Karlsruhe Institute of Technology

Sustainability assessment of urban water infrastructure systems with special focus on the urban water-energy nexus

Case study Chillán, Southern Central Chile

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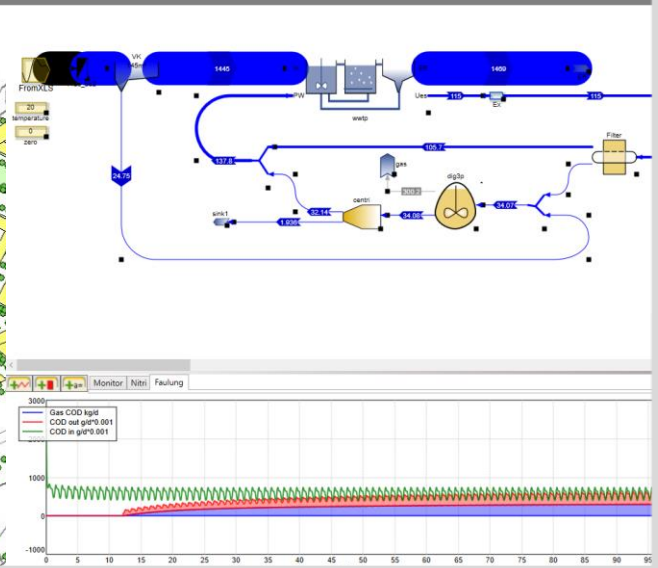
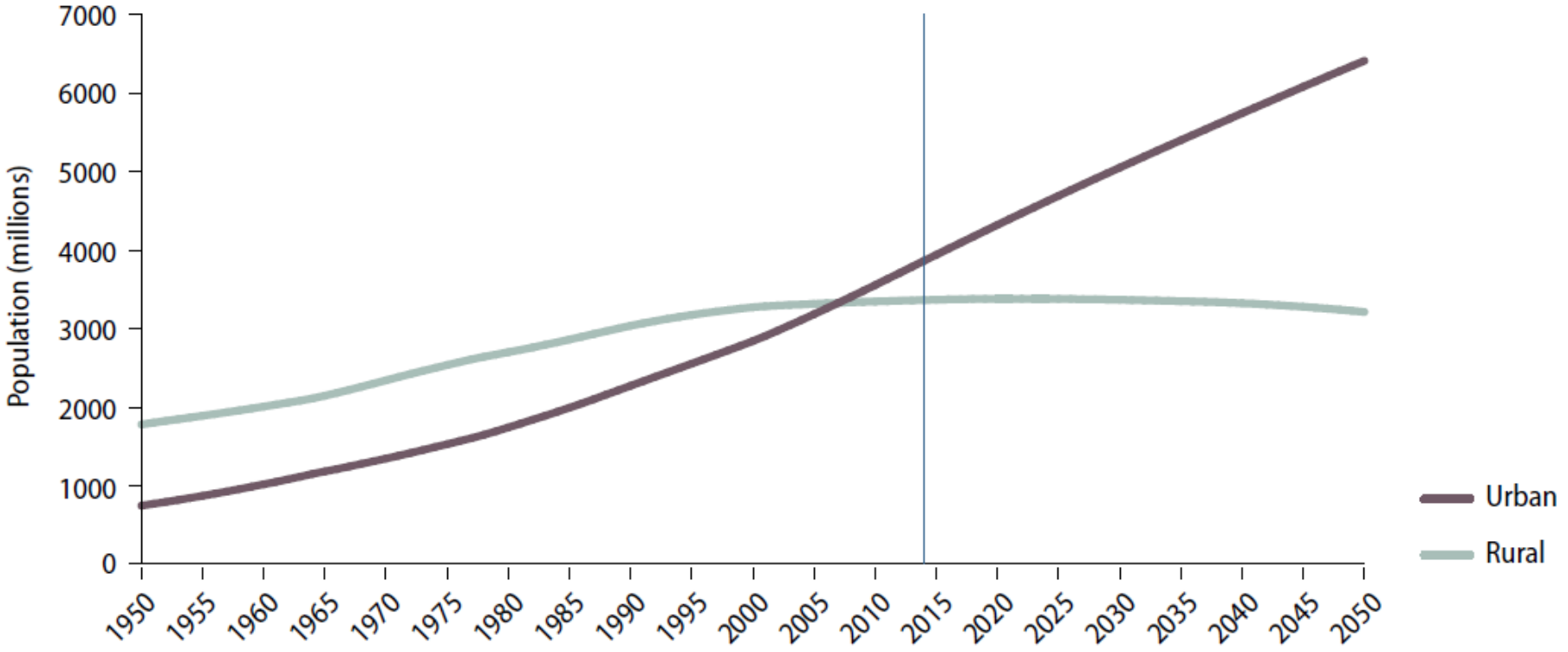
REALCORP Conference Vienna



Challenges – population growth & urbanisation

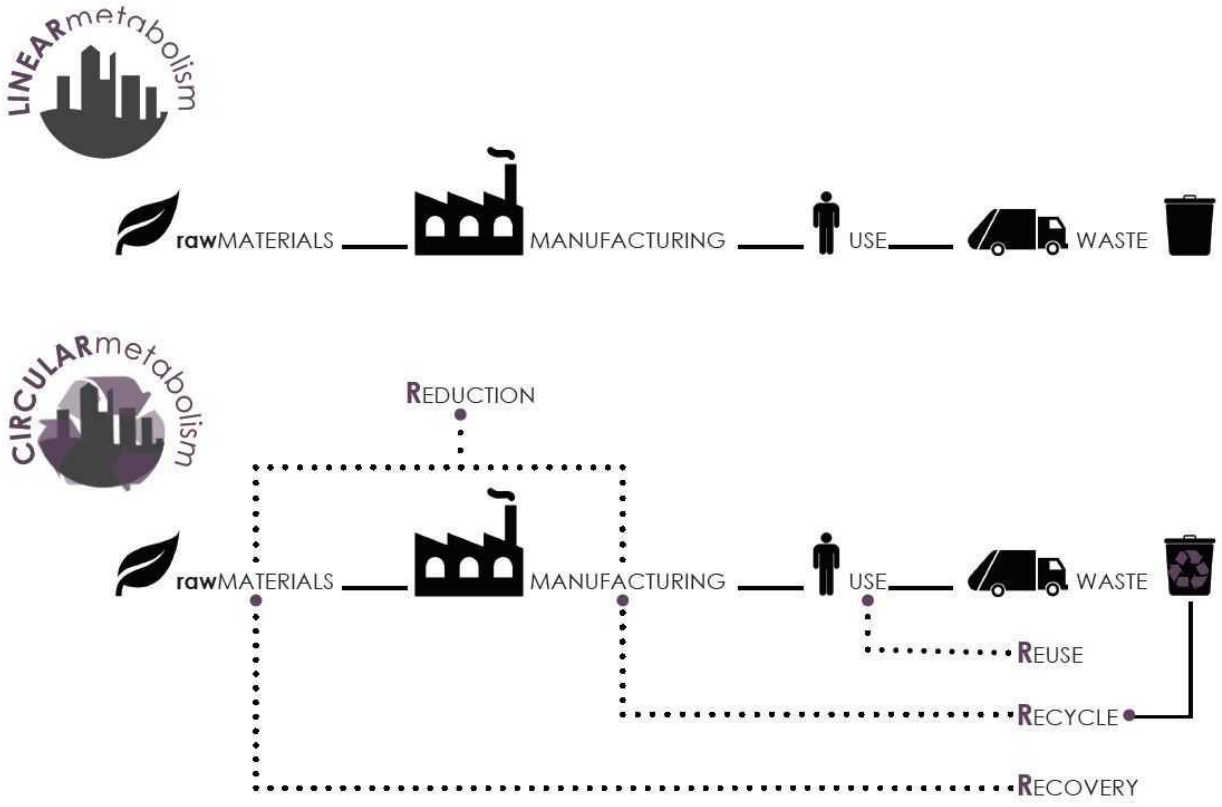


United Nations 2014

→ Infrastructures have to cope with those challenges

Challenges – limited resources

- High population concentration in cities
- Climate change



SWAT studio 2015

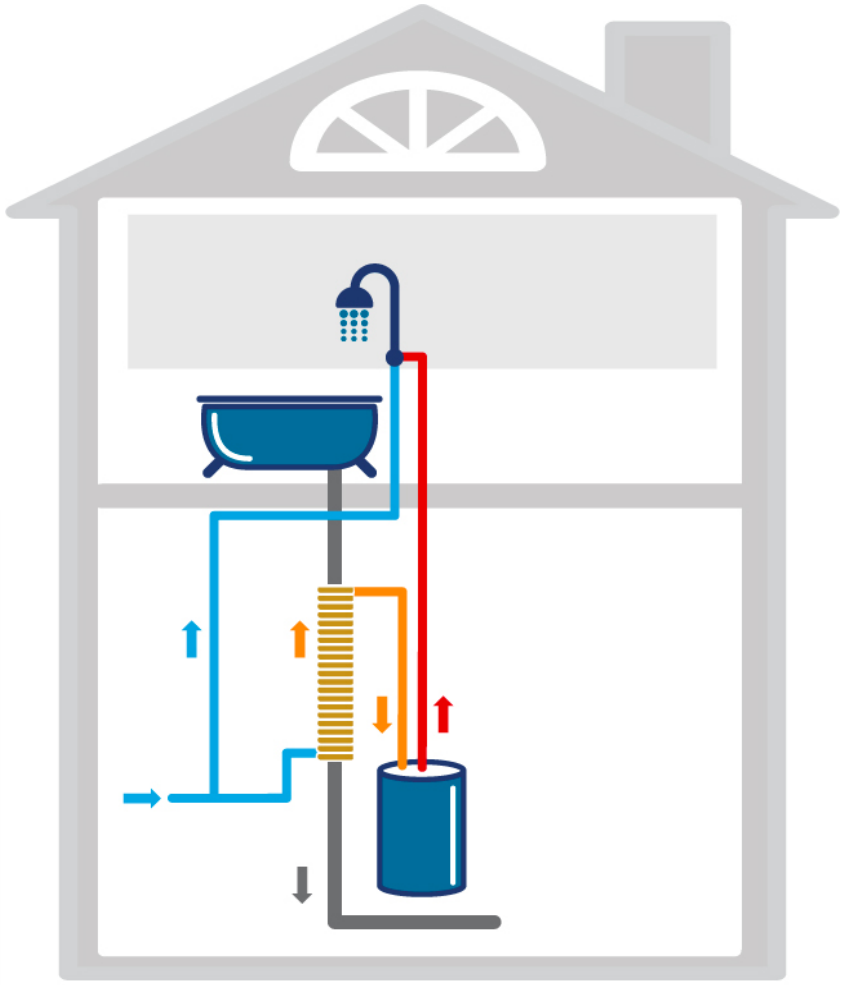
Urban water-energy nexus – challenge and opportunity

In US 50% of water withdrawals used for cooling of thermoelectrics
(Halstead et al. 2014)

Water related energy use in the US accounts for 13% of nation's electricity consumption
(Griffiths-Sattenspiel et al. 2009)

But: Waste water has high energy content!

Innovative water system components – greywater (1)



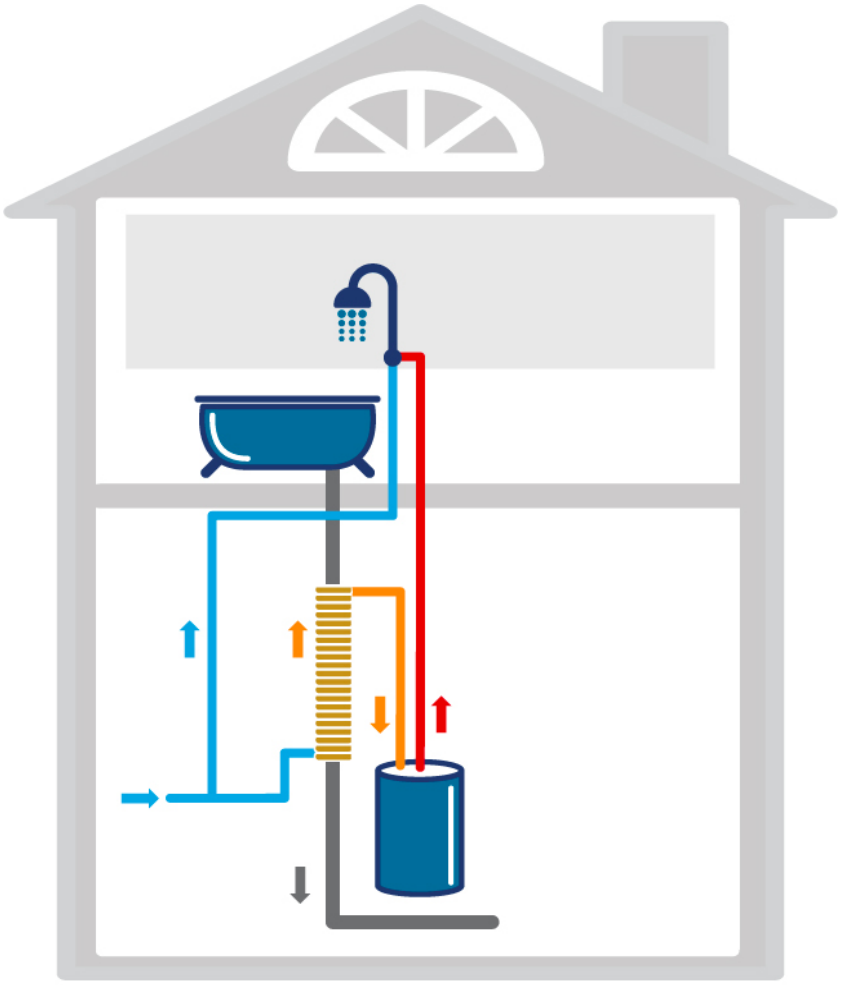
Cold water

Hot water

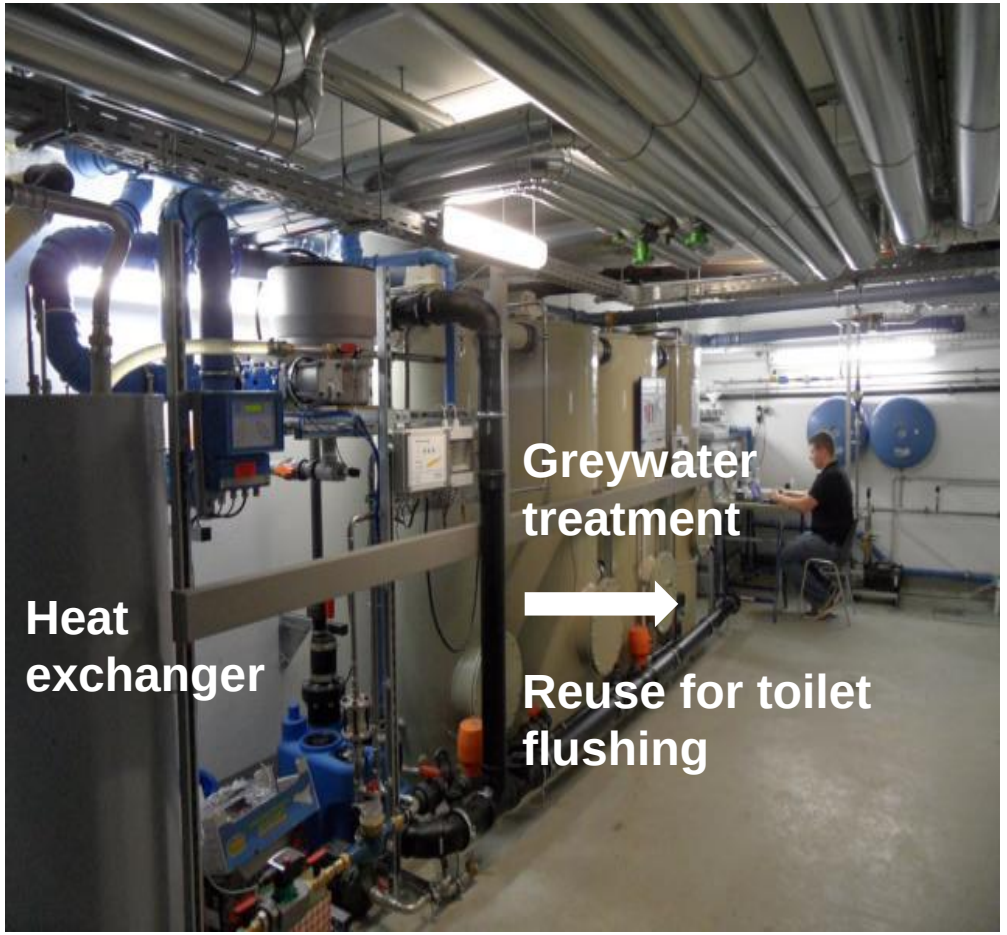
Pre-warmed water

Treated greywater for reuse

Innovative water system components – greywater (2)



Installed in Passive House in Berlin for ca. 120 tenants



Innovative water system components - blackwater

- Installed in Lübeck Flintenbreite, Germany (ca. 500 inhabitants)

Research objectives

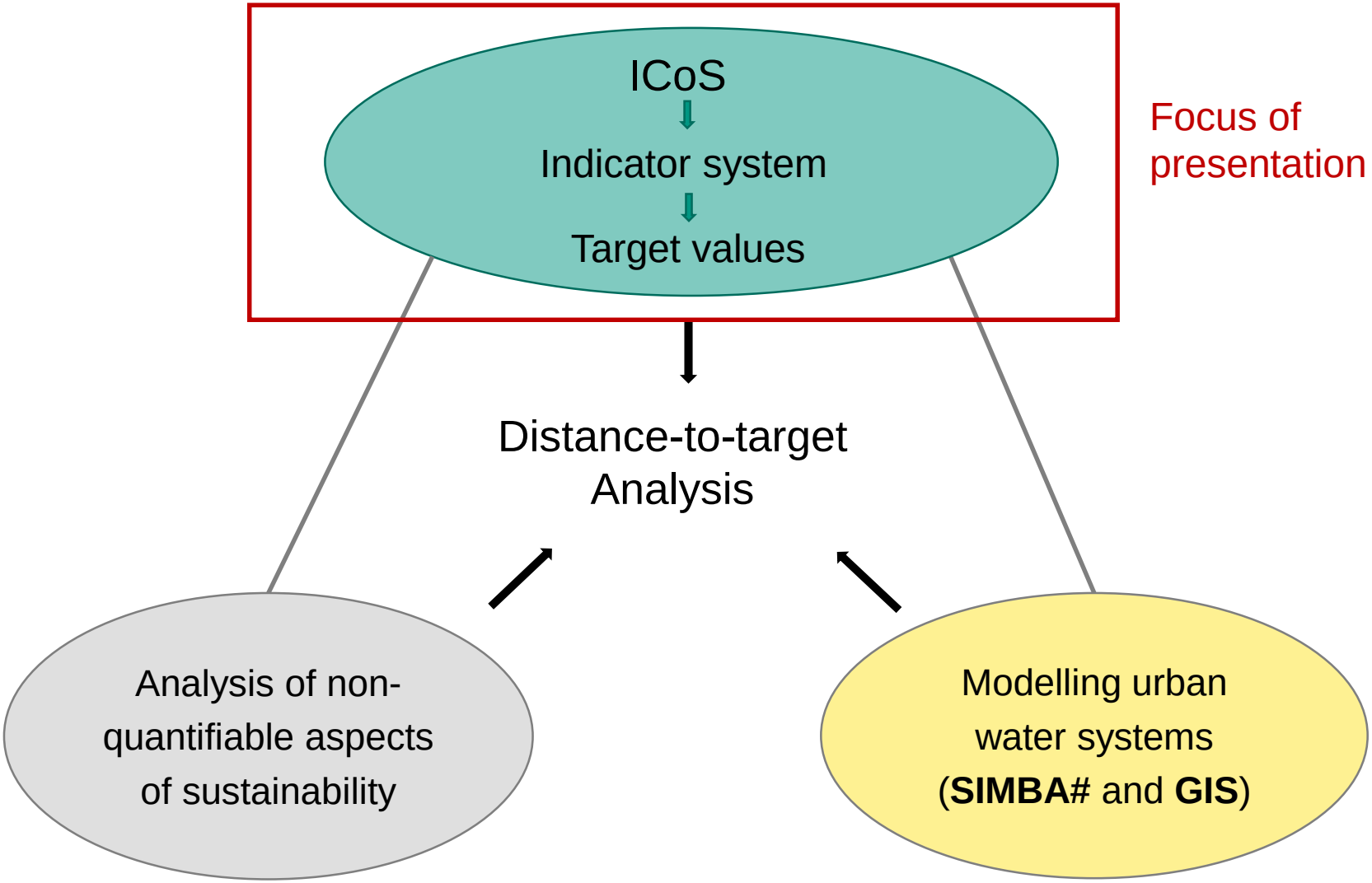
- Develop methodology for sustainability assessment of urban water systems
- Comparison of conventional centralized water system and innovative water infrastructure systems
- Provide basis for decision support

- Case study: city district in Chillán, Southern Central Chile

Typical new-built Chilean Neighbourhood

Methodological approach

Integrative Concept of Sustainable Development (ICoS)

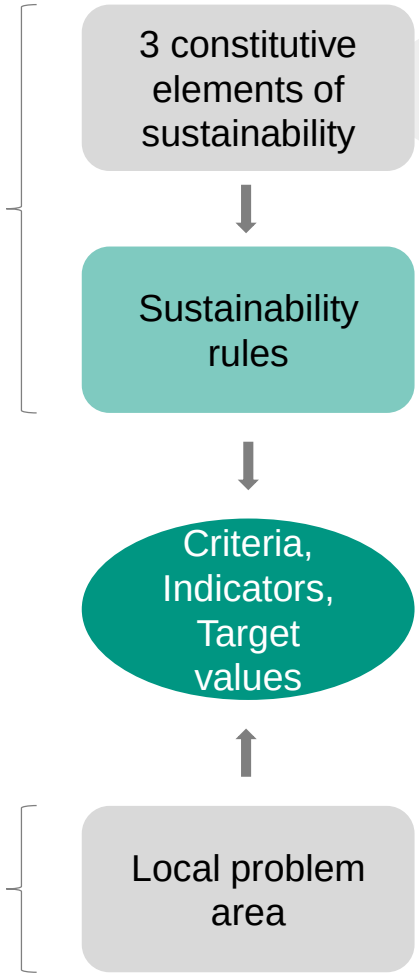


Integrative Concept of Sustainable development (ICoS) – contextualization developing indicators

Top-down approach

(scientific perspective, normative)

- Systematic compilation of sustainability deficits
- Including phenomena that are not perceived as problem within society



Bottom-up approach

(problem-oriented, stakeholder perspective)

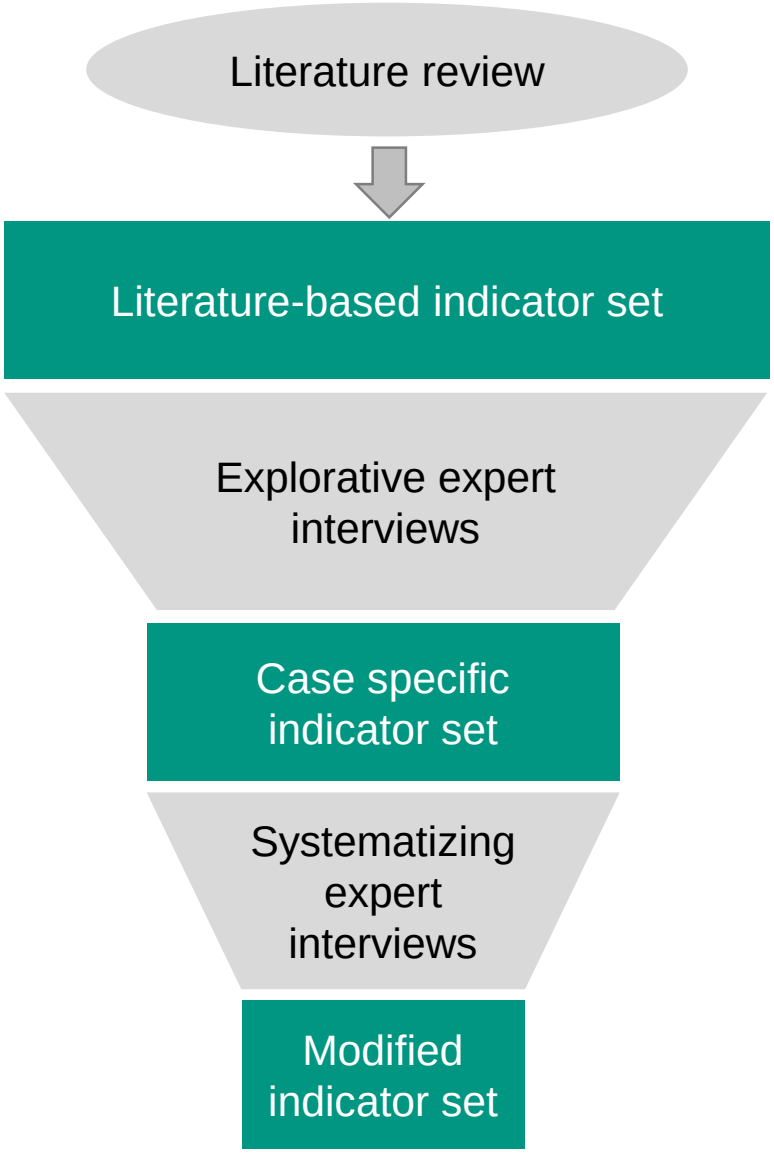
- Focusing on central problems
- Societal perception of sustainability deficits

(Kopfmüller et al. 2001)

The integrative concept of sustainable development (ICoS) – principles defining minimum requirements

General sustainability goals		
Securing human existence	**Maintaining society's productive potential**	**Preserving society's options for development and action**
Substantial rules		
1.1 Protection of human health	2.1 Sustainable use of renewable resources	3.1 Equal access of all people to information education and occupation
1.2 Ensuring satisfaction of basic needs	2.2 Sustainable use of non-renewable resources	3.2 Participation in societal decision-making processes
1.3 Autonomous subsistence based on income from own work	2.3 Sustainable use of the environment as a sink for waste and emissions	3.3 Conservation of cultural heritage and cultural diversity
1.4 Just distribution of chances for using natural resources	2.4 Avoiding technical risks with potentially catastrophic impacts	3.4 Conservation of the cultural function of nature
1.5 Reduction of extreme income or wealth inequalities	2.5 Sustainable development of man-made, human and knowledge capital	3.5 Conservation of social resources (e.g. tolerance or solidarity)

Development of sustainability indicators for Chillán



Aim: Prospective assessment (before implementation)

Application in Latin America

Example from resulting indicator set (1)

Topic	Indicator	Rele-vance	Appli-cability
Protection of human health	Fecal coliforms [MPN/100 ml] in the receiving water bodies upstream and downstream of the discharge points of the corresponding treatment plants	High	Medium
Protection of human health	Fecal coliforms [MPN/100 ml] in effluents of the specific treatment plants	High	High
Protection of human health	Fecal coliforms [MPN/100ml] in shallow aquifers possibly influenced by wastewater influence (sewage leakage or infiltration of polluted water)	High	Medium
Protection of human health	Average temperature difference between urban zone and rural environment in summer months (day and night temperatures) [°C]	Low	Medium

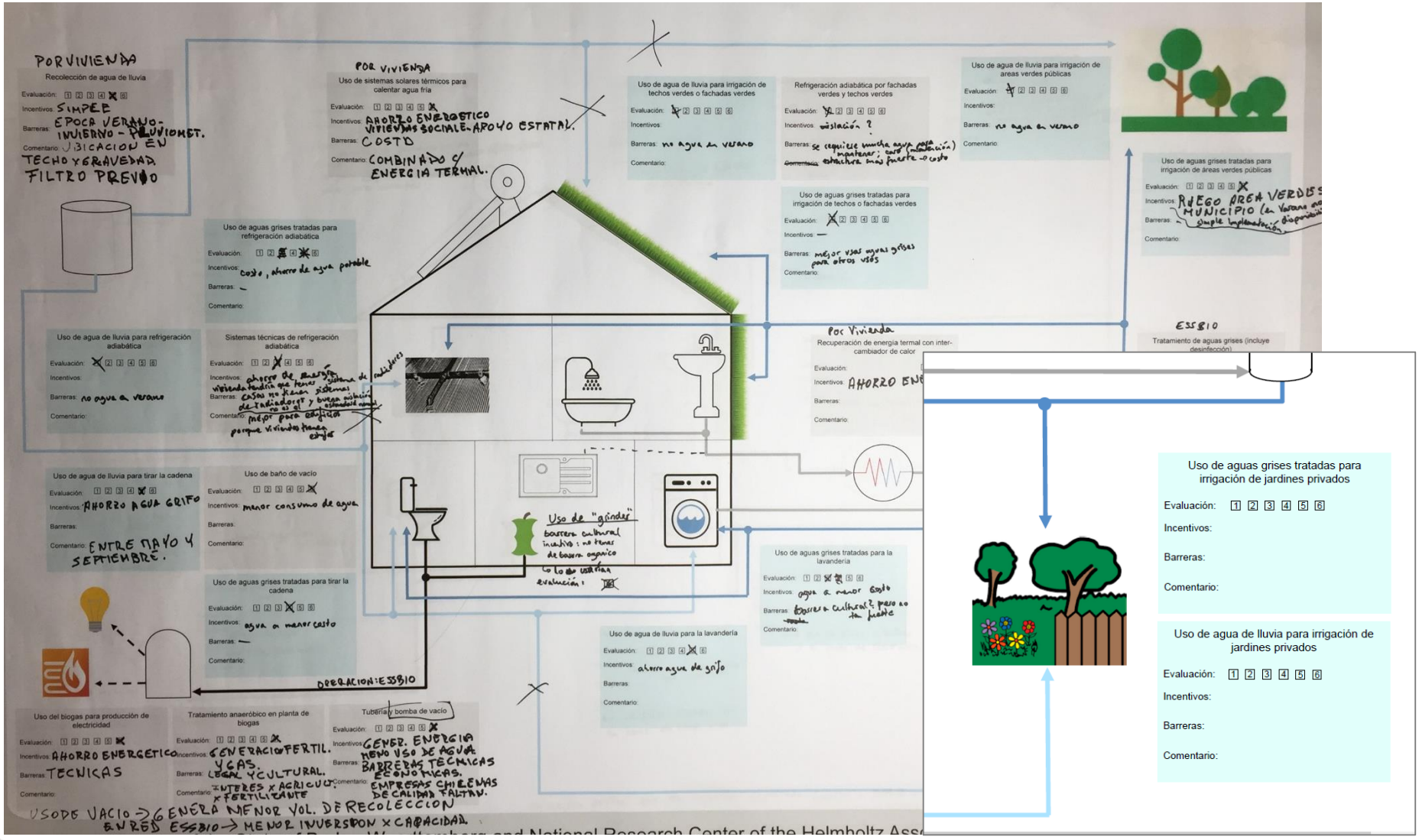
Example from resulting indicator set (2)

Topic	Indicator	Rele-vance	Appli-cability
Sustainable use of renewable resources	Ratio of total water demand to renewable water resources in the sub-basin of the river Chillán	High	Medium
Sustainable use of renewable resources	Ratio of water extracted from river Chillán to flows in river Chillán	High	Medium
Sustainable use of non-renewable resources	Energy demand of the operation of the urban water system based on non-renewable resources per supplied inhabitant	High	High
Sustainable use of non-renewable resources	Possible coverage of nutrient demand in sub-basin of the river Chillán by use of wastewater residues as fertilizer (%)	Medium	Medium

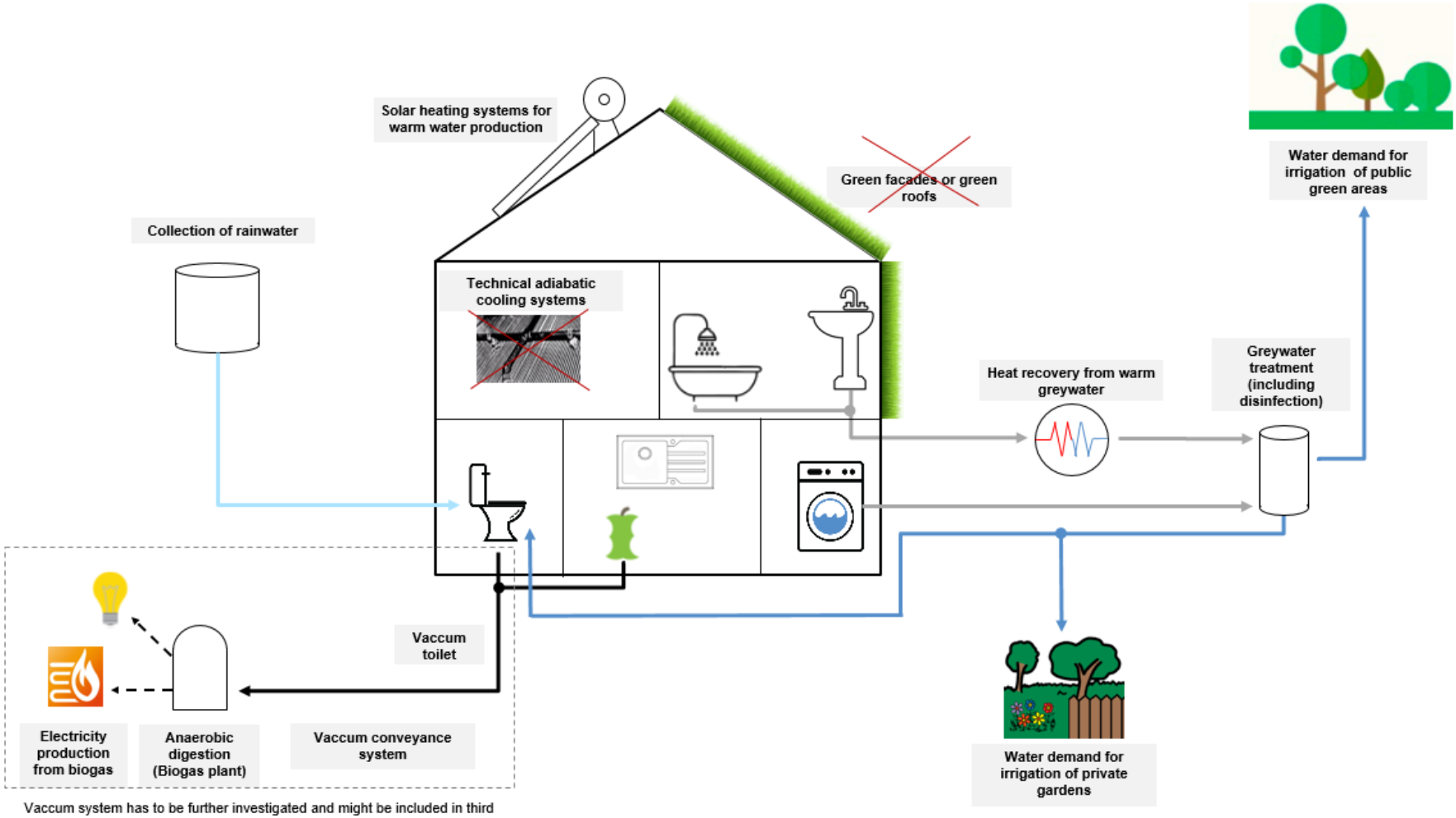
Example from resulting indicator set (3)

Topic	Indicator	Rele-vance	Appli-cability
Conservation of the cultural function of nature	Fecal coliforms [MPN/100 ml] in the receiving water bodies used for bathing upstream and downstream of the discharge points of the corresponding treatment plants	High	Medium
Conservation of the cultural function of nature	Days of the year during which the flow in the river Chillán is below the environmental flow	High	Low

Expert interviews for technology choice using visualization of flows for evaluation of components



Technology choice - Resulting system design



Vaccum system has to be further investigated and might be included in third system/comparison case

Thank you for your attention!

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