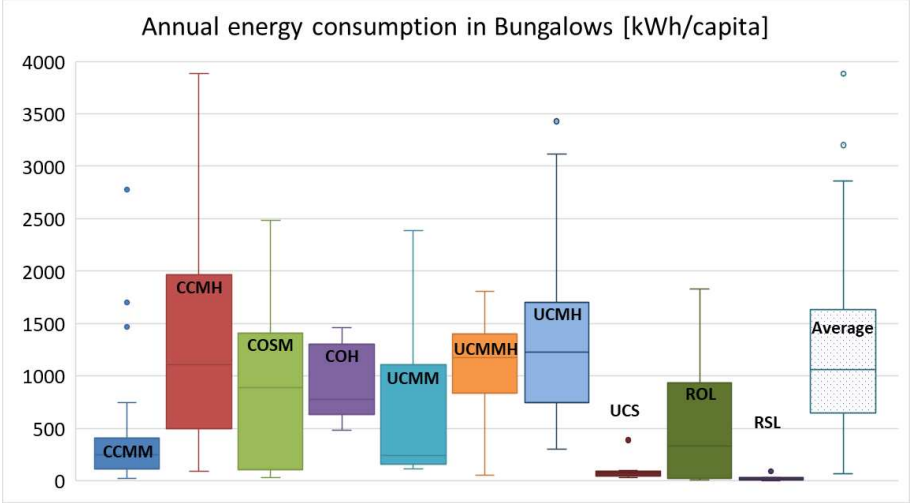
Variations in energy consumption by building type

- Total energy consumption in rudimentary buildings is not exceptionally low
- Large difference is observed in electricity consumption, but not in charcoal
- Due to lack of open space (for outdoor kitchen), charcoal is not used in apartments
- Large variance is observed in Bungalows

ENERGY CONSUMPTION IN RUDIMENTARY BUILDINGS AND BUNGALOWS



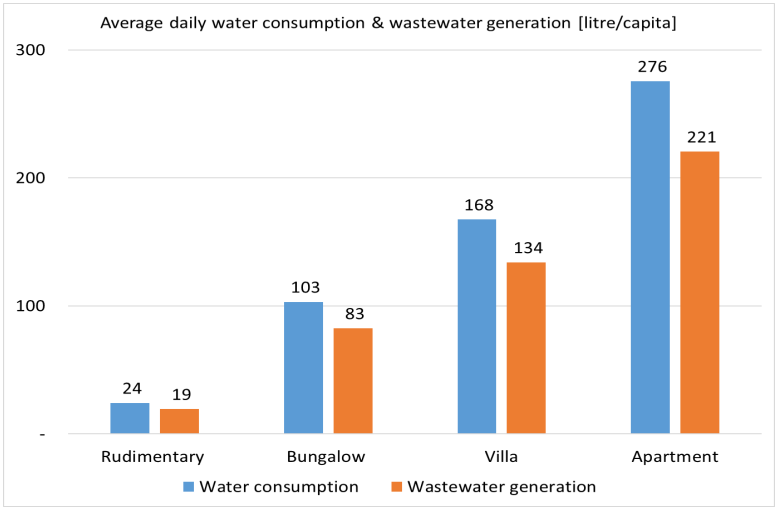
Variations in energy consumption in rudimentary buildings



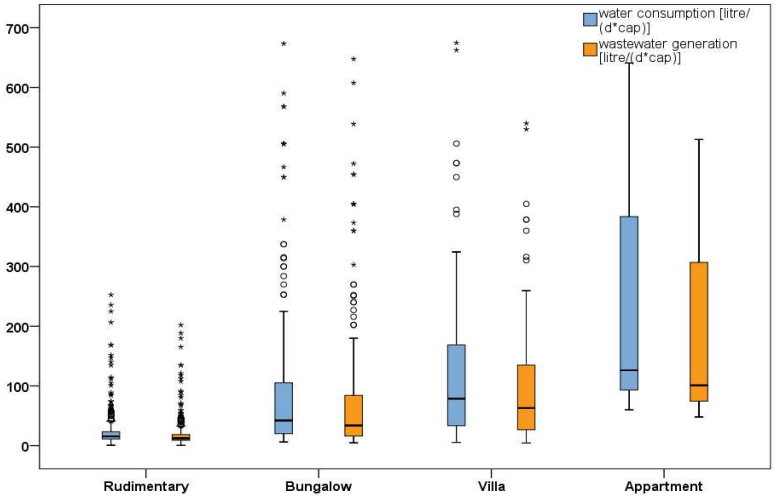
Variations in energy consumption in Bungalows

- Large variations are visible in bungalows, especially between urban and rural households; the rural average in Bungalows is similar to that in the Rudimentary households.
- On an average, Households living in Rudimentary buildings have lower energy consumption (between 50 to 1300 kWh per annum & capita)
- Energy consumption is heavily influenced by building types and location of the household
- Due to high variations in consumption across building types and location, we propose to use Median values instead of average (mean) values for consumption patterns as the median is less affected by outliers and skewed data

WATER CONSUMPTION & WASTEWATER GENERATION



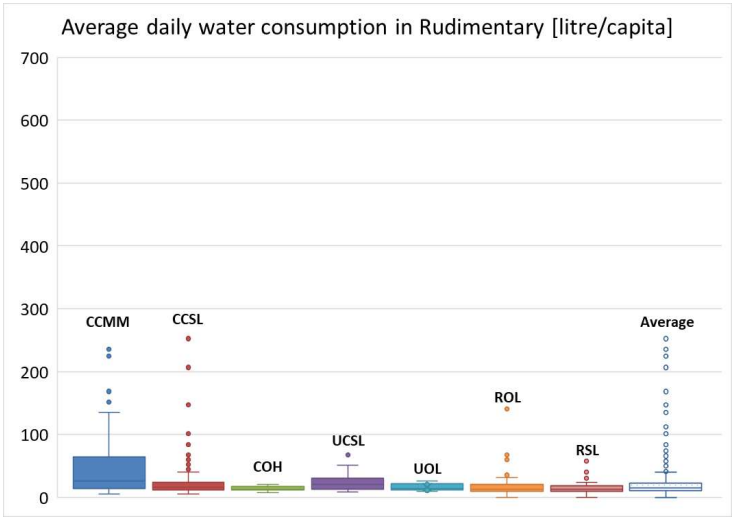
Water consumption by building type



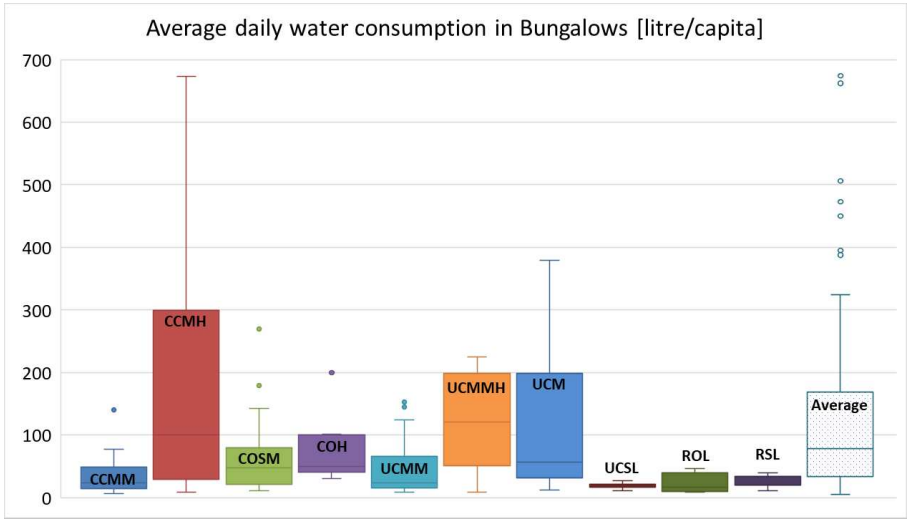
Variations in water consumption by building type

- Highest water consumption & wastewater generation per capita is observed in apartments
- Water consumption in rudimentary building types is exceptionally low as many households do not have water connection in their dwelling
- Additionally, in most rural parts of Kigali, only one (public) water pump/tap is available

WATER CONSUMPTION IN RUDIMENTARY BUILDINGS AND BUNGALOWS



Variations in water consumption in rudimentary building

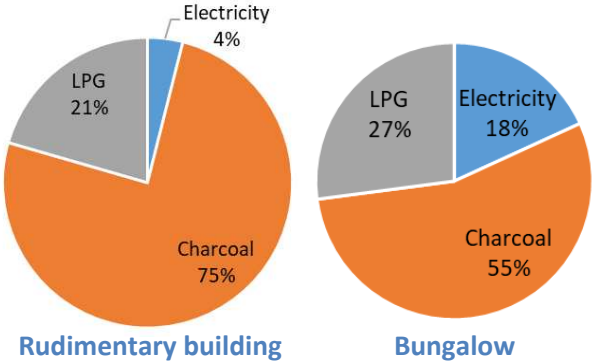


Variations in water consumption in Bungalows

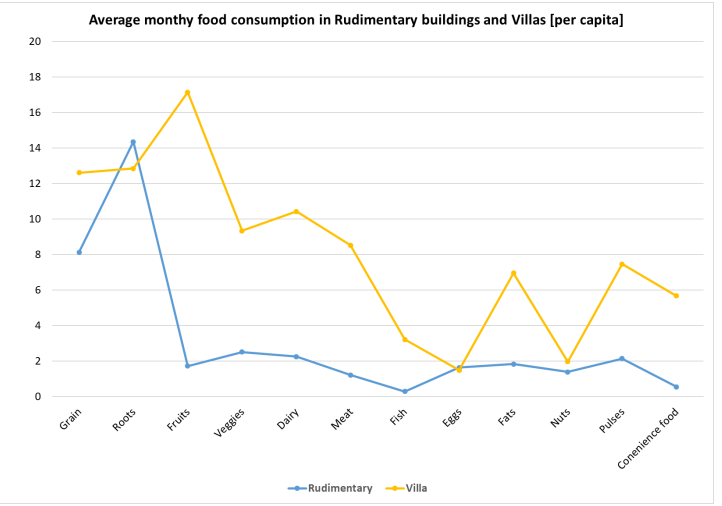
- Large variations are observed in bungalows (and Villas), where are very few variations are seen in Rudimentary households
- Households living in Rudimentary buildings have the lowest water consumption per day & capita, as many informal settlements lack proper infrastructure
- Daily water consumption is heavily influenced by life style class, building types and location of the household
- Due to high variations in consumption across building types and within each building type, we propose to use Median values instead of average values (mean) for consumption patterns as they are less affected by extremes or outliers compared to mean

ADDITIONAL RESULTS

Share of energy carriers by building type



Food consumption by building type



Waste generation (per capita) by building type

Building type	Waste [kg*cap^{-1}*d^{-1}]	Carton	Glass	Metal	Paper	Plastic	Organic	Other
Rudimentary	0.61	1%	0%	1%	2%	2%	81%	13%
Bungalow	0.41	5%	7%	3%	4%	9%	64%	9%
Villa	0.66	1%	0%	0%	3%	2%	78%	16%
Apartment	0.59	6%	7%	4%	7%	1%	72%	4%

Devices/appliances (par HH) by building type

	Rudimentary	Bungalow	Villa	Apartment
Mobile phone	2.68	4.52	4.61	2.33
Refrigerator	0.12	0.89	1.2	1
LCD TV	0.24	0.76	1.12	0.67
Computer/laptops	0.23	1.25	1.71	2
Car	0.05	1.04	1.24	0.5

For additional data and results, please go through our deliverables, reports and posters

DEALING WITH UNCERTAINTIES!

Some degree of uncertainty is inherent in surveys (Li et al, 2013; Spielman et al, 2014)

- Sampling error:
  - Sampling size: bigger the sample size, lesser the uncertainties, how far should we go?!?!
  - Heterogeneity: 100 % homogeneity does not occur in real world
- Measurement error:
  - poor question wording, faulty assumptions and imperfect scales.
- Coverage error & non-response error:
  - Covering all spatial and demographic patterns
  - Households in some test areas are more approachable than others
- Achieving ideal survey time of 20 minutes?!?!
- Low-income and high-income groups have a higher Gini coefficient and a higher variance in income, which results in high variance in consumption patterns

Goal: Achieving quality results quickly while dealing with the aforementioned uncertainties!!

LESSONS LEARNT: KIGALI

- City and municipal officials play a vital role in introducing the project to the city, district and local staff, and getting an **approval** to conduct the survey in chosen test areas.
- A **compact** questionnaire covering all infrastructure sectors should be compiled, i.e. maximum **interview duration** should **not exceed 30 minutes**
- The local staff/field assistants **must be trained** by the international consultants. The training does not only include getting familiar with the App and the tablet, but also **understanding the questions** and **expected outcome**.
- The questionnaire must then piloted with the local assistants observing their initial responses and making appropriate changes as the survey progresses.
- Simultaneously, the **head of each district/cell/ward** should be **informed beforehand** to avoid encountering any possible trouble while conducting the survey in the community.
- Throughout the survey, at least two international consultants must accompany the field assistants. It is advised to attend the interview sessions at random to ensure that the survey was conducted efficiently and effectively.
- Analysed data must be checked for **any uncertainties** or **unreliable data.**
- Additionally, data must be cross-checked with available data (e.g. literature, census, community survey, etc.) and verified using **Top down** and **bottom up approach**

MFA AS BASIS FOR URBAN PLANNING & RESOURCE MANAGEMENT

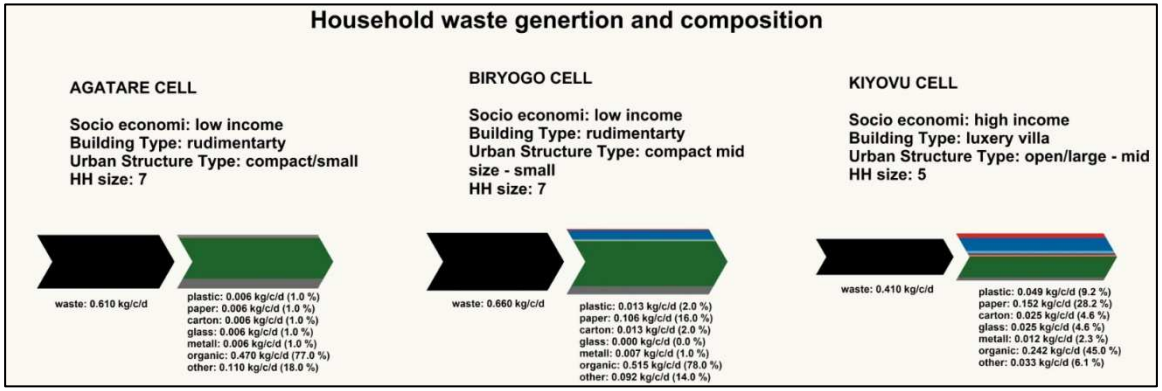
MFA FOR SUPPLY AND DISPOSAL SECTORS

RESEARCH QUESTION

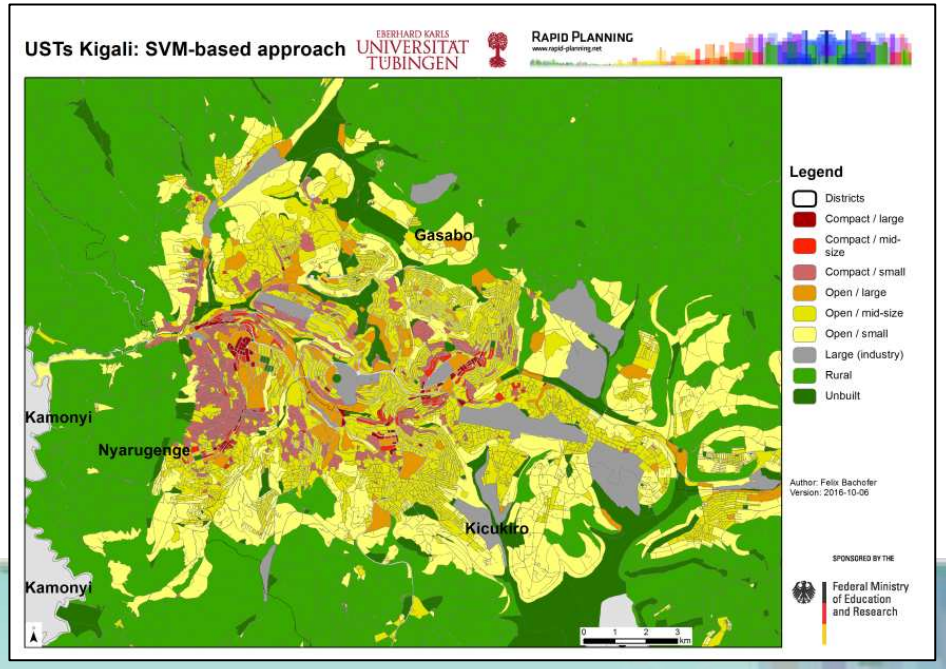
CAN THE RAPID DATA GATHERING APPROACH GENERATE CORRECT DATA OF THE SUPPLY AND DISPOSAL SECTORS OF A CITY ?

… AND THEREFORE WORK RELIABLY IN ANY CITY REGARDLESS OF THE AVAILABILITY OF LOCAL DATA?

MFA FOR SUPPLY AND DISPOSAL SECTORS



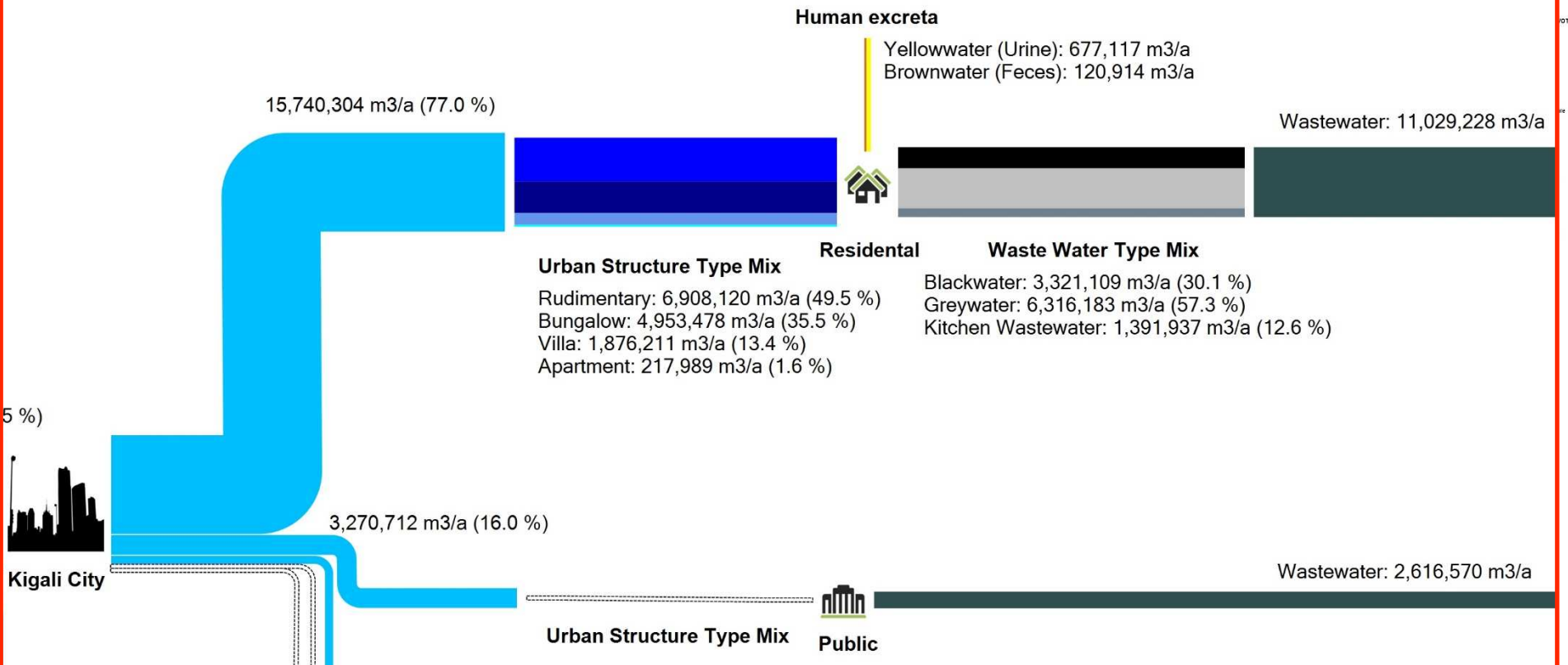
Bottom up data



RAPID PLANNING METHODOLOGY

END WATER BY CONSUMER

WASTE WATER BY CONSUMER



MFA FOR SUPPLY AND DISPOSAL SECTORS

- CROSS CHECK SHARPENS THE BOTTOM UP DATA GATHERING METHOD
- VISUAL TOOL TO EXCHANGE WITH LOCAL PARTNERS (DATA GAPS ETC.)
- MFA IN PRACTICE – FROM CITY PERSPECTIVE:

  STATUS QUO SUPPORTS LOCAL PARTNERS IN PLANNING , E.G.

  (SOLID WASTE COLLECTION LOGISTIC: ROUTING, HUMAN RESOURCE, TRUCK CAPACITY, DIMENSIONING TRANSIT/RECYCLING/DISPOSAL SITES)

COPED GROUP

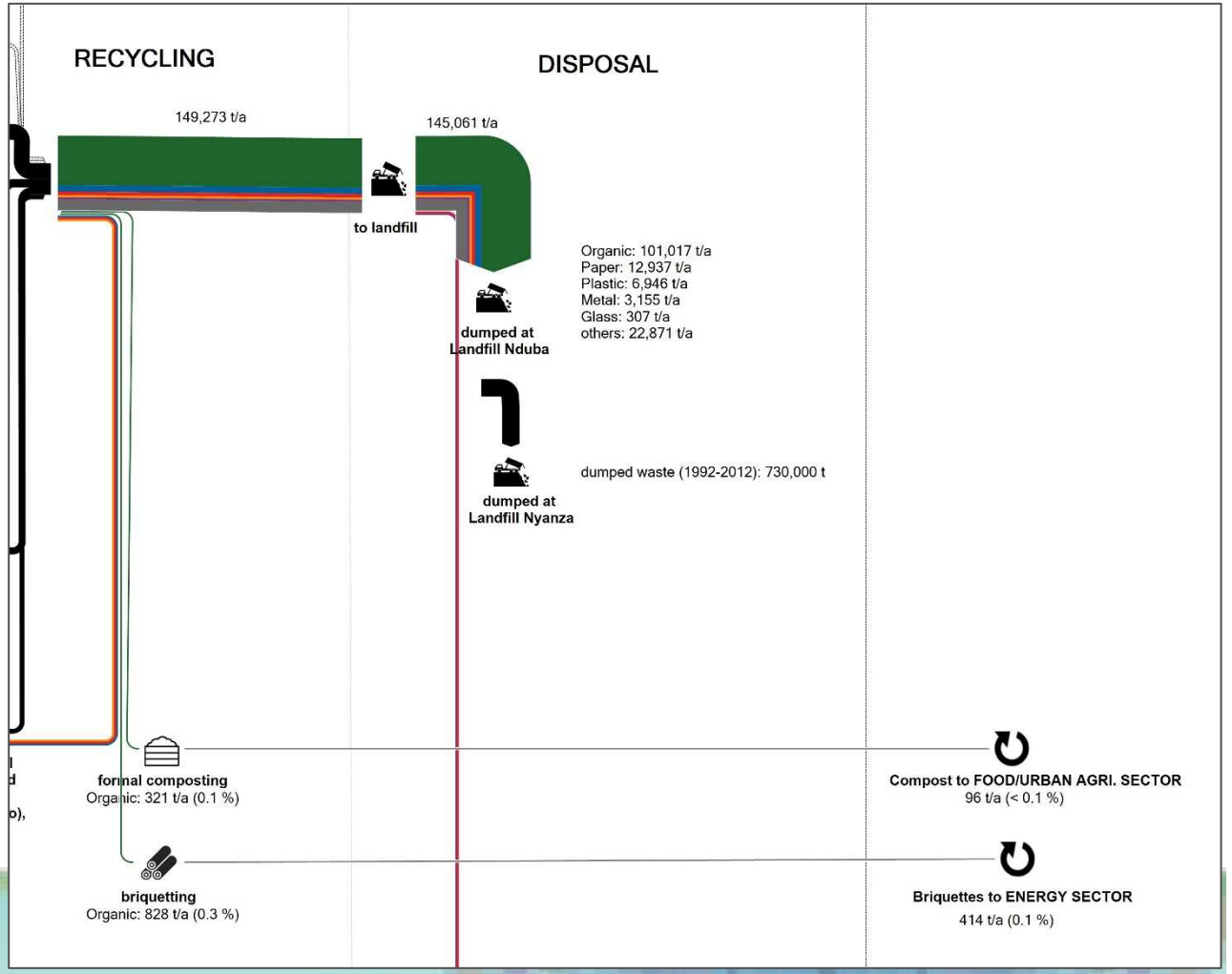
SECTOR SPECIFIC RESOURCES AND POTENTIAL SYNERGIES

RESEARCH QUESTION

CAN RAPID PLANNING APPROACH IDENTIFY TRANS-SECTORAL SYNERGIES BETWEEN THE SUPPLY AND DISPOSAL SECTORS AND THEREBY SUPPORT SUSTAINABLE INFRASTRUCTURE PLANNING?

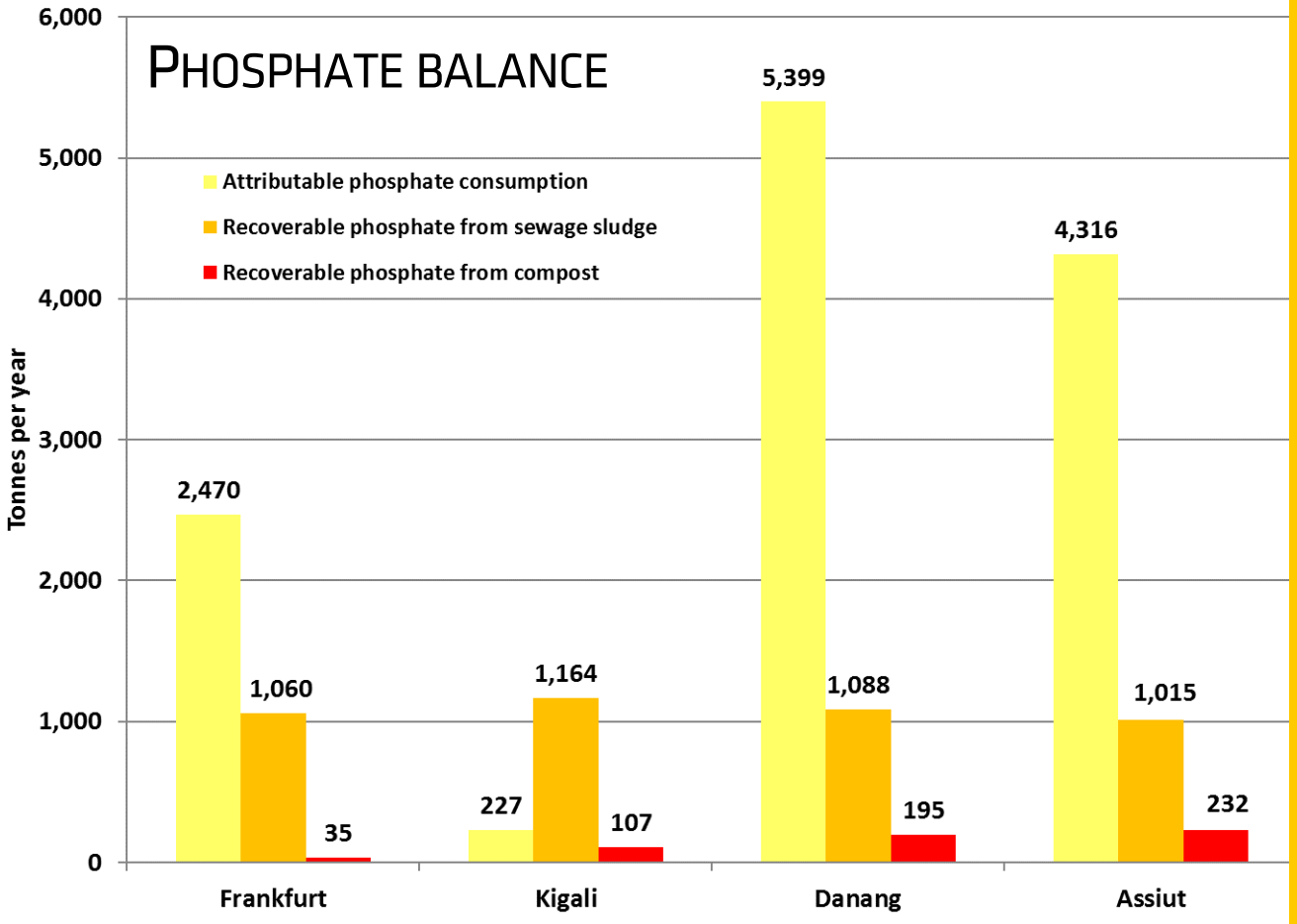
SECTOR SPECIFIC RESOURCES AND POTENTIAL SYNERGIES

ZOOM-IN THE MFA



SECTOR SPECIFIC RESOURCES AND POTENTIAL SYNERGIES

WASTE WATER / SOLID WASTE ←→ FOOD SECTOR



- Per-capita phosphate use in agriculture of Vietnam and Egypt larger than in Germany.
- More phosphate in Kigali's sewage than amount used in agriculture to feed Kigali's population.
- P in compost is of minor importance.

SECTOR SPECIFIC RESOURCES AND POTENTIAL SYNERGIES

TRANS-SECTORAL SYNERGIES: THE MFA PERSPECTIVE

Action area / Impact on	Energy	Water	Waste water	Solid waste	Food & Agriculture
Energy		**Very low** - electricity for pumping	**Low** - sludge incineration - biogas	**Medium** - biochar - MSW incineration	**Low** - energy in agriculture
Water	**Low** - local hydro power - cooling water needs		**Medium** - grey water reuse - groundwater protection - stormwater management	**Medium** - groundwater protection	**Medium** - irrigation demand - groundwater protection
Waste water	**Low** - sludge co-firing - power plant operations	**High** - more water -> more waste water		**Medium** - combined treatment of MSW and sewage sludge	**Low** - managing runoff water quality
Solid waste	**Low** - combustion residues	**Very low** - treatment residues	**Medium** - co-composting		**Medium** - waste reduction - organic waste composting
Food & Agriculture	**Low** - land use competition	**High** - sewage sludge utilization	**High** - ensuring water quality for food production	**High** - organic waste composting	

ANALYSES OF CLIMATE RELEVANT ASPECTS AND IMPACT ON URBAN QUALITY

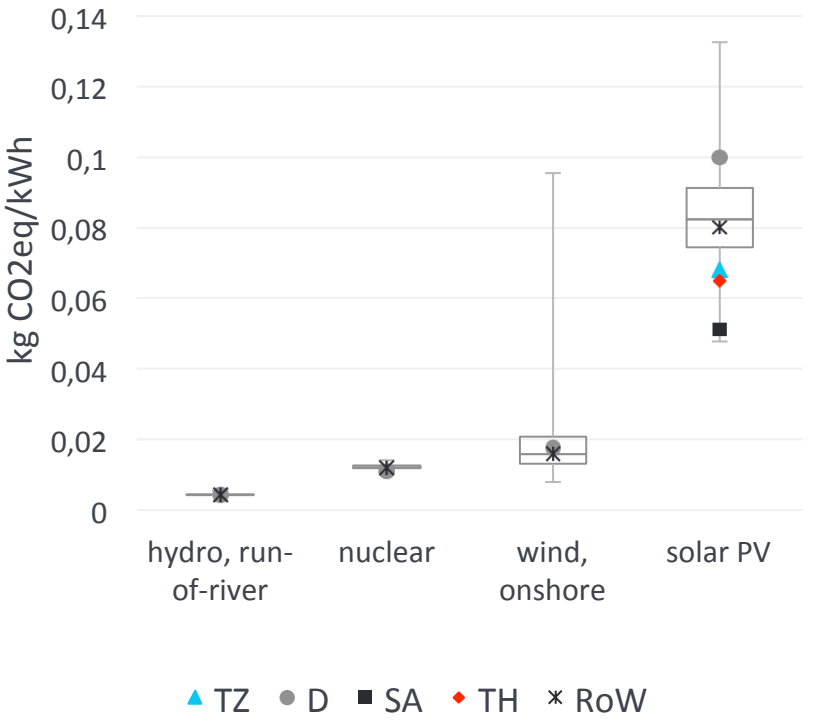
RESEARCH QUESTION

CAN A LIFE CYCLE IMPACT ASSESSMENT (LCIA) OF LOCAL USED TECHNIQUES IDENTIFY THE MAJOR ENVIRONMENTAL IMPACTS AT CITY AND GLOBAL LEVEL AND THEREBY SUPPORT THE SELECTION OF TECHNIQUES?

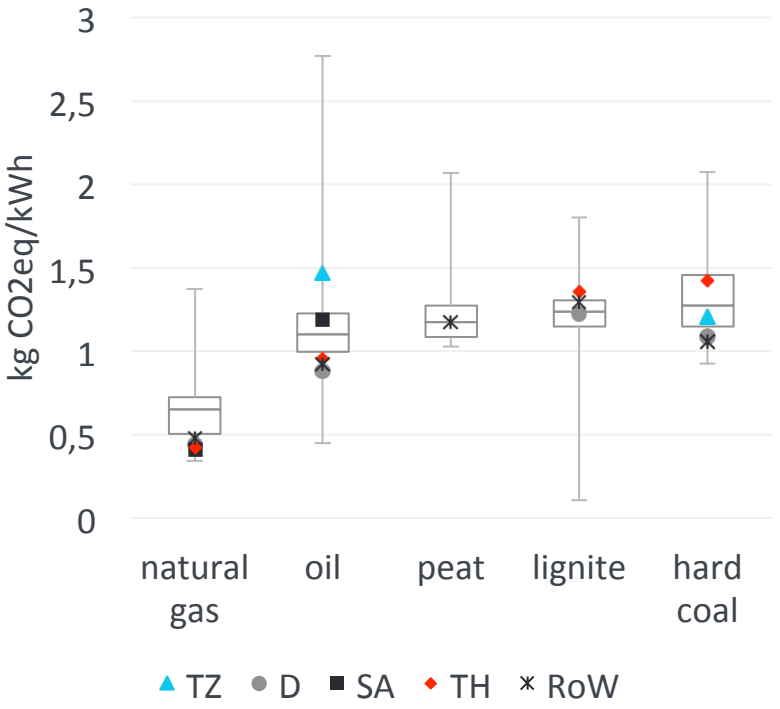
ANALYSES OF CLIMATE RELEVANT ASPECTS

The global energy system is the single largest contributor to climate change (IPCC, WRI)
→ Electricity generation: Life-Cycle GHG Emissions of several technologies

Renewables/Nuclear



Conventional

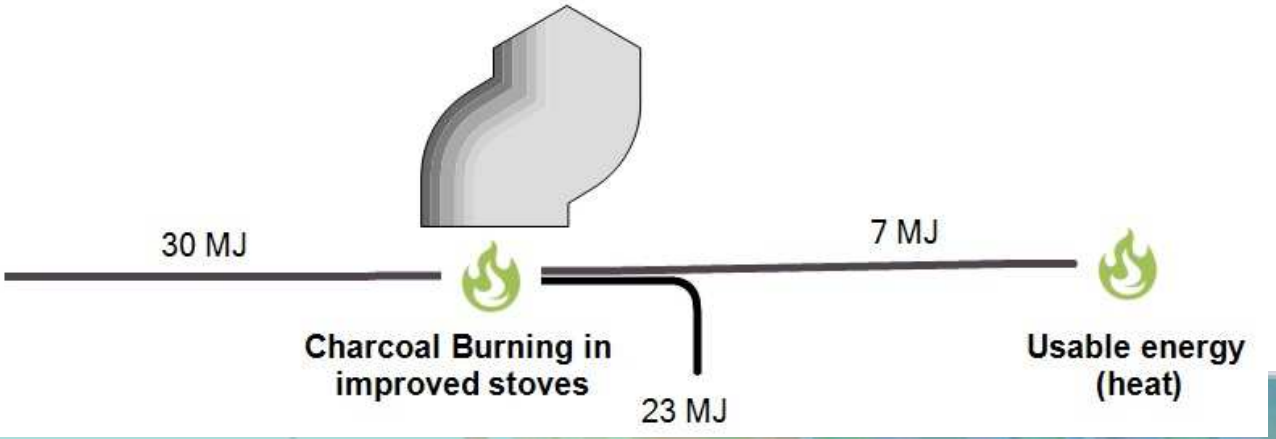


→ expansion of renewable energies show high GHG mitigation potential (**Paris Agreement**)

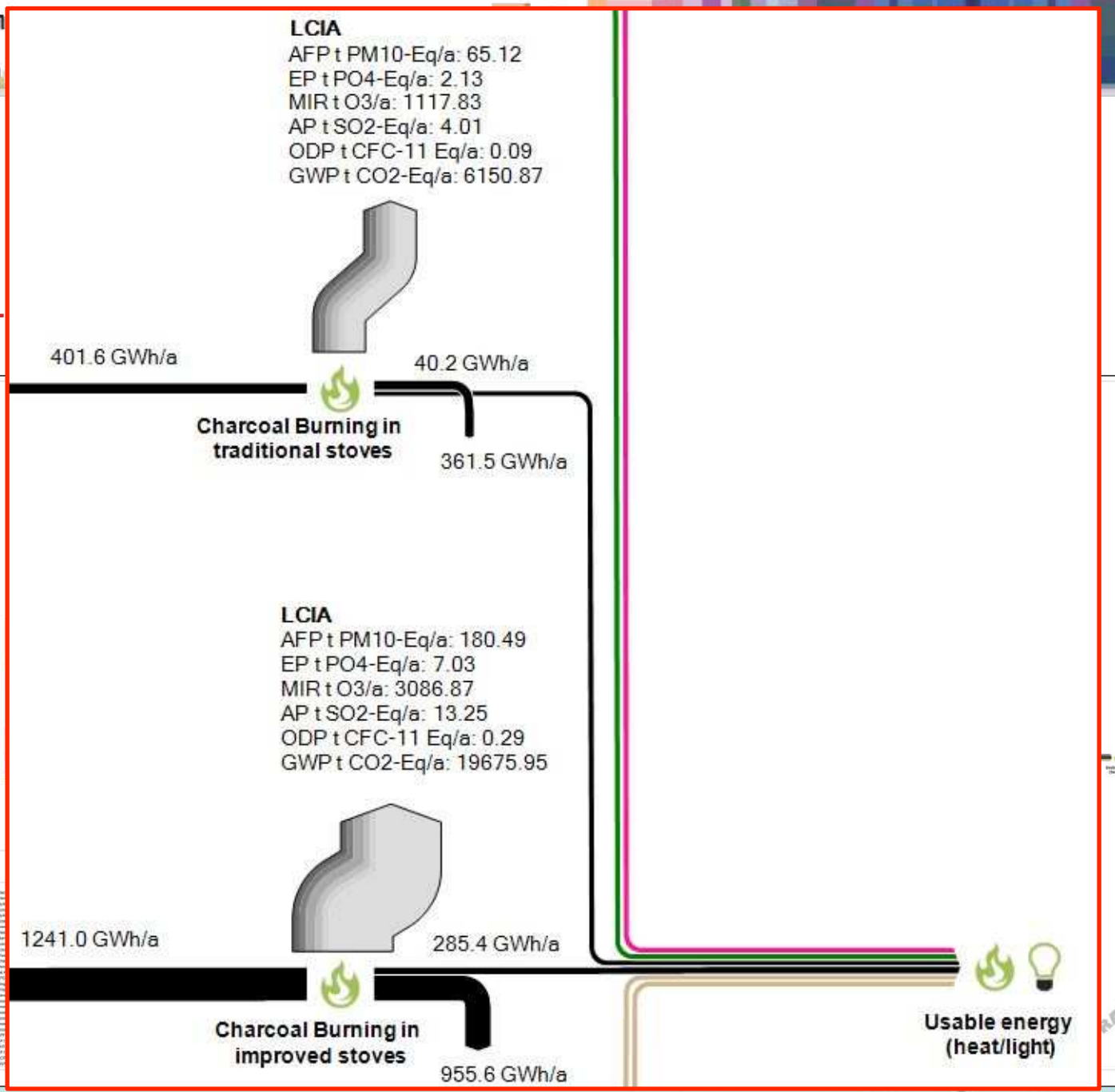
ANALYSES OF IMPACT ON URBAN QUALITY

LCIA OF LOCAL TECHNIQUES

LCIA
AFP kg PM10-Eq/kg input: 0.0018118
EP kg PO4-Eq/kg input: 0.0000706
MIR kg O3/kg input: 0.0309864
AP kg SO2-Eq/kg input: 0.0001330
ODP kg CFC-11 Eq/kg input: 0.0000029
GWP kg CO2-Eq/kg input: 0.1975100

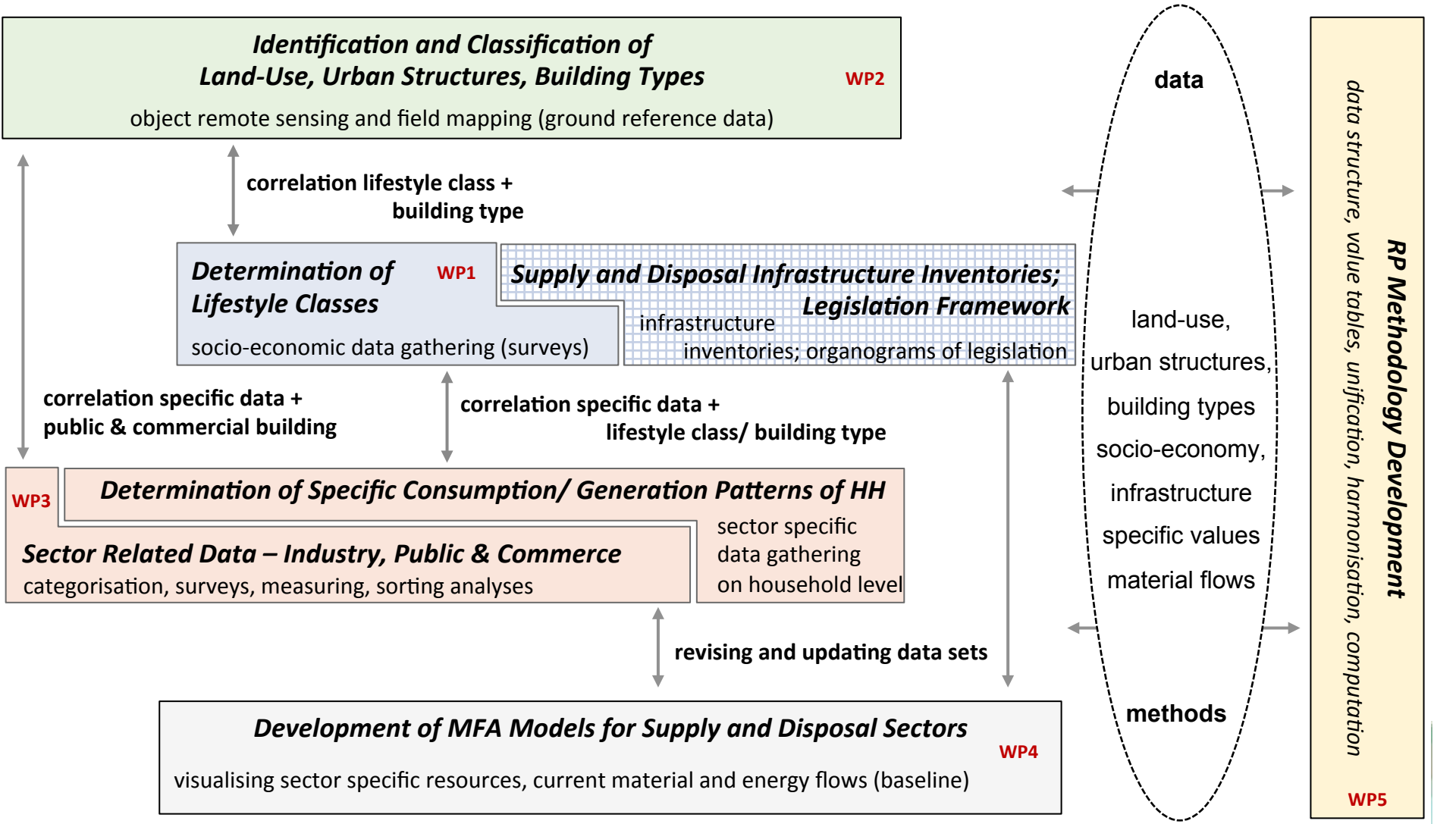


LCIA +


LCIA
AFP t PM10-Eq/a: 65.12
EP t PO4-Eq/a: 2.13
MIR t O3/a: 1117.83
AP t SO2-Eq/a: 4.01
ODP t CFC-11 Eq/a: 0.09
GWP t CO2-Eq/a: 6150.87
401.6 GWh/a
40.2 GWh/a
Charcoal Burning in traditional stoves
361.5 GWh/a
LCIA
AFP t PM10-Eq/a: 180.49
EP t PO4-Eq/a: 7.03
MIR t O3/a: 3086.87
AP t SO2-Eq/a: 13.25
ODP t CFC-11 Eq/a: 0.29
GWP t CO2-Eq/a: 19675.95
1241.0 GWh/a
285.4 GWh/a
Charcoal Burning in improved stoves
955.6 GWh/a
Usable energy (heat/light)

CONCLUSIONS

DATA GENERATION PROCESS OVERVIEW



Thank you

Asante sana

Cảm ơn

Danke

Murakoze

شكرا

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