

Lecture 1 - ENV 402 Sanitary Engineering for Development

**Dr Jess MacArthur
Eawag-Sandec**



Water collection at a tapped spring in Ethiopia

Source: MacArthur 2024

Early Birds

washdata.org



Today's Objectives

- Understand the expectations of the course, deliverables required and how to access material
- Explain the relevance of WASH in different contexts such as humanitarian settings, dense urban areas, climate change and low-income countries
- Describe the importance of the SDGs, and how WASH impacts the different SDGs.



Today's Topics

Part 0	Background	15 minutes
Part I	Setting the Scene	20 minutes
Part II	WASH & Public Health	20 minutes
<i>Stretch</i>		5 minutes
Part III	WASH & the SDGs	20 minutes
Part IV	Semester Group Work	20 minutes

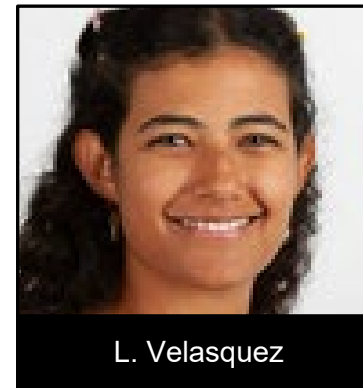
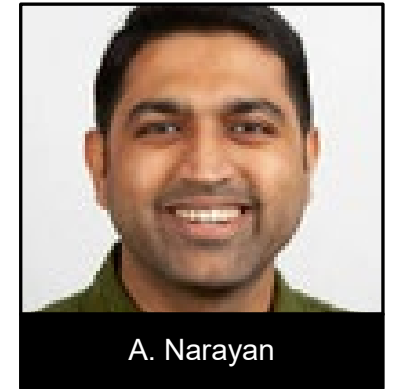
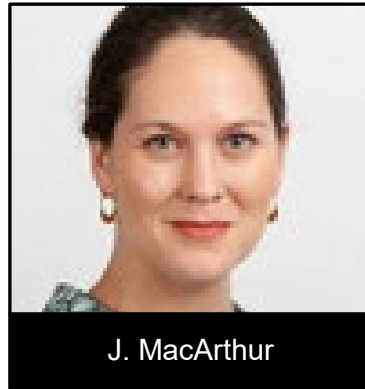
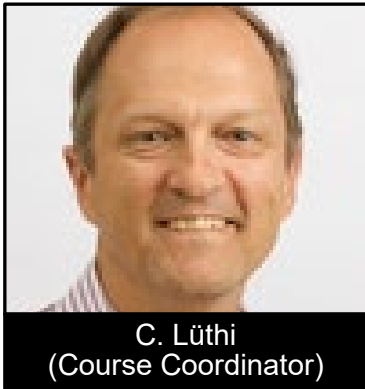
Course Overview

Lectures: Thursdays at 10:15

Group work: ~1 hour/week

No.	Date	Topic	Lecturer
1	11 Sept	Intro to ENV 402, overview, SDGs, public health	J. MacArthur
2	18 Sept	Water treatment and safe storage	L. Fache
3	25 Sept	Water supply from source to consumer	M. Boller
4	2 Oct	Municipal solid waste management	D. Tosi
5	9 Oct	Sanitation systems and technologies Part 1	A. Narayan / P. Reymond
6	16 Oct	Sanitation systems and technologies Part 2	K. Coppens
	23 Oct	Semester break	
7	30 Oct	Guest lecture: Innovations & WASH	Michael Kropac – Co-Director Cewas
	6 Nov	Group work	
8	13 Nov	WaSH in humanitarian settings	K. Gallandat
9	20 Nov	Becoming a WASH and Solid Waste Management Researcher	F. Suter / Velasquez L. / Peguero D.
10	27 Nov	Environmental sanitation planning	A. Narayan
11	4 Dec	Innovative Sanitation Planning in practice	A. Narayan
	11 Dec	Group work Q+A (on-line: 10:15 – 11:00)	C. Lüthi
	18 Dec	Mock exam, career prospects	C. Lüthi
	Winter Break		
	15 Jan	Final written exam	C. Lüthi

Course Lecturers



Course Objectives

Overall: Understand and reflect on key issues of global WASH targets, trends and developments

Water [Lectures: 2,3]	Solid Waste [Lecture: 4]	Sanitation [Lectures: 5,6]	Cross-cutting [Lectures 7-11]	Group work
<ul style="list-style-type: none">• Become familiar with water treatment options and promotion & marketing challenges• Understand key tools and methods for assessing human health aspects of WASH	<ul style="list-style-type: none">• Understand key challenges for planning/implementing basic services in rapidly growing urban areas• Understand the challenges and opportunities in municipal solid waste management	<ul style="list-style-type: none">• Understand the sanitation system chain and be familiar with typical solutions in each functional group• Understand the issues of faecal sludge management and be familiar with treatment solutions	<ul style="list-style-type: none">• Learn about recent innovations in WASH• Explore WASH in humanitarian settings• Reflect on becoming a WASH and solid waste planning researcher• Explore innovative and environmental sanitation planning	<ul style="list-style-type: none">• Apply course knowledge: Analyze a case study assignment and provide realistic solutions for drinking water, sanitation and solid waste management

Course Moodle



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<https://go.epfl.ch/ENV-402>

- ✕ Close course index
- General**
- Course Introduction
- Course Discussion Forum
- Announcements
- 11-Sept: Introduction to ...
 - Documents
- 18-Sept: Water treatment...
 - Documents
- 25-Sept: Water supply fro...
 - Documents
- 02-Oct: Municipal solid w...

Environmental Sciences and Engineering (SIE) / SIE - Master

Sanitary engineering for development

[Course](#) [Participants](#) [Grades](#) [More](#)

 You are viewing this course currently with the role: **Student**
Return to my normal role

General

[Collapse all](#)

Welcome to our course: **Sanitary Engineering in Developing Countries.**

This course is held in person every Thursday from 10:15 to 12:00 in room GRA 331.

Introducing Sandec



The Sandec Team (retreat May 2025)

Sandec Groups

Sanitation, Water and Solid Waste for Development

Municipal Solid
Waste
Management

Strategic
Environmental
Sanitation
Planning

Management of
Excreta,
Wastewater and
Sludge

Water Safety
Management

Water Supply
and Treatment

Organizations
and Climate

new!

Public Health,
Infrastructure
and Climate

new!

Paired Discussion (2 minutes)

What is your motivation for being in this course?

About me – Dr Jess MacArthur

Academic Background

- BSc in Chemical Engineering – University of Calgary
- MSc in Water Science, Policy and Management – University of Oxford
- Phd in Sustainable Futures – University of Technology Sydney

Professional Background

- iDE, Bangladesh – WASH Advisor, WASH Director
- Save the Children, Global – Research and Learning Advisor
- Institute for Sustainable Futures – Adjunct Research Fellow
- Independent Consulting (HKI, IRC-WASH, WaterAid, Splash...)
- Sandec-Eawag since May 2025 – Knowledge Broker

Lived: Australia, Bangladesh, Canada, Indonesia, Switzerland, Thailand, Turkey, the United Kingdom, and the United States.

Extensive professional experience: Bangladesh, Cambodia, Ethiopia, Nepal, Ghana, Togo, Zambia, and Zimbabwe.

Additional support: Bhutan, Burkina Faso, Democratic Republic of Congo (DRC), Laos PDR, Madagascar, Mali, Mozambique, Niger, Timor-Leste, Uganda, Vanuatu, and Vietnam.

[https://sites.google.com/
view/jess-macarthur](https://sites.google.com/view/jess-macarthur)

Part I

Setting the Scene

















Key Terms

- **WatSan** – Water and Sanitation (outdated, less common)
- **WASH** – Water, Sanitation and Hygiene
- For this course (and at Sandec) we also include Solid Waste Management

Water

- Supply
- Treatment

Sanitation

- Facilities/Collection
- Transport
- Treatment
- Disposal/Use

Hygiene

- Handwashing
- Menstrual
- Bathing
- Toothbrushing

Solid Waste

- Storage
- Collection/Transport
- Treatment/Recycling
- Disposal/Use

Rapid Urbanisation

In 1950, 30% of the population lived in urban areas; today 56% (2024), with a projected 68% in 2050.

Rapid urbanisation means that households do not connect to the municipal system because they:

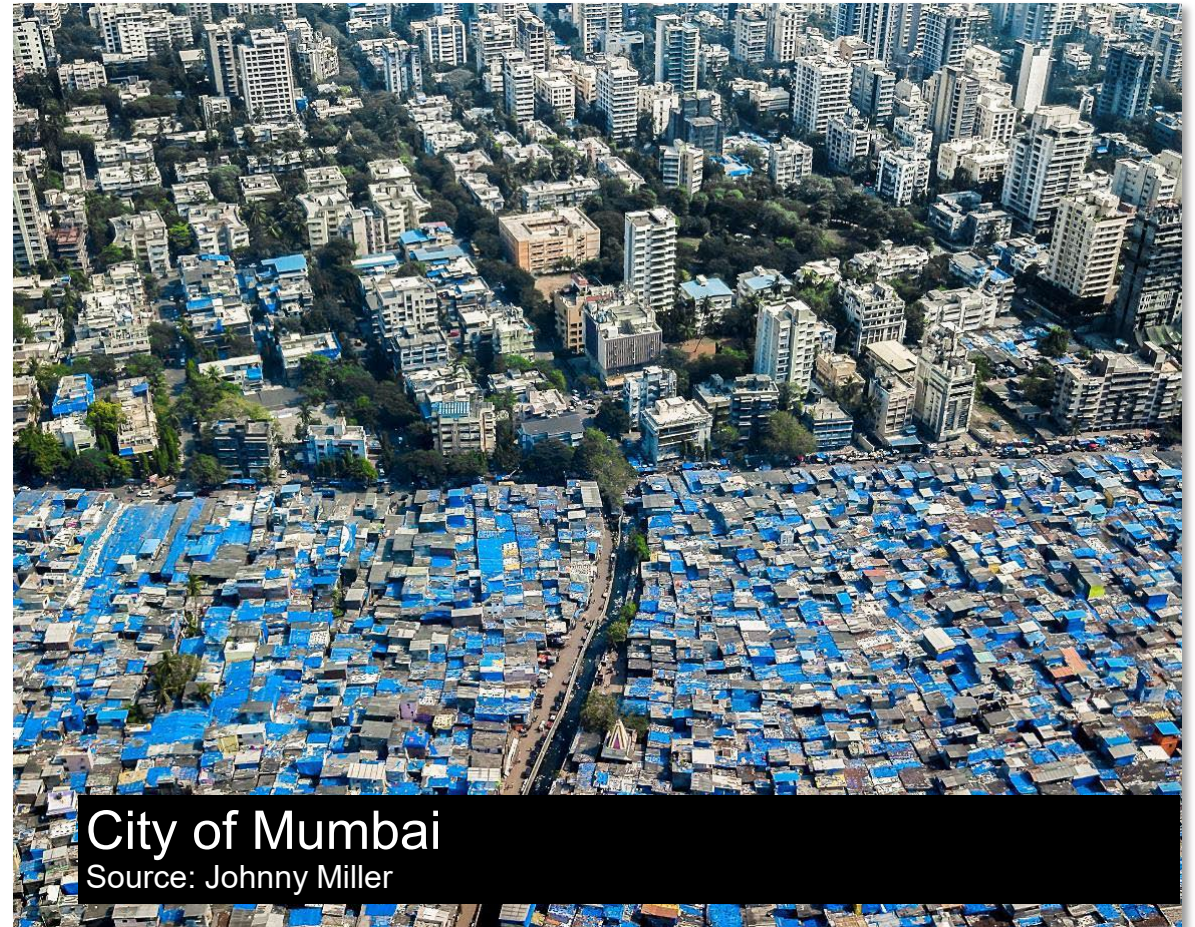
- ...live outside the area served by the formal system
- ...live in informal settlements and are denied connections to public services
- ...are unable to pay service charges
- ...are unwilling to pay because they already have some form of service



A view of Korail slum in Dhaka, Bangladesh
Source: [AM Ahad/AP](#)

Context: Low- and middle-income urban areas

- Low-income (informal) settlements
- Densely populated
- High poverty levels
- Lack of (adequate) waste collection services
- Lack of water, wastewater or solid waste treatment plants
- Discharging wastewater and solid waste into environment



City of Mumbai
Source: Johnny Miller

WASH Challenges: Low- and middle-income urban areas



Informal Settlements: Characteristics

- Today ~1 billion slum dwellers
- Substandard housing
- No or insufficient access to services (water, sanitation, waste mgmt.)
- Lack of tenure security
- Many slum dwellers rent and do not own their structures



Informal Settlements: Sanitation Facilities

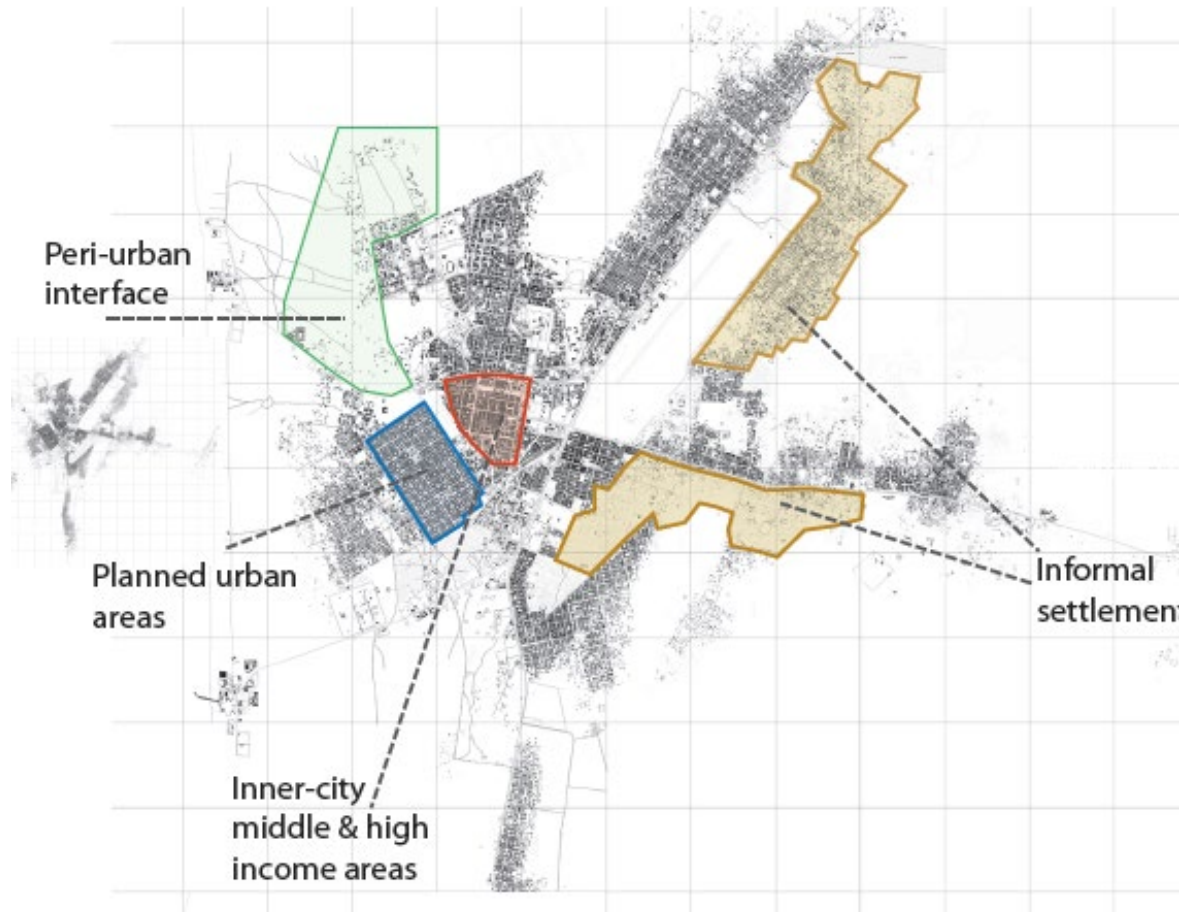


Shared sanitation facilities

Source: [U-Act](#)



Poorly maintained shared latrines in the Langrug informal settlement, Franschhoek Source: [Kevin Winter](#)



Importance: Sanitary engineering & contextual planning

Understand the context, design from evidence

✓ Cities and people are complex & dynamic

✓ WASH services are context-dependent and must be socially accepted

= There is a need for a range of service models, no one-size fits all solutions!

Range of urban contexts

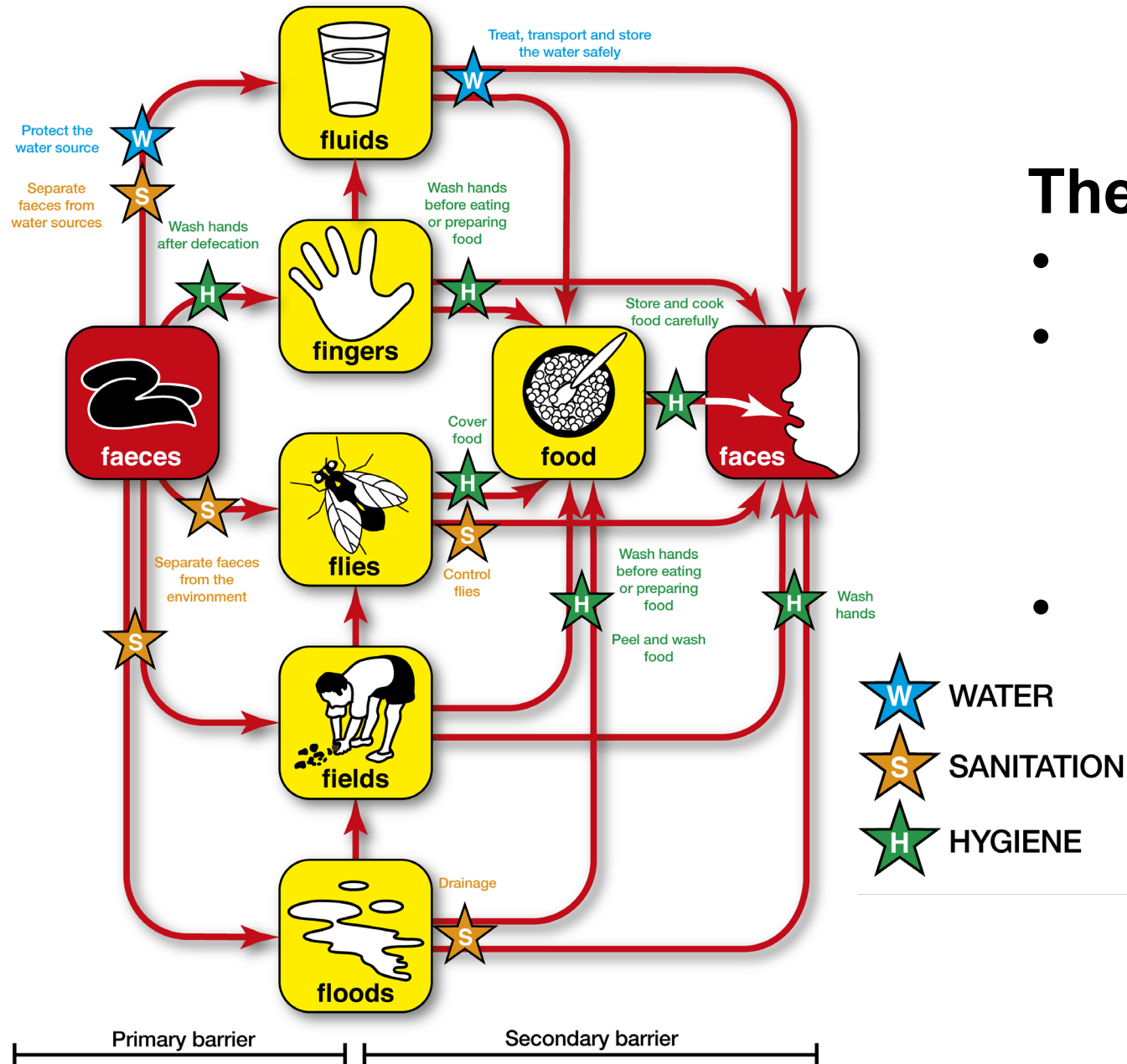
Source: [Reymond et al. 2016](#)

Considerations: Sanitary engineering & contextual planning

Physical context	Socio-cultural context	Political, legal & institutional context	Financial & economic context	Technical capacity context
<ul style="list-style-type: none"> • Climate (temperature, rainfall...) • Soil (rock, sand...) • Water availability • Groundwater • Population density 	<ul style="list-style-type: none"> • Defecating posture (sitting/squatting) • Anal cleansing material used (washers/wipers) • Cultural and gender aspects (privacy, taboos on handling waste...) 	<ul style="list-style-type: none"> • Regulations and standards • Organizational setup and responsibilities • Political will and support • Bureaucracy 	<ul style="list-style-type: none"> • Affordable technology • Willingness to pay for appropriate service level • Availability of credits and loans 	<p>Availability of</p> <ul style="list-style-type: none"> • Local skills • Human power • Materials & tools • Financial resources <p>(Needed for sustainable operation and maintenance)</p>

Part II

WASH & Public Health



The «F-Diagram»

- All key words are "F"
 - From Faeces to Faces
- Shows pathogen movement from faeces of a sick person to a potential new host
- Different measures to prevent transmission

Diseases	Estimated Morbidity (episodes per year or people infected)	Estimated Mortality (deaths per year)	Relationship of Disease to Water and Sanitation Conditions
Diarrheal diseases	1,000,000,000	2,200,000 to 5,000,000	Strongly related to unsanitary excreta disposal, poor personal and domestic hygiene, unsafe drinking water
Intestinal helminths	1,500,000,000 (people infected)	100,000	Strongly related to unsanitary excreta disposal, poor personal and domestic hygiene
Schistosomiasis	200,000,000 (people infected)	200,000	Strongly related to unsanitary excreta disposal and absence of nearby sources of safe water
Dracunculiasis	150,000 (in 1996)	---	Strongly related to unsafe drinking water
Trachoma	150,000,000 (active cases)	---	Strongly related to lack of face washing, often due to absence of nearby sources of safe water
Poliomyelitis	114,000	---	Related to unsanitary excreta disposal, poor personal and domestic hygiene, unsafe drinking water
Trypanosomiasis	275,000	130,000	Related to the absence of nearby sources of safe water

WASH Health Impacts

Per year:

2.2 – 5 million deaths due to diarrhea

1.5 billion intestinal infections

Morbidity refers to illness or disease

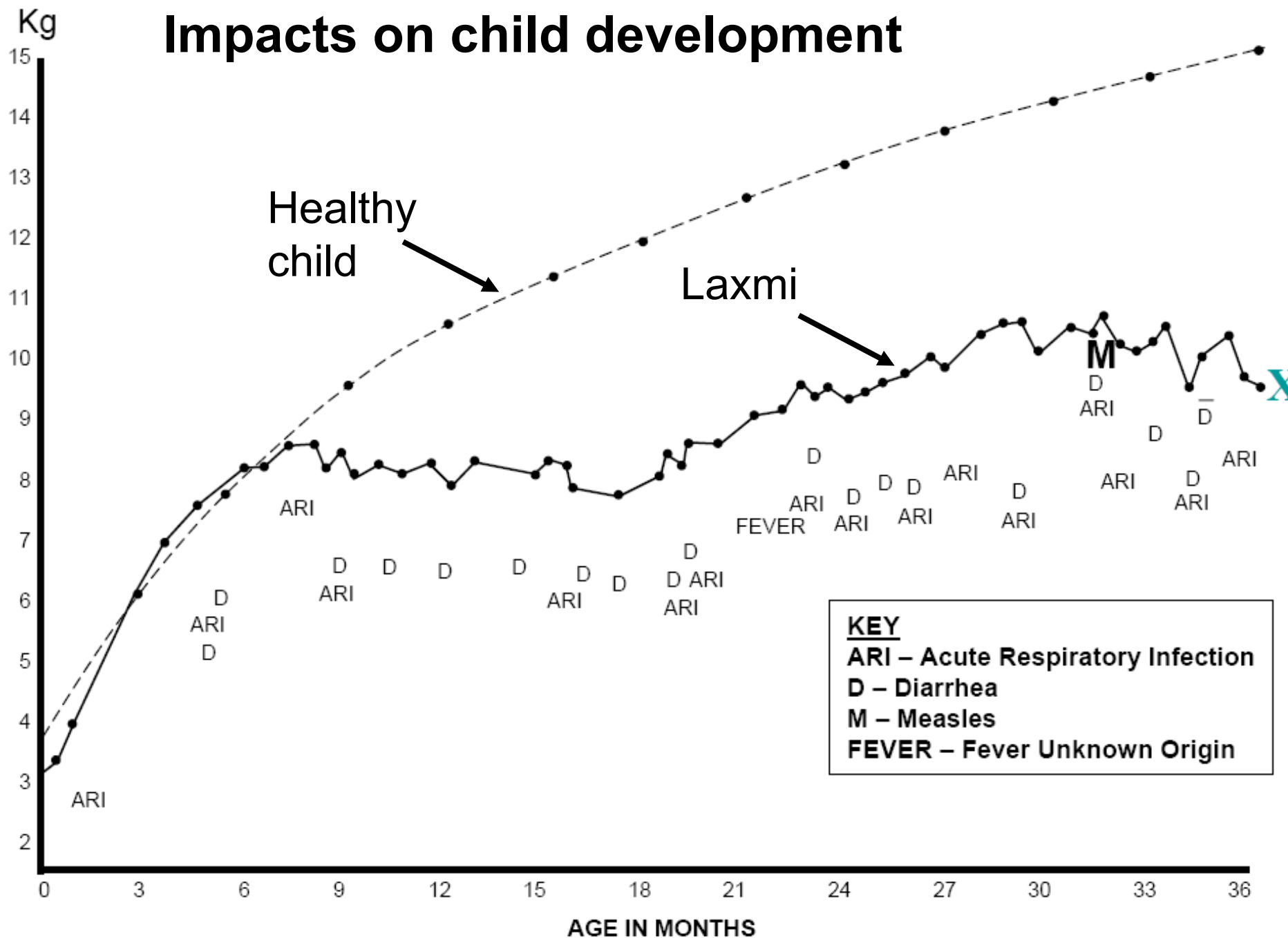
Mortality refers to death

Group	Diseases
<i>Water-borne diseases</i> (diseases transmitted by water)	Cholera; Typhoid; Bacillary dysentery Infectious hepatitis; Giardiasis
<i>Water-washed diseases</i> (caused by lack of water)	Scabies; Skin sepsis and ulcers; Yaws; Leprosy; Lice and thypus; Trachoma; Dysenteries; Ascariasis; Parathphoid
<i>Water based diseases</i>	Schistomiasis; Dracunuliasis; Bilharziosis; Filariasis; Threadworm
<i>Water-related insect vector diseases</i>	Yellow fever Dengue fever Bancroftian filariasis Malaria Onchocerciasis

Types of water-related diseases

- 4 different groups
- Water-borne diseases most relevant to WASH interventions
- Causing diarrhea, which causes dehydration and malnutrition!

Impacts on child development



Laxmi's short life.

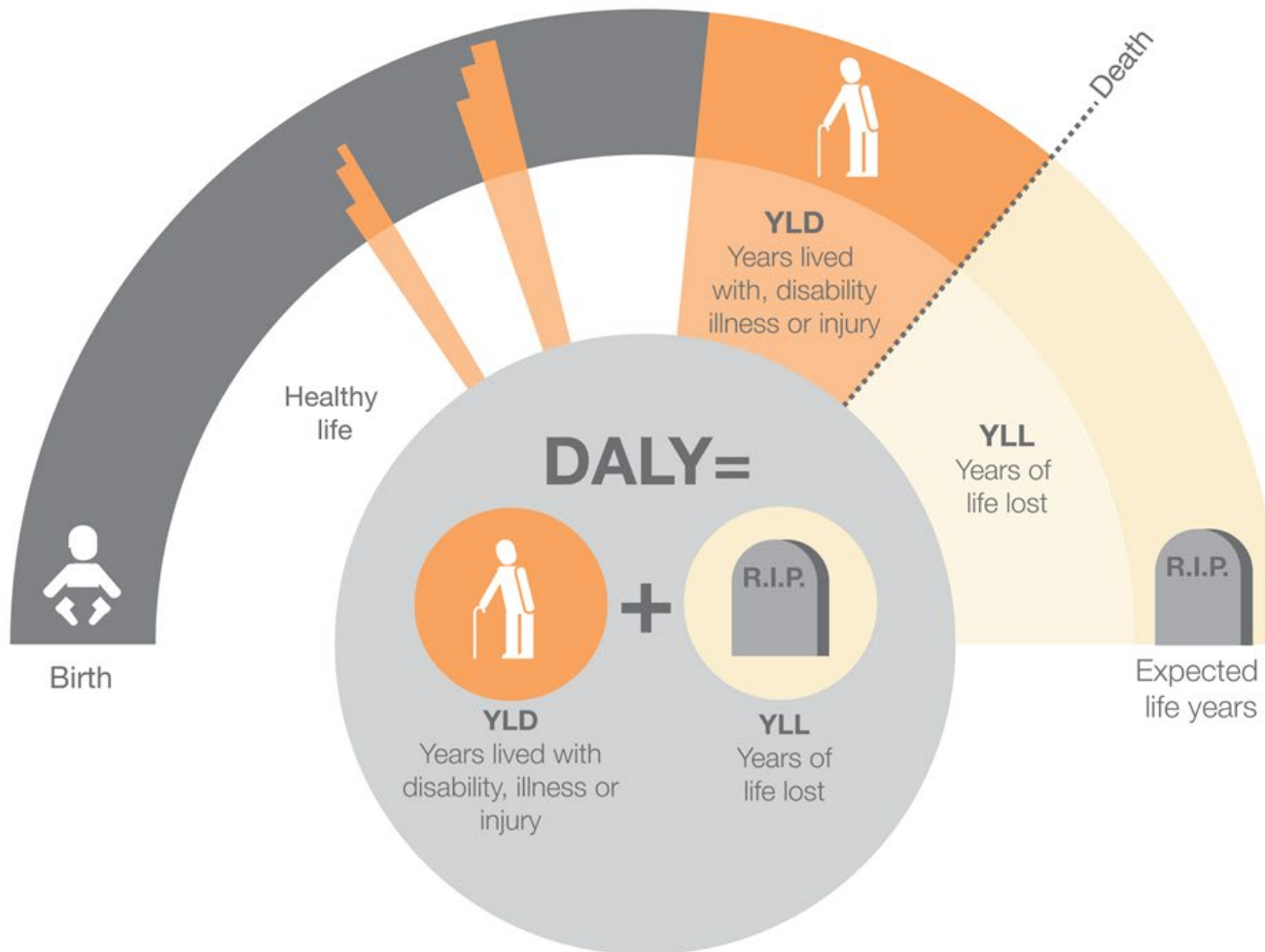
Source: Dooley, UNICEF
Presentation, 2008

Visible Effect: Stunting



Source: Gates Foundation

Invisible Effect: Disability Adjusted Life Years



Disability-Adjusted Life Years (DALYs)

- the years of life lost as a result of premature death
- the years lived with a disease

Questions

Stretch Break

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Part III

WASH & the SDGs

WASH as a human right

Water, Sanitation & Hygiene (WASH) gained in pertinence:

- 2000: Millennium Development Goal (MDG) #7 includes a target sustainable access to safe drinking water and basic sanitation.
- 2010: The UN recognises WASH as basic human right.
- 2015: Dedicated Sustainable Development Goal (SDG) #6 on clean water and sanitation.



2000 – 2015: MDGs



**HUMAN RIGHTS TO
WATER AND SANITATION**

2020 (10 years)



2015 – 2030: SDGs

Sustainable Development Goals (SDGs)

- 17 Goals
- 169 Targets
- 232 Global Indicators



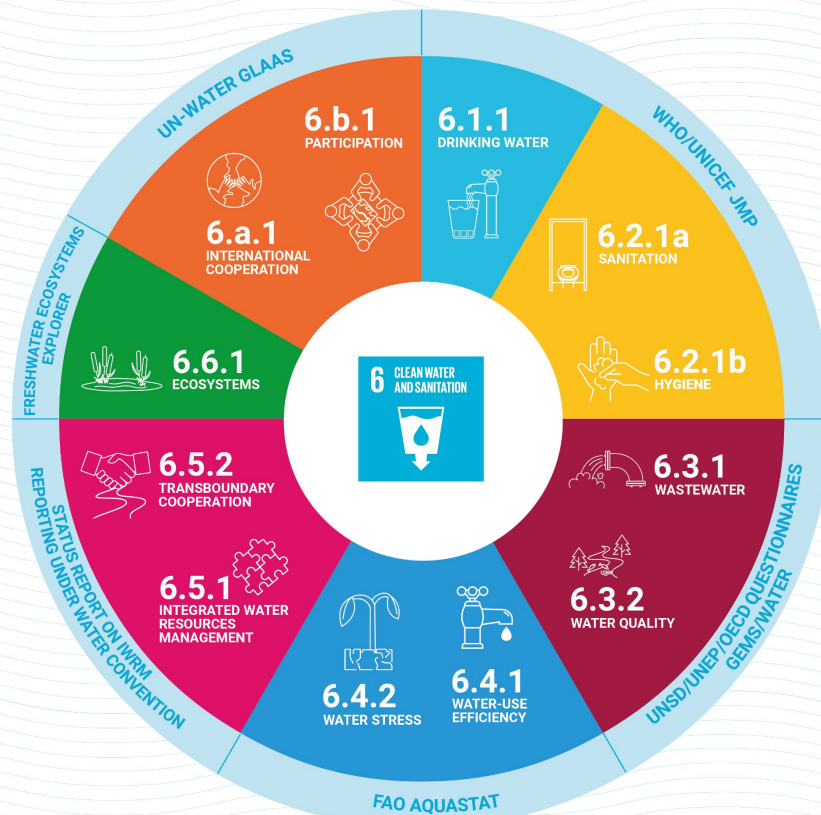
Linkages between the Goals

- How many goals do you think are linked to **WASH?**



SDG Goal 6

UN WATER
INTEGRATED MONITORING INITIATIVE FOR SDG 6



INDICATORS	CUSTODIANS
6.1.1 Proportion of population using safely managed drinking water services	WHO, UNICEF
6.2.1 Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water	WHO, UNICEF
6.3.1 Proportion of domestic and industrial wastewater flows safely treated	WHO, UN-Habitat, UNSD
6.3.2 Proportion of bodies of water with good ambient water quality	UNEP
6.4.1 Change in water-use efficiency over time	FAO
6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	FAO
6.5.1 Degree of integrated water resources management	UNEP
6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation	UNECE, UNESCO
6.6.1 Change in the extent of water-related ecosystems over time	UNEP, Ramsar
6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan	WHO, OECD
6.b.1 Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management	WHO, OECD

- Multiple UN organizations responsible

SDGs 6.1 and 6.2



6.1 Safely managed drinking water services
Nepal (Source: [Ariane Schertenleib](#))

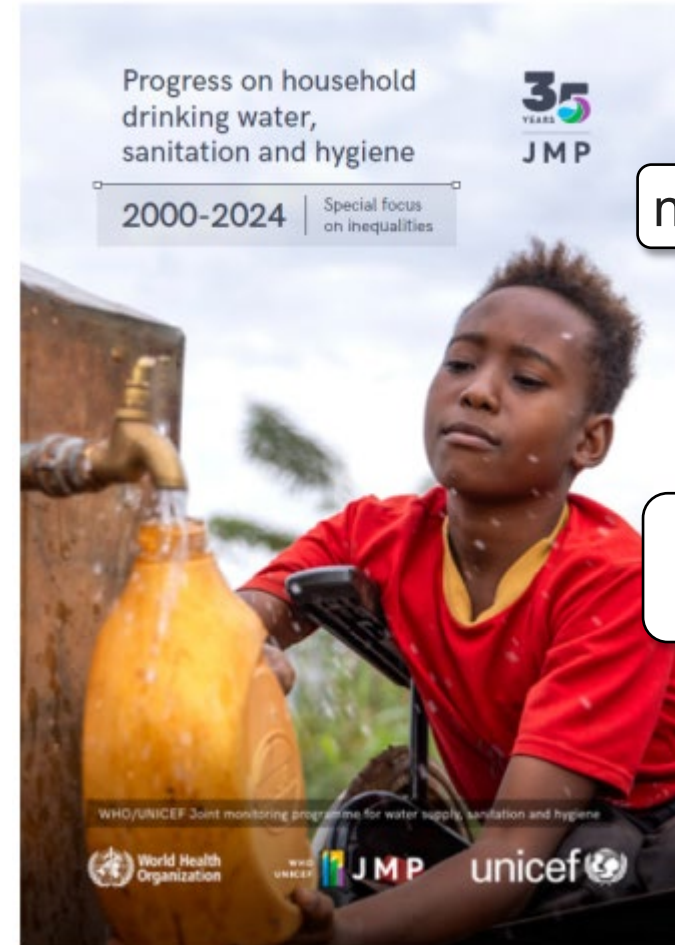


6.2 Safely managed sanitation services
Source: U-Act

Joint Monitoring Programme (JMP)

UNICEF and WHO are mandated to jointly monitor 6.1 and 6.2.

- Data, Monitoring and Reporting
- Including special focuses:
 - Inequalities
 - Health care facilities
 - Schools
 - Menstruation
 - Gender



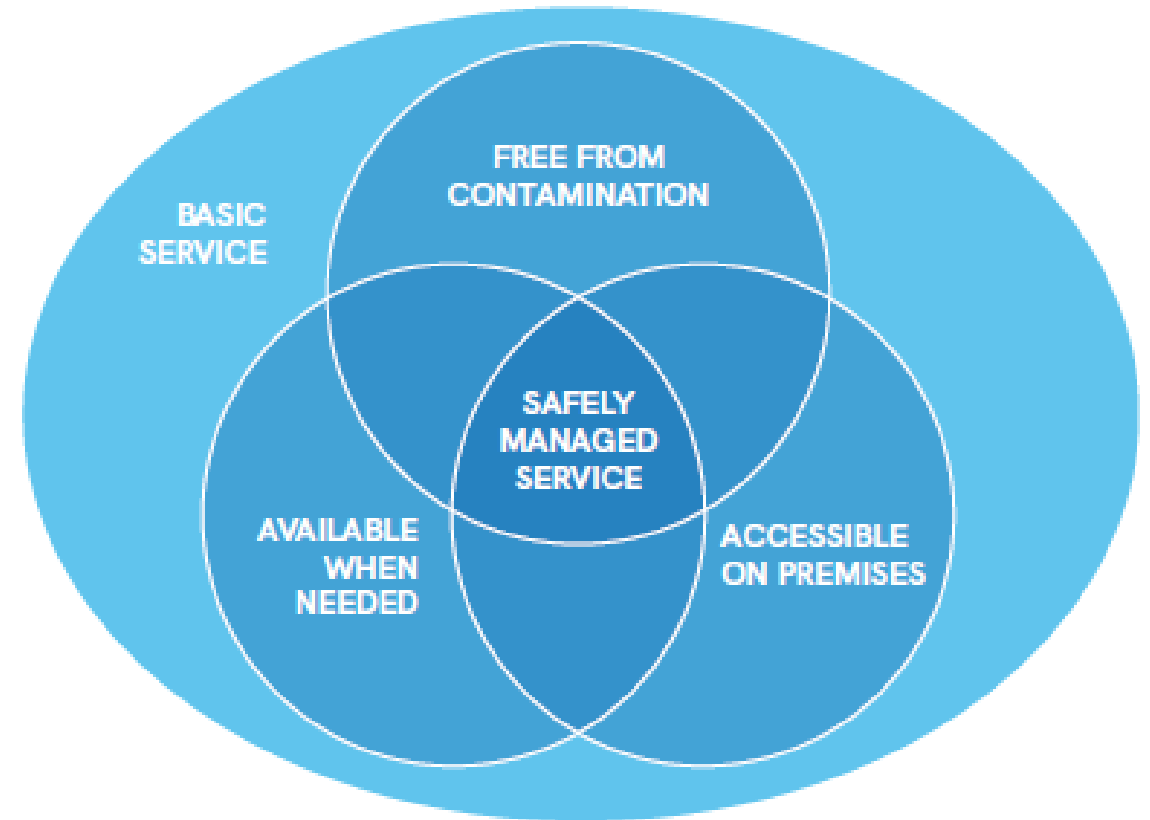
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washdata.org

Source: [WHO/UNICEF 2025](#)

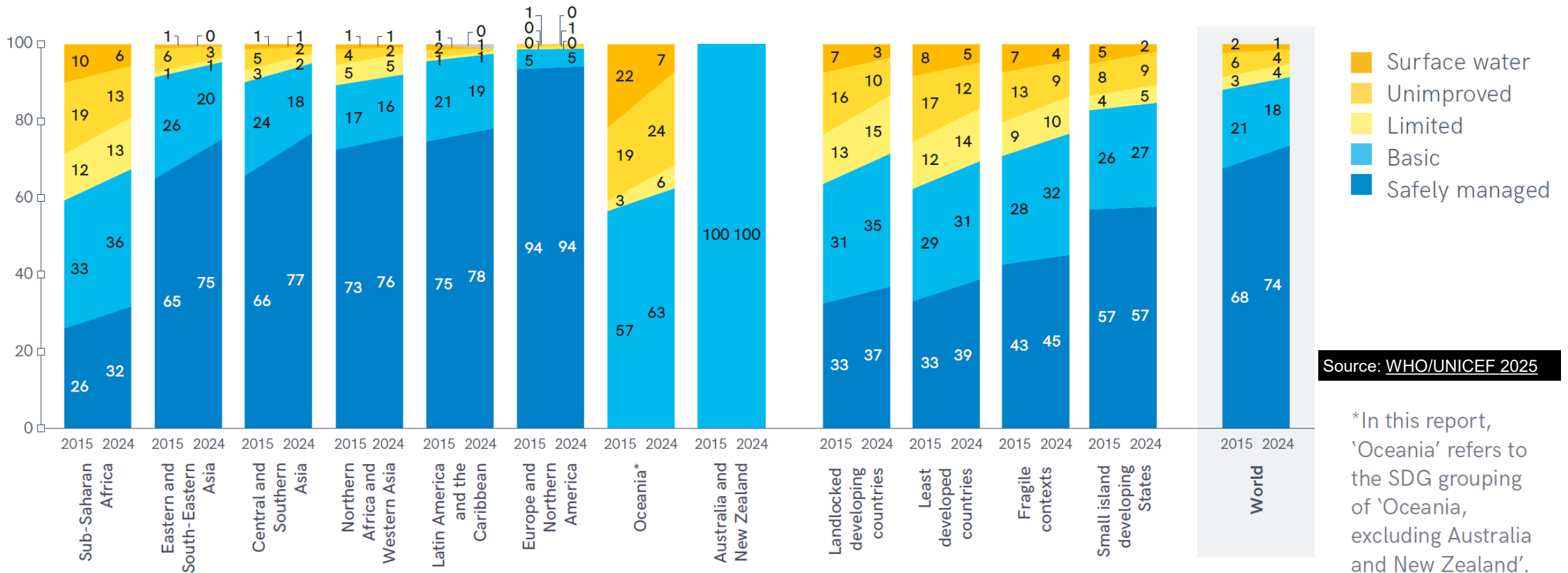
Water Service Levels

SAFELY MANAGED	Drinking water from an improved source that is accessible on premises, available when needed and free from faecal and priority chemical contamination
BASIC	Drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip, including queuing
LIMITED	Drinking water from an improved source, for which collection time exceeds 30 minutes for a round trip, including queuing
UNIMPROVED	Drinking water from an unprotected dug well or unprotected spring
SURFACE WATER	Drinking water directly from a river, dam, lake, pond, stream, canal or irrigation canal



Global and regional drinking water coverage, 2015–2024 (%)

In 2024, three out of four people had safely managed drinking water, but people in least developed countries were more than twice as likely to lack access

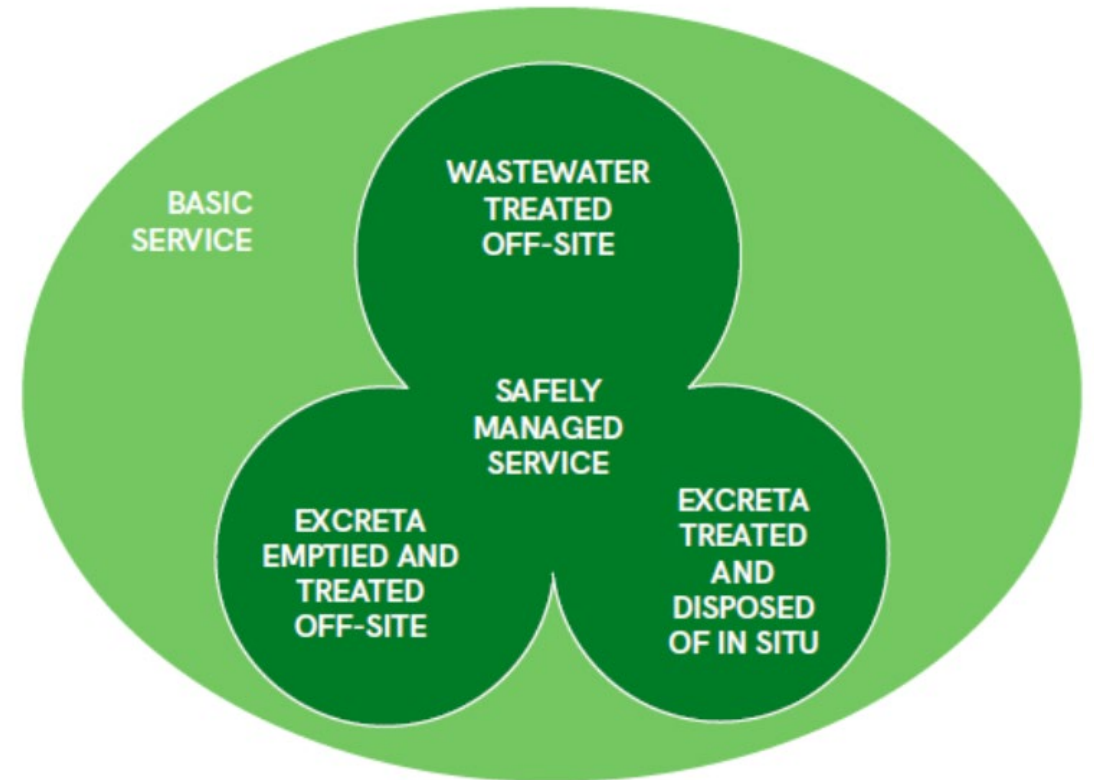


Source: WHO/UNICEF 2025

*In this report, 'Oceania' refers to the SDG grouping of 'Oceania, excluding Australia and New Zealand'.

Sanitation Service Levels

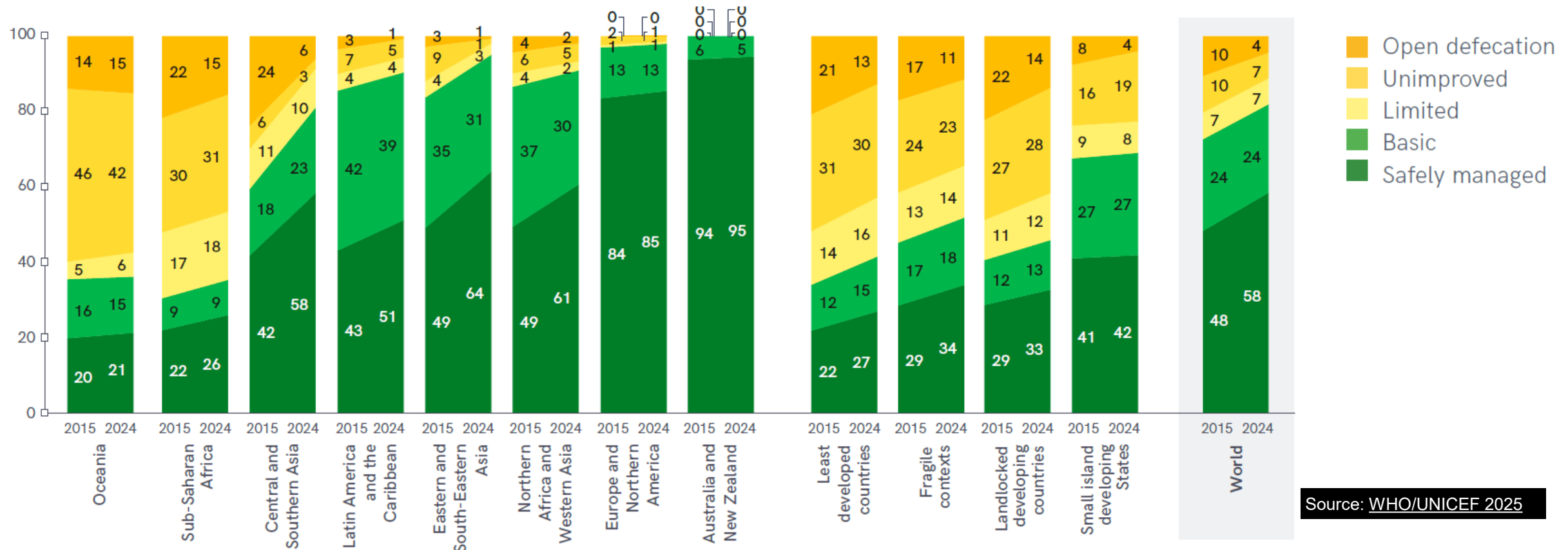
SAFELY MANAGED	Use of improved facilities that are not shared with other households and where excreta are safely disposed of in situ or removed and treated off-site
BASIC	Use of improved facilities that are not shared with other households
LIMITED	Use of improved facilities that are shared with other households
UNIMPROVED	Use of pit latrines without a slab or platform, hanging latrines or bucket latrines
OPEN DEFECCATION	Disposal of human faeces in fields, forests, bushes, open bodies of water, beaches or other open places, or with solid waste



Source: [WHO/UNICEF 2025](#)

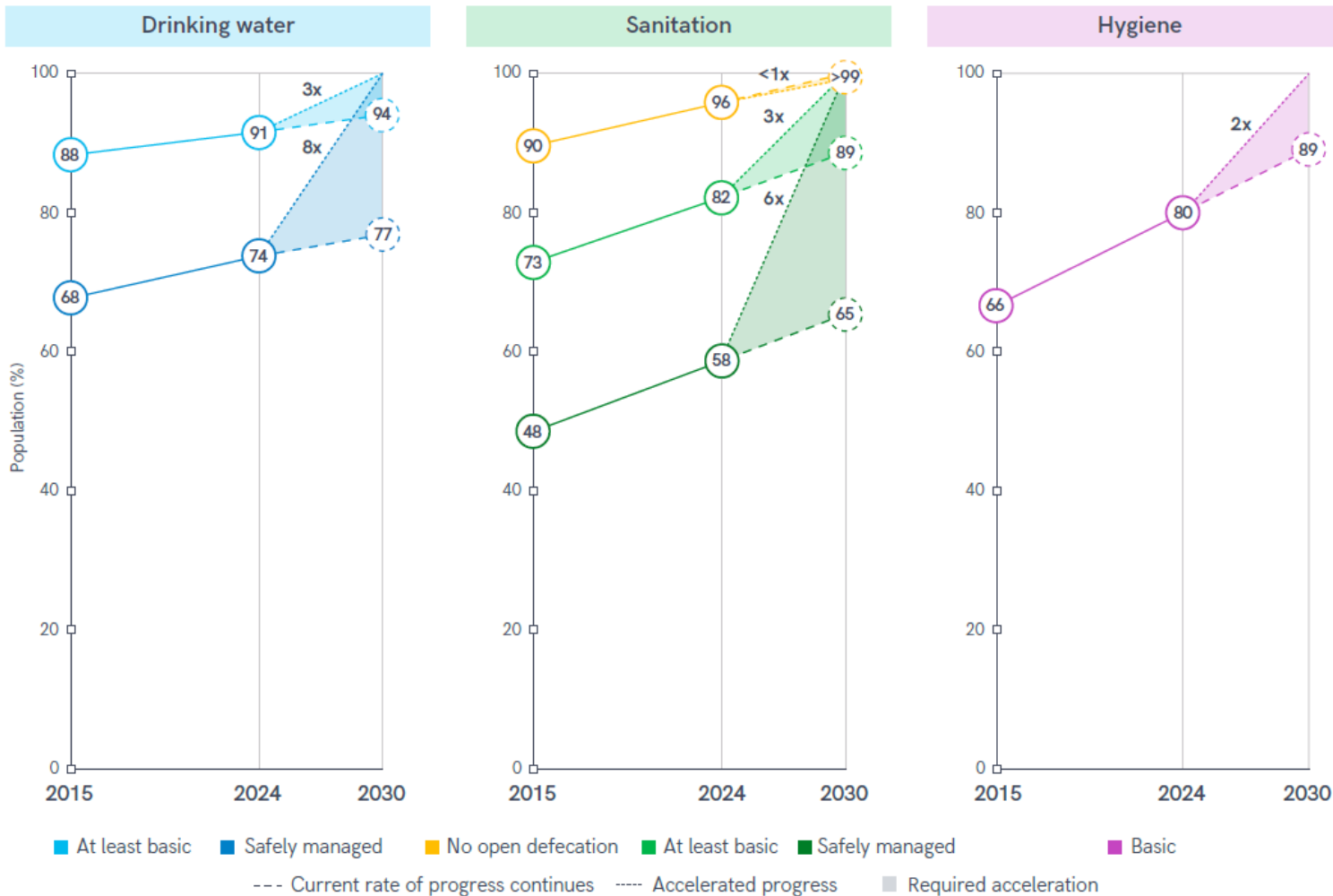
Global and regional sanitation coverage, 2015–2024 (%)

In 2024, three out of five people had safely managed sanitation services, but people living in least developed countries were nearly twice as likely to lack access



Source: WHO/UNICEF 2025

Are we on track to meet the SGDs?



Global coverage of WASH services, 2015–2024 (%), and acceleration required to reach universal coverage (>99%) by 2030

- **3x for basic drinking water**
- **3x for basic sanitation**
- **2x for basic hygiene**

Part IV

Semester Group Work

Case Study: Wobulenzi, Uganda



Wobulenzi Town
Source: [Mbazila Cylux](#)

Background

Location: Uganda

- ➔ Central Region
- ➔ Luweero District
- ➔ Katikamu sub-county
- ➔ Wobulenzi municipality

~31,000 inhabitants



Source: NordNordWest/Wikipedia

Group assignment: Handout

eawag
aquatic research o o o

CASE STUDY OF WOBULENZI, UGANDA

I - GROUP ASSIGNMENT

Learning Objectives

The lectures explore ways to improve water supply, sanitation, and solid waste services to meet development goals for disease prevention, resource management, and environmental protection. In this case study, the students should critically discuss the content of the lectures with their colleagues and continuously integrate the newly acquired theoretical knowledge into a «real case». With this, the students should then be able to:

1. Apply course knowledge on water supply, sanitation, and solid waste to a real-world case study.
2. Analyse and prioritise case study information to identify key issues and challenges associated with water supply, sanitation, solid waste management and their interlinkages.
3. Develop contextually appropriate solutions to address the challenges presented from a real-world case study.

Overall assignment description

Context: Your group is a consortium of consultants with international experience, working jointly for the African Development Bank to engage with the Wobulenzi Town Council (WTC) to develop a short proposal on how to improve drinking water, sanitation, and solid waste services in the town. The Town Council and service providers will use your proposal to implement the technical and social interventions. The African Development Bank, using a grant from their trust fund, will fund the implementation. Your proposed solution must be as realistic as possible.

Assignment: Review the provided text and maps to identify the main challenges faced by the population, with respect to water, sanitation, and solid waste management and how they are interconnected. Present these challenges and propose solutions as if you were an external consultant hired by the African Development Bank. Focus on prioritising key interventions to address these issues effectively.

Detailed task description

Task 1: Water supply

Background: The main drinking water source in Wobulenzi is groundwater. Residents regularly switch to alternative water sources based on availability and cost, especially during the rainy months (March to May, and September to October) when many households harvest rainwater.

Need: The Town Council wants to provide enough water to the town to avoid water scarcity. Yet, the Town Council and the National Water & Sewerage Corporation (NWSC) have recognised that they will not be able to provide piped house connections to all. However, they expect to increase the number of house connections by 50% from the current level. The remaining coverage shall be met with public posts situated in urban neighbourhoods managed by NWSC and with new boreholes built in rural areas managed by District authorities and the Town Council.

1

6

million people, with Kampala here is presently development Wobulenzi, a Town Highway in Luwero District. 77 metres above sea level.

Wobulenzi Town Council

Wobulenzi Town Council in Luwero District (right)

Wobulenzi in Uganda. The various

Mean temperature and precipitation in Wobulenzi in 2017.

25

Handout contains:

- **General assignment overview**
- **Background info on Wobulenzi**
- **Sectorial analysis:**
 - Water supply
 - Sanitation
 - Solid waste management
 - Interlinkages
- **Appendix**
 - Maps
 - Flow diagrams

Group Work Tasks

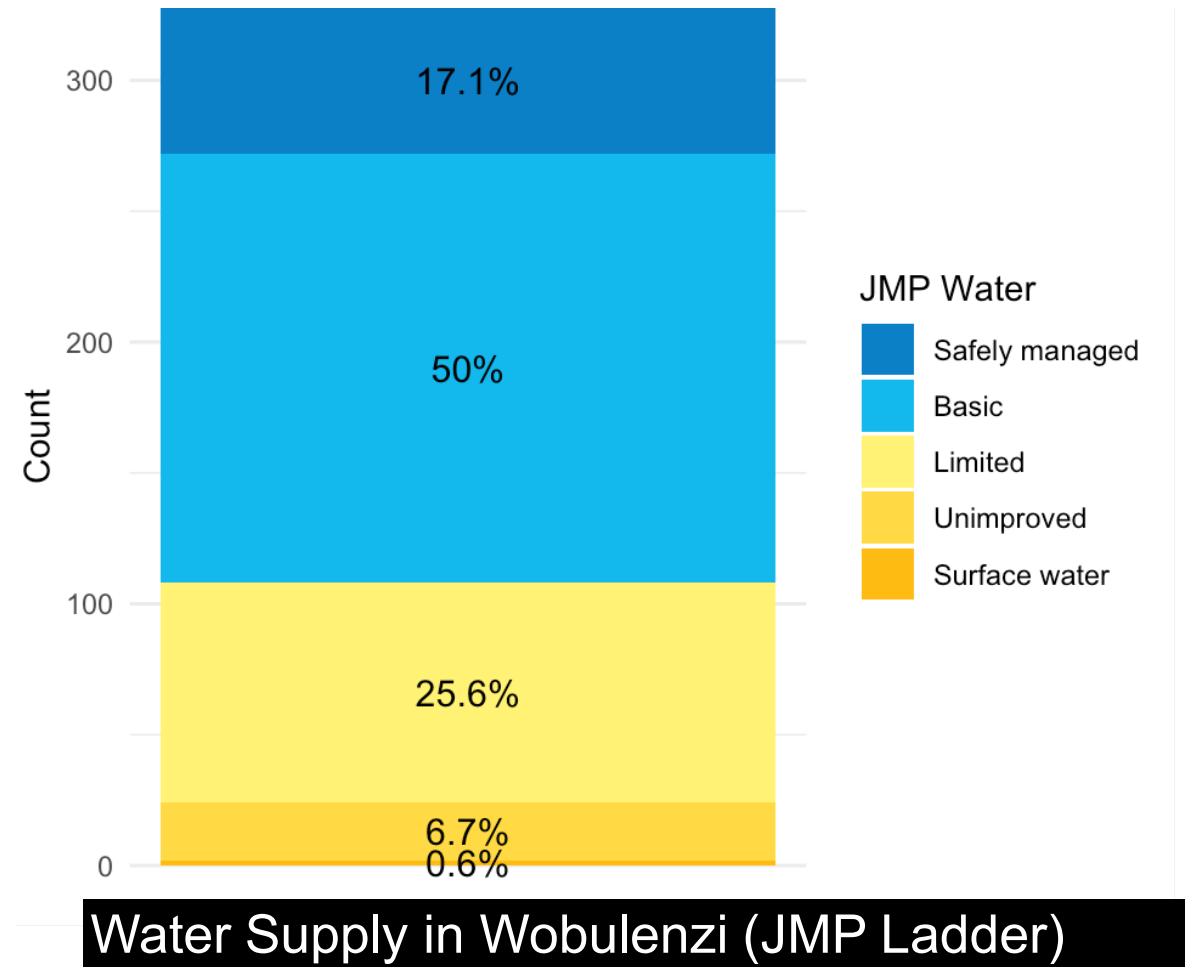
- Develop a decentralized **water access** and distribution approach (treatment & sales) for the project area
- Design a small-scale **sanitation solution** for the project area
- Develop a business and operational plan for a small enterprise to manage **solid waste** in this community
- Critically reflect on the limitations of the proposed solutions in task 1-3 and discuss the possibility of combining some solutions into an integrated system

Water Supply: Background

Water Service Access

- Piped water: 44.2%
- Yard connections: 22.6%
- PSPs: 21.6%

- Half of households have basic service
- Regular supply interruptions
- Inadequate chlorine dosing → E. coli contamination
- Dirty storage containers → Recontamination!



Water Supply: Context



Public Stand Pipes (PSPs) with taps
Source: Sandec



Water from borehole with a pump
Source: Sandec

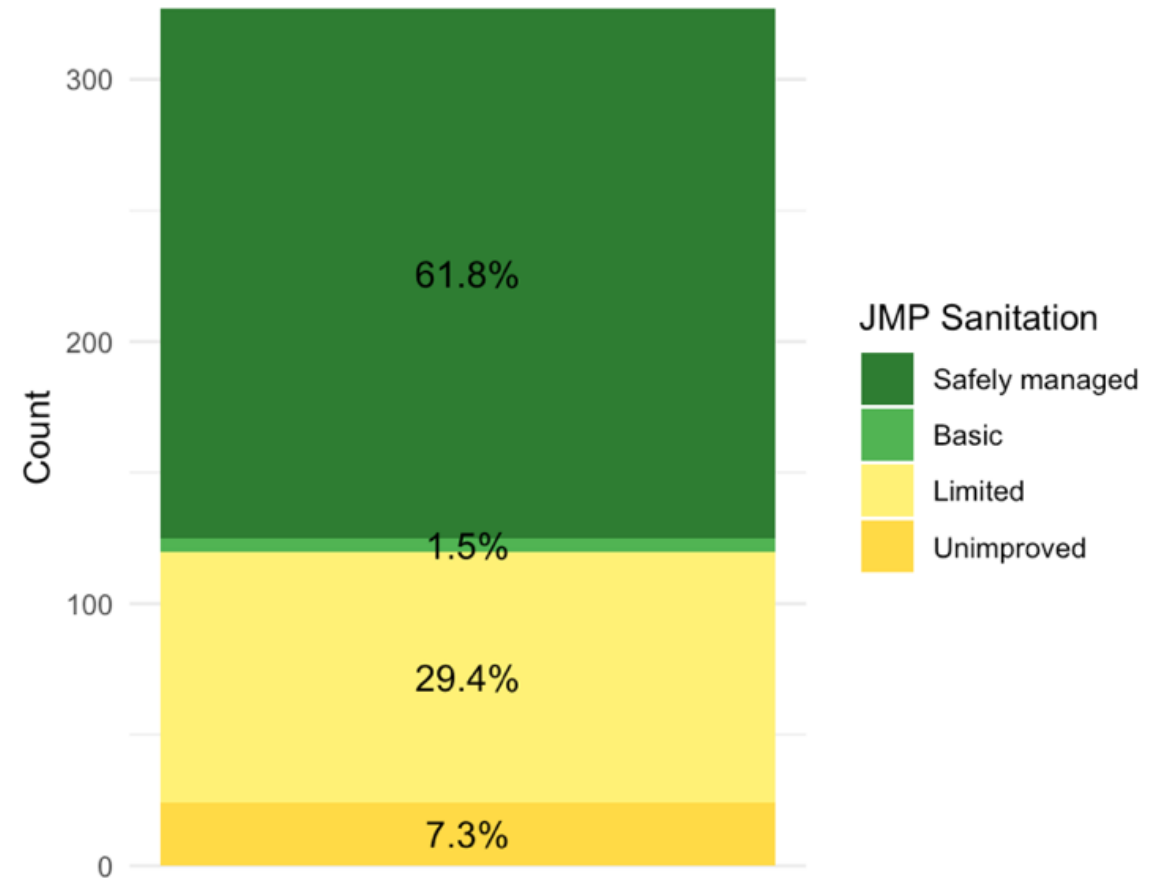
Sanitation: Background

Sanitation Facilities

- Simple pit latrines
- Most are unlined (only 22% are fully lined)

Limited emptying services: only 3% emptied

Underutilized Faecal Sludge Treatment Plant (FSTP)



Sanitation in Wobulenzi (JMP Ladder)

Sanitation: Context



Simple pit latrine
Source: Sandec

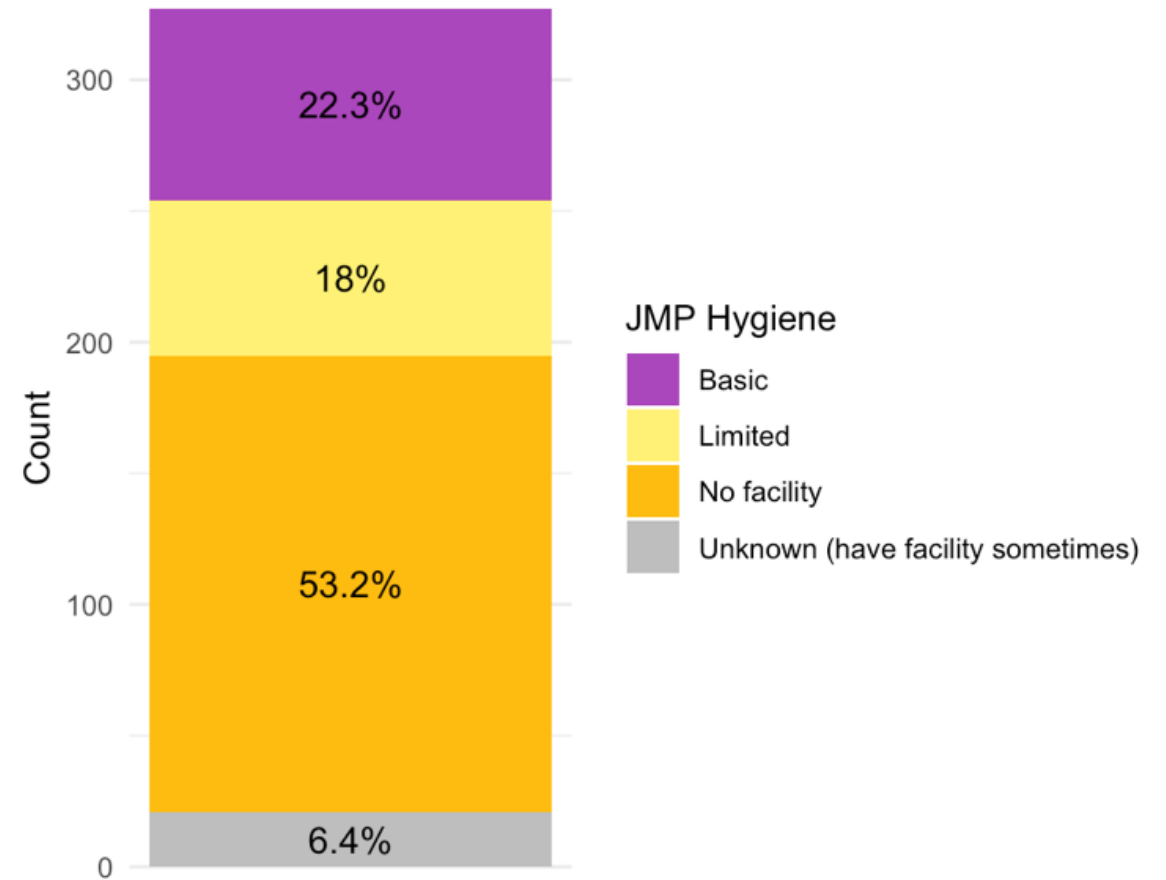


Very clean pour flush toilet
Source: Sandec

Hygiene: Background

Handwashing Facilities

- Lacking for 53% of households
- Mostly functional where available



Handwashing in Wobulenzi (JMP Ladder)

Solid Waste Management: Background

Relies on informal and formal waste collection

Waste disposed in uncontrolled dumpsites: Open dumping & burning

Collection workers face irregular payment

Collection trucks in poor condition



Solid Waste Management: Context

High segregation of kitchen waste, recyclables, and garden waste

Informal junk buyers purchase recyclable items from households

PET is the most separated recycled material by households



Negative Interlinkages

Disposal of solid waste into pits, water bodies, or stormwater drains

Animal interaction with sanitation facilities and water storage

Drinking water contamination by:

Leaks from sanitation containers

Poor hygiene practices

Landfill leachate: Nearby water source contamination



Positive Interlinkages

Greywater reuse for:

- cleaning
- toilet flushing
- garden irrigation
- animal feeding

On-site composting for:

- nutrient recovery
- recycling of materials from the solid waste stream



Agriculture site

Source: Sandec

Expected outputs, grading & next steps

Final grade:

- Exam **70%**
- Group work **30%**

Group Work Tasks

- Form groups of 5 students
- One group member communicates members + student ID# to Christoph Lüthi by email
- Each week your group meets to discuss and work on proposal
- Hand in final report by 18th December 2025 as pdf file by email

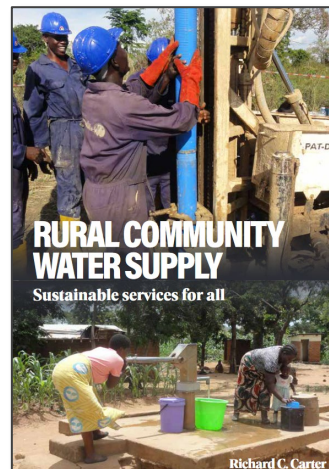
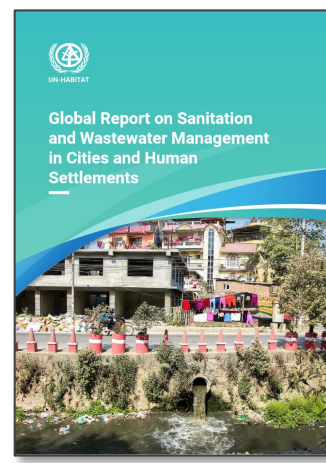
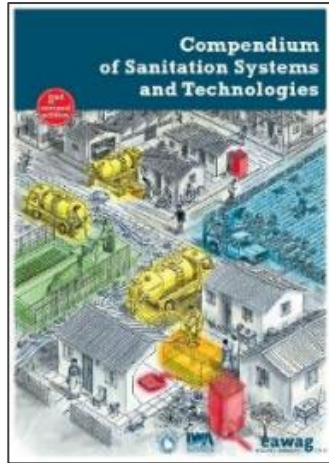
1 report (max. 13 pages, Arial 10, single lined).

Christoph.Luethi@eawag.ch

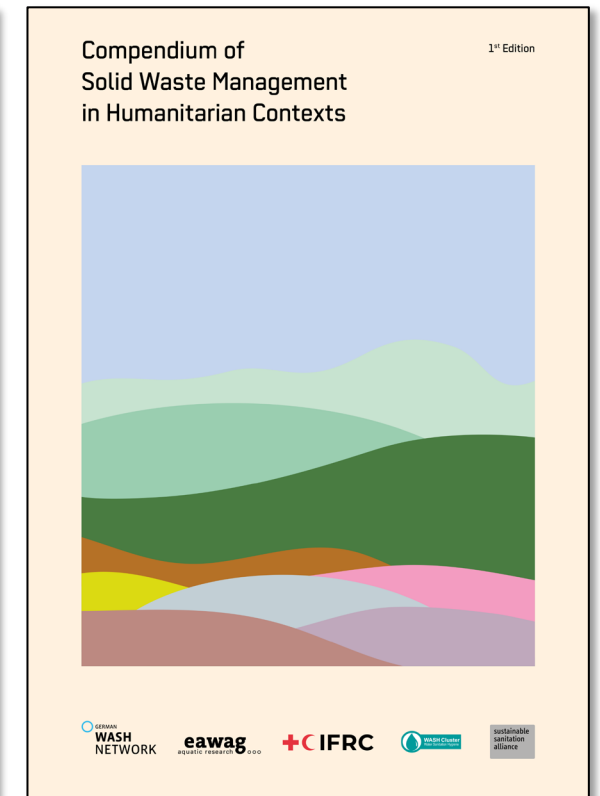
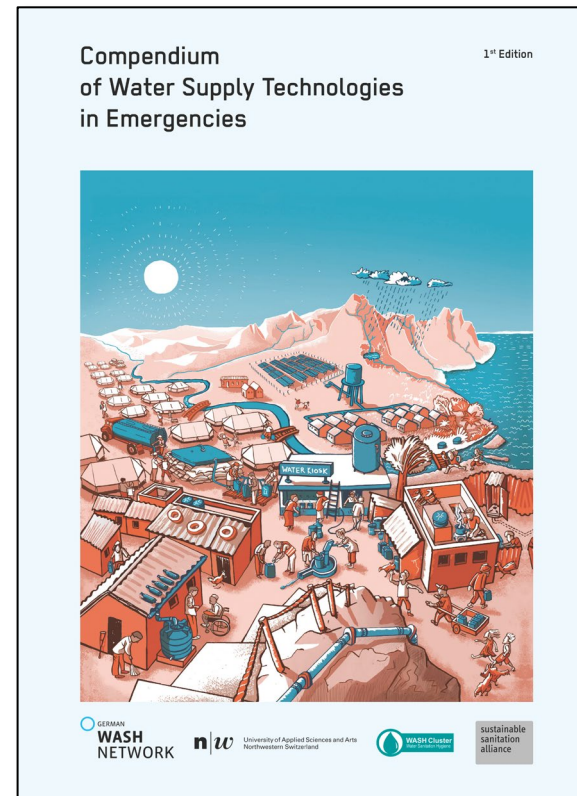
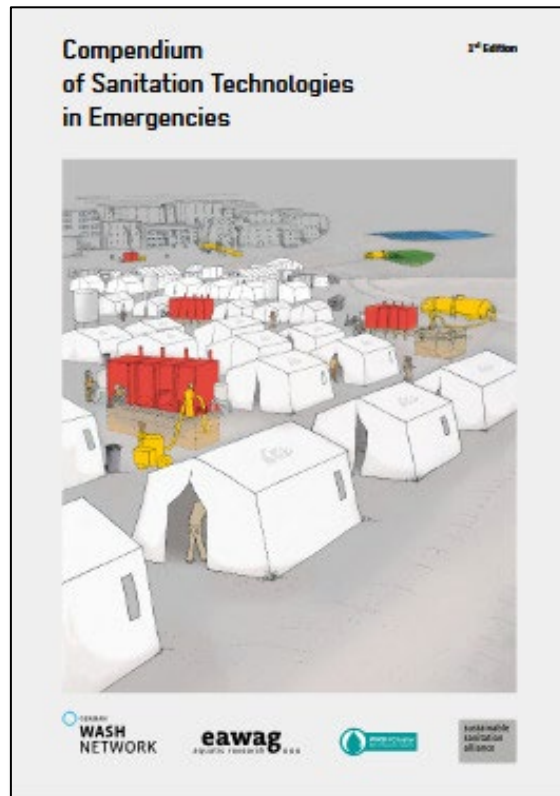
Group Work: Learning Goals

- Apply course knowledge on water supply, sanitation, and solid waste to a real-world case study.
- Analyse and prioritise case study information to identify key issues and challenges associated with water supply, sanitation, solid waste management and their interlinkages.
- Develop contextually appropriate solutions to address the challenges presented from a real-world case study.

Key resources (Part 1 of 2)



Key resources (Part 2 of 2)



emergency-wash.org

Questions

Herzlichen Dank !

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Thank you!