COSTEA REUSE STRUCTURING ACTION WASTEWATER REUSE IN AGRICULTURE

FINAL SYNTHESIS

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This report is on the final synthesis of the project. After chapter 1 describes the methodology, chapter 2 addresses the country syntheses based on a comparative table of quantitative elements, and chapter 3 presents an analytical synthesis organised around the four themes. Chapter 4 is devoted to the organisation and conclusion of the participatory workshops in the target countries, with particular reference to the 12 posters produced by the operators on this occasion. Chapter 5 focuses on the final seminar: the link with the FAO (Food and Agriculture Organisation) /OSS (Sahara and Sahel Observatory) approaches and the recommendations that emerged from it. The regulatory and institutional benchmark is the subject of a specific report.

INTRODUCTION

COSTEA (the Scientific and Technical Committee for Agricultural Water, French name: Comité Scientifique et Technique sur l'Eau Agricole), led by AFEID (French Association for Water, Irrigation and Drainage, French name: Association Française pour l'Eau, l'Irrigation et le Drainage) and financed by AFD, is a network that aims to promote the sharing of knowledge and experience between actors in irrigation in order to support agricultural water operations and policies.

The reuse of wastewater for irrigation (REUSE) in agriculture is widely practiced throughout the world, whether directly or indirectly, controlled or uncontrolled. With the growth of urban populations and development of sanitation, it is set to play an important role in integrated water resource management, especially when conventional resources are limited.

One of COSTEA's structuring actions, entitled 'REUSE', specifically aims to document wastewater reuse systems and experiences in six countries (Algeria, Bolivia, Morocco, Palestine, Senegal and Tunisia) in order to develop common and specific recommendations. It is coordinated by SCP (Société du Canal de Provence).

The general objective of this structuring action is to provide public actors and stakeholders the keys to develop and optimise the irrigation sector, in this case through REUSE operations.

Three specific objectives have been identified: 1/ Capitalise on successful experiences, 2/ Draw up recommendations for each country, 3/ Network experts and decision makers.

For each country, the structuring action mobilises **'national operators'** who play a role in collecting and analysing information, as well as producing deliverables according to a common methodology. These operators are in close contact with **'focal points'**, who are representatives of the main ministries concerned.
This project aims to work on **two distinct scales**:

- **reuse in peri-urban areas**, with significant volumes of treated wastewater (TWW), large irrigation schemes and often intensive purification processes;
- **reuse after decentralised sanitation systems** that produce smaller volumes of water.

The objective is not to oppose rural and urban but to address cases with different volumes of available water and different types of treatment, collection and even collective organisation.

Four work themes provide angles to characterise a REUSE operation:

- Theme 1: Unplanned REUSE, extensive treatments, sludge management;
- Theme 2: Governance, acceptability, consultation, training;
- Theme 3: Integrated water resource management and the economic impact of REUSE;
- Theme 4: Effectiveness of the equipment and practices.

Two teams are closely involved in producing the outputs:

- An international coordination team led by Société du Canal de Provence;
- Pairs of national operators for each of the six target countries.

The work is organised in five stages:

1. The **establishment** of a team of international experts and of a common intervention methodology,
2. A **synthesis in each target country** of the REUSE situation, and the production of reports,
3. For each country, the choice of two exemplary operations, and **the organisation of four participatory workshops**, two at national level and two at local level,
4. The drafting of a **regulatory and institutional benchmark** for the six target countries,
5. The holding of a **final feedback seminar** and the drafting of a report with recommendations.

1. METHODOLOGY ADOPTED

1.1 Terminology

Centralised sanitation system: characterised by a single, often large sewage network that gathers RWW to a single treatment site, as is often the case in urban areas.

Decentralised sanitation system: composed of several treatment sites served by often small sewage networks, and often characteristic of rural areas.

Direct REUSE: *'wastewater is mobilised at the outlet of a wastewater system, regardless of the level of treatment (simple sewer, or primary, secondary or tertiary wastewater treatment plant)'.*

Indirect REUSE: *'water is discharged to the natural environment, diluted with conventional water, and then pumped back for reuse, whether in a planned or unplanned scheme'.*

IWRM (integrated water resource management): multi-actor approach aimed at reconciling resources and uses, including natural environments, and based on a global qualitative and quantitative approach at the scale of a water basin.

Planned REUSE: *'the reuse of wastewater as part of a planned project in which the wastewater is properly treated and the water quality monitored, for that specific purpose'.*

Primary treatment: first stage of raw wastewater treatment, generally consisting of screening, de-gritting, oil removal, or even an anaerobic biological treatment phase.

REUSE: Reuse of treated or untreated wastewater.

RWW: Raw wastewater that can be of urban or industrial origin.

Secondary treatment: second stage of wastewater treatment following the primary treatment, and most often composed of a biological process by 'activated sludge', aeration basins then decanters.

Sludge: Solid by-product of wastewater treatment, rich in nutrients and sometimes including pollutants that need to be controlled.

Tertiary treatment: third stage of wastewater treatment following the secondary treatment, consisting of a filtration stage (e.g. sand filters) and/or a disinfection stage (e.g. UV lamps).

TWW: Wastewater that has been purified through treatment (treated wastewater), regardless of the level.

TWWR: Reuse of treated wastewater after it has been collected and passed through a treatment station.

Unplanned / informal / de facto REUSE: '*the reuse of treated or untreated wastewater, after discharge into the natural environment and possibly dilution with conventional surface or groundwater resources. Initially this reuse is incidental and unknowing; over time it may continue knowingly, but always outside of a planned project in which the wastewater would be properly treated and the water quality monitored, for that specific purpose*'.

WWTP or WWPP: Wastewater treatment or purification plant.

1.2 Development of the methodology and timetable

The project methodology was developed according to following timetable:

- The first semester of 2021 enabled a common working methodology to be discussed, detailed and rolled out;
- In January, pairs of national operators were selected for five of the target countries following interviews with COSTEA's Technical Secretariat and the international coordination team;
- In March, the proposed methodology was revised collectively with the pairs, and approved;
- In April, a kick-off meeting was held with the focal points of the target countries representing the main administrations concerned;
- In May, Bolivia joined the group;
- In July, adjustments to the content of the approach were decided for Tunisia in order to take account of the specific situation of this country which has been practicing REUSE since 1965.

In terms of deliverables, the table below gives an overview of the production periods of each phase of COSTEA's REUSE structuring action.

In terms of meetings and monitoring:

- Six meetings with the full team were held between April 2021 and March 2022;
- Three meetings were also held with COSTEA's 'REUSE' consultative group, on 08/07/21, 30/05/22 and 31/08/22;
- Regular monitoring with COSTEA's Scientific and Technical Committee was carried out.

1.3 Structure of the country synthesis reports

Each pair of national operators was in charge of preparing a synthesis report on the REUSE situation in the target country.

A plan was proposed by the coordination team then revised and approved by COSTEA's operators and Scientific and Technical Committee. The main chapters of this plan are as follows:

- Overview of the REUSE situation: national sanitation situation, projects and operations underway, regulatory framework and planning, research situation;
- Analysis of the situation from the perspective of the four COSTEA REUSE themes and using a SWOT matrix (strengths/weaknesses/opportunities/threats);
- Presentation of the multi-criteria analysis grid for the choice of sites, which will be used during the following stage.

1.4 Organisation of workshops in the target countries

This stage was central for **feedback** on successful national **experiences**, and for their **representativeness** on **both study scales**, on the **four COSTEA themes**.

Two workshops were held **at national level** with institutional actors (ministries, state agencies, research, civil society, etc.), and two workshops were held at **local level**.

National workshop 1

This first workshop marked the **launch** of the national approach. It aimed to present and validate the results of the documentary research (country synthesis, stage 2) and to select two local sites. These sites had to be of interest in the sense of COSTEA's overall REUSE approach, and correspond to the logic of the two levels of scale: a large peri-urban REUSE site, and a REUSE site organised around decentralised sanitation.

The sites were selected based on a multi-criteria evaluation applying each of the four COSTEA REUSE themes.

TOPICS	CRITERIA
T1 Reuse and environment	1.1 Informal, unplanned REUSE
	1.2 Environmental impact on surface- or groundwater
	1.3 Agronomic recycling of sludge
T 2 Governance and social	2.1 Local governance scheme
	2.2 Verification of the application of standards
	2.3 User commitment and acceptability
T3 IWRM and economics	3.1 IWRM (needs-resources approach by water basin)
	3.2 Water pricing
	3.3 Marketing of agricultural produce
T 4 Technique and sanitation	4.1 Tertiary treatment equipment
	4.2 Irrigation equipment
	4.3 Sanitary impact

Local workshops

Two local workshops were held, one for each of the selected sites (i.e. one site for each scale level). These workshops mainly brought together local users involved in REUSE operation: decentralised services, local authorities, WWTP managers, farmers, value chain actors, etc. They aimed to identify with the actors the main difficulties encountered and the key success factors.

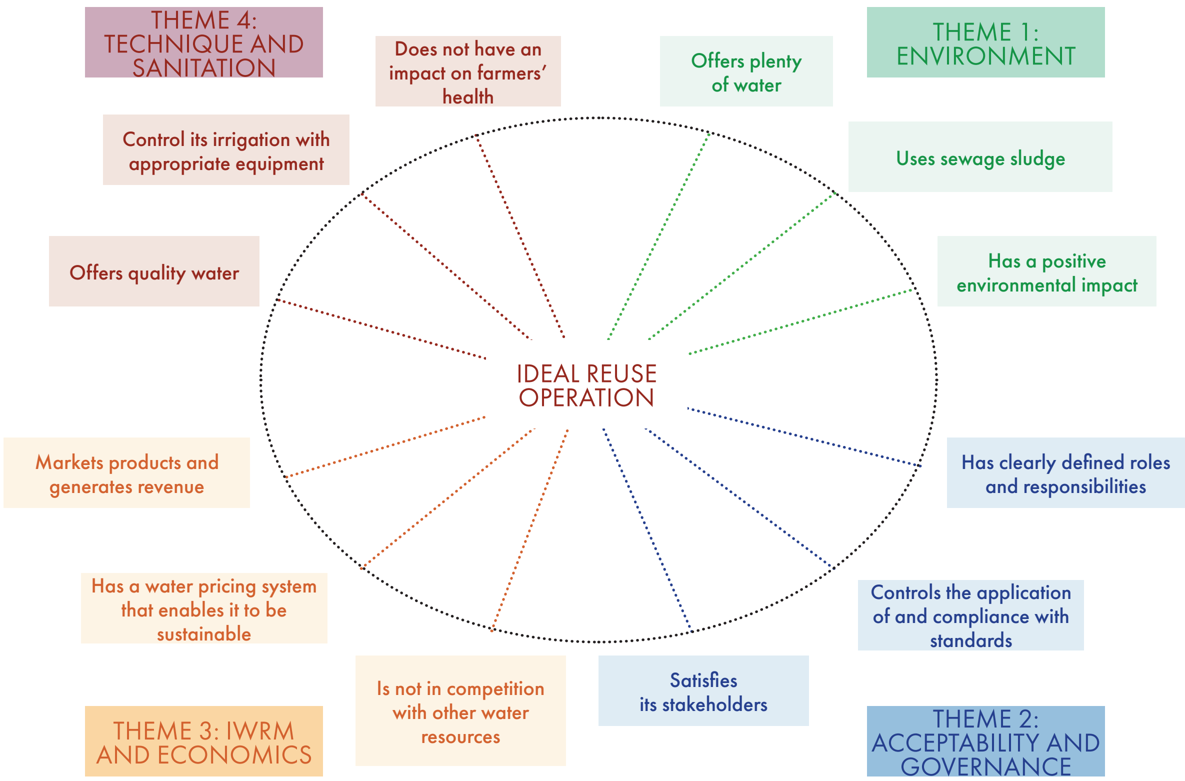
During the local workshops, the participants took part in the 'REUSE wheel' exercise, which aims to collectively determine the operating status of irrigated schemes.

National workshop 2

Once the two local workshops had taken place and their reports had been prepared, a second national workshop was organised, with the following objectives:

- **Report on** and discuss the content of the local workshops;
- **Formalise** national **recommendations** for the development of REUSE.

Figure 1: The REUSE wheel



This workshop was held with the institutional actors present at the first national workshop (ministries, state agencies, research, civil society, etc.). At least one representative from each local workshop participated to present the content of their local discussions.

NB: *The case of Algeria is a little different: a scientific meeting was held before the first national workshop with the institutions, and then the output was the subject of ongoing work with the focal point.*

1.5 Final feedback seminar

This seminar was **the culmination of the process**, with the following objectives:

i. Bring together all the actors who contributed to the COSTEA REUSE structuring action;

ii. Report on the work carried out;

iii. Take into account their comments;

iv. Agree on the collective follow-up to be given to this structuring action.

It brought together the national operators and their focal points for each of the six target countries, as well as OSS and FAO participants involved in REUSE networks.

Due to Tunisia's historical experience of REUSE, this country was chosen to host the seminar, which took place in Hammamet on 14 and 15 June, over two days. The seminar brought together some 50 participants from five of the target countries. The Algerian participants (operators and focal points) were unable to attend in person.

The timetable of the workshop was as follows:

- Tuesday 14 June

Morning: presentation of the Tunisian 2050 REUSE strategy, presentation of the 12 COSTEA REUSE sites (posters), presentation of the 'country' syntheses;
Afternoon: presentation of the transversal analyses, regulatory and institutional benchmark.

- Wednesday 15 June

Morning: presentation of the parallel FAO and OSS approaches, thematic discussions in workshops on the four COSTEA REUSE themes;
Afternoon: visit of the Nabeul SE4 treatment plant and of the irrigated scheme of Wadi Souhil.

1.6 Identification and characterisation of ongoing parallel approaches

REUSE, and more broadly the use of non-conventional water, is an ancient practice, which is not always regulated. It is now being promoted in a context of increasing pressure on water resources due to climate change on the one hand, and the development of sanitation on the other. Several **international organisations** have launched parallel approaches. We can note:

- **The OSS, with AFD,** whose current approach is focused on the conditions and good practices for the use of non-conventional water in the five African countries of the southern Mediterranean (Algeria, Egypt, Libya, Morocco and Tunisia):
  - national and regional syntheses,
  - high level regional workshop;
- **FAO, with the Arab Maghreb Union** (Algeria, Libya, Morocco, Mauritania and Tunisia), whose approach is focused on unlocking the agricultural potential of treated wastewater and drainage water:
  - cost-benefit analyses,
  - pilot sites,
  - collaborative platform.

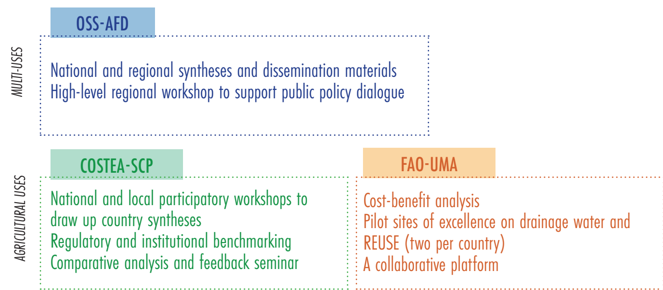
The objectives and content of the three FAO, OSS and COSTEA approaches vary.

Objectives

Three countries concerned: Algeria, Morocco, Tunisia

Content

Three countries concerned: Algeria, Morocco, Tunisia



In a logic of general interest, the different approaches must be **complementary** and bring specificities.

The specificities of the COSTEA REUSE approach are as follows:

- A **broad geographical approach** including three target countries outside the Maghreb zone: Bolivia, Palestine and Senegal;

- A **focus on a regulatory and institutional benchmark** (deliverable 4);
- A **participatory approach** through four workshops for each of the target countries: two national workshops and two local workshops (deliverable 3).

The OSS and FAO were contacted on several occasions for discussions, invited to the kick-off and final seminar, and informed of the 'country' seminars.

Efforts to forge closer links were made and should be continued to ensure this complementarity.

1.7 Specific cases, adjustments depending on the country

Tunisia, one of the six target countries, was recently the subject of a pilot site support initiative by the Mediterranean Water Institute (IME), and is currently the subject of the development of a national REUSE 2050 plan with AFD.

The Ministry of Agriculture wanted the COSTEA methodology to be adapted to take into account these two initiatives and avoid redundancy.

It was therefore requested that the 'country' synthesis report specifically focus its analysis on three themes:

- Communication and extension on REUSE,
- The agricultural value chains involved in REUSE, especially for the optimisation of irrigated production,
- The environmental impact of REUSE.

A specific agreement was signed between COSTEA and the Directorate-General for Rural Engineering and Water Exploitation (DGGREE) to formalise this change in the scope of Deliverable 2 'country synthesis' for the case of Tunisia.

2. SITUATIONAL OVERVIEW OF REUSE IN THE SIX TARGET COUNTRIES

A comparative overview of the REUSE situation in the six target countries was carried out. This work was based on the use of homogeneous and 'objective' characterisation criteria that were determined during working meetings on the methodology with the pairs of national operators in the first half of 2021.

2.1 Definition of objective criteria

The following is the list of REUSE characterisation criteria that was retained, organised into four main themes, and informed by the country synthesis reports.

Wastewater treatment installations:

- Number of WWPPs
- Type of treatment
- Volumes treated annually
- Proportion of tertiary treatment

REUSE operations:

- Start-up year
- Regulatory texts
- Planning documents (e.g. master plan)
- Number of 'operational' agricultural REUSE operations (= functional with system and users), and identification if their number is low (<7)
- Number of projects
- Annual volumes reused
- Irrigable areas
- Nature of other REUSE uses

Sewage sludge management:

- Planning documents (e.g. master plan)
- Tonnage produced annually
- Recovery chains
- Tonnage recovered

Research:

- Teams/laboratories
- Subjets addressed

2.2 Comparison in the target countries

This first table compares the state of play in the six target countries on the basis of the above criteria.

Table 1: Comparison in the 6 target countries

	Algeria	Bolivia	Morocco	Palestine	Senegal	Tunisia
PURIFICATION INSTALLATIONS						
Number of WWTPs	- 268 sanitation centres, - 200 WWTPs (2021).	- 230 WWTPs.	- 156 WWTPs and 8 offshore sewage outfalls, In 156 WWTPs, purification rate ≈ 66 %, - 79 WWTPs currently being built.	27 WWTPs: - 22 in the West Bank, - 5 in the GAZA Strip.	20 WWTPs in 2022. 17 sewage sludge treatment plants in 2022. In rural areas, open defecation is at 30 %.	- 123 WWTPs (2020).
Type of treatment	Of the 154 WWTPs managed by ONA: -> 76 activated sludge-type WWTPs, -> 75 natural lagoon-based or aerated WWTPs, -> 3 planted filters.	- Natural treatment systems (39 %) (stabilisation lagoons, natural wetlands, biofilters, dynamic aerobics). - Anaerobic technologies (38 %) (FAFA RAFA RALF anaerobic bioreactors). - Primary systems (22%) (septic tanks, Imhoff tanks, sedimentation chambers). - Aerobic technologies (1 %) (trickling filters).	-> 78 % = natural lagoon. -> 12 % = activated sludge. -> 4 % = trickling filters. -> 3 % = infiltration/percolation. -> 2 % = Aerobic decantation pre-treatment. -> 1 % = algal channel.	Of the 27 WWTPs: -> 8 activated sludge, -> 3 anaerobic/aerobic basins, -> 3 hydrid systems, -> 1 rotating biological contactor, -> 5 lagoon-based, -> 3 sedimentation basins, -> 2 membrane bioreactors, -> 1 trickling filter.	-> 6 activated sludge-type WWTPs. -> 14 natural lagoon-based WWTPs.	-> 77 % = low-rate activated sludge. -> 9 % = average-rate activated sludge -> 12 % = lagoon-based. -> 2 % = trickling filters.
Volumes treated annually	Volume of WW generated: = 1.6 billion m^3/year (2017). Volume treated in 2021: 400 million m^3.	275 million m^3/year.	Volume of TWW = 394.6 million m^3 (without counting the volumes discharged by offshore sewage outfalls).	Volumes of TWW (WB and Gaza) = 47.9 million m^3/an (volume of treated or untreated WW = 114 million m^3/an).	Volume of treated water: = 19.8 million m^3 (2021).	Volume of treated water: = 287 million m^3 (2020).
Proportion of tertiary treatment	No WWTP currently equipped, 16 planned.	No WWTP currently equipped.	67 WWTPs, i.e. 43 %, equipped for tertiary treatment (lagoon-based or filtering/disinfection).	Of the 22 WWTPs of the West Bank zone, only 8 are equipped for tertiary treatment.	Of the 20 WWTPs, 4 are equipped for tertiary treatment (3 with sand filtering and 1 lagoon-based).	Of the 66 WWTPs concerned by REUSE, 25 are equipped for tertiary treatment (maturation basins, sand filters, UV, or a combination of the three).
REUSE OPERATIONS						
Year of commencement	Formal reuse of wastewater for agricultural purposes started in 2007, which makes it a relatively new practice in Algeria.	REUSE was first reported in the 2012 irrigation inventory. National actions to promote REUSE for agricultural began in the 2010s, including the Bolivia-Germany-Mexico triangular cooperation project (COTRIMEX) and the formation of a joint intersectoral commission.	No large-scale formal agricultural REUSE operations to date. Numerous operations for other uses, however, since the 2000s.	The REUSE regulations were approved in 2012, while the regulations for sludge were approved in 2014. No operations before this date.	The practice began around the 1970s in Pikine, informally, after the rupture of an untreated wastewater pipe. It mainly concerns irrigation for market gardening.	REUSE has been practised in Tunisia since the 1960s.
Regulatory texts	'Legal arsenal' put in place to protect users and managers. 1. Legislative framework: law 05-12 of 4 August 2005 on water (articles 76 and 78); 2. Regulatory framework: Decree 07-149 of 20 May 2007 + inter-ministerial implementing order of 02/01/2012; 3. Regulatory framework: Technical guide for good REUSE practices + Algerian standard NA 17683.	No specific regulatory framework for the reuse of treated wastewater. The existing framework to protect water resources is made up of: 1. The Bolivian Constitution, articles 342, 345, 347, 373 and 374; 2. Law 031. Framework law on autonomy and decentralisation; 3. Law 1333 on the environment and its regulations; 4. Law 2878 on the promotion and support of the irrigation sector for agricultural production, livestock and forestry; 5. Law 745: Decade Law on Irrigation 2015-2025; 6. Law 300: Law Mother Earth (Loi Mère-Terre).	1. Water law 10-95, revised in 2016 to become the new water law 36-15. 2. Decree no. 2-97-657 of 4 February 1998 on the use of wastewater. 4. Order 1276-01 of 17 October 2002 establishing quality standards for water intended for irrigation. 5. Order of 2006 on specific domestic limit values.	1. Palestinian water law 14 (2014). 2. Palestinian environmental law 7 (1999). 3. Guidelines for using reclaimed wastewater in agriculture (2010). 4. The Palestinian treated wastewater standard (technical specification) (2012). 5. Law on the association of water users (2018).	Sanitation governed in Senegal by law 2009-24 of 8 July 2009 on the Sanitation Code - Reuse of treated wastewater: articles L74 to L78.	Legal arsenal in place for reuse of treated wastewater: 1. Decree of July 1989 establishing the terms and conditions for reuse of treated wastewater in agriculture; 2. Standard on the quality of TWW, NT 106.03, revised by a ministerial order of March 2018; 3. Order of June 1994 on the list of authorised crops.

	Algeria	Bolivia	Morocco	Palestine	Senegal	Tunisia
Planning documents (ex: master plan)	Strategic plan of AGIRE (Agence de gestion intégrée des ressources en eau, Integrated Water Resource Management Agency) for the five-year period 2020-2024. General study for the identification of reuse sites (2021).	The government plan 2020-2025, known as 'The Patriotic Agenda 2025', mentions TWWR briefly but does not contain a specific strategic planning document for it. The sectoral plan for integral development (PSDI) of the Ministry of the Environment and Water (MMAyA), and in particular, the national wastewater treatment strategy (ENTAR), currently being drawn up, which contains guidelines and objectives related to REUSE.	- National water plan (2020-2050) in the process of being finalised, - National mutual sanitation plan 2018 (PNAM), - National liquid sanitation plan (PNA), - National rural sanitation programme (PNAR), - National programme for the reuse of purified wastewater (PNREU), - National programme for drinking and irrigation water supply (PNAEPI), - Forecasts of the Directorate for Irrigation and Agricultural Land Use Planning (DIAEA, 2014), - CESAR project 2015-2020 (creation of job prospects in the rural sanitation sector in Morocco).	PWA National Water Sector Strategic Plan and Action Plan (2017-2022): one of the five strategic objectives concerns water treatment and reuse.	Integrated water resource management action plan (2020-2035). The TWWR is mentioned in a section devoted to the recovery of water for growth and food security.	National 'REUSE 2050' plan being drawn up in 2021.
Number of formal 'operational' agricultural REUSE operations	Of the 200 WWTPs, 17 reuse treated wastewater for irrigation purposes.	Estimate: 81 systems irrigated with REUSE, for the most part informal Formal REUSE apparently only concerns 4 WWTPs in the country. 26 % (56) of the WWTPs are concerned by informal REUSE.	No large-scale agricultural REUSE projects are operational. Small-scale pilot projects are in operation (400 to 1000 m³/day).	There are few planned and unplanned TWWR activities in Palestine: REUSE planned in Jenin, Ramallah and Nablus. - Jericho operational: date palm irrigation. REUSE of 82% of treated effluent. Farmers pay 0.15€/m3 of water and are responsible for pumping. - Jenin operational (TWW = 2 200 m³/d): irrigation of 5 000 dunums (= 500 ha) of fodder crops (alfalfa) and fruit trees.	Three pilot operations with tertiary treatment (filtration/disinfection) have been set up. - Cambérène wastewater treatment plant: used for agriculture by the producers of Patte d'Oie, 1 000 m³/d pilot (FAO 2010 project with ONAS and UPROVAN (Producers' Organisation of the Valley of Niayes). - Pikine water treatment plant: 1 000 m³/d pilot. Uncontrolled reuse of RWW is reduced to 8 % in the Niayes of Patte d'Oie and Pikine. Thiès with a capacity of 3000 m³ per day used by producers in the Commune of Fandène.	31 irrigated schemes.
Number of projects	The five-year '2021-2024' plan: launch of works for which studies have been carried out. A further 4 800 hectares for an investment of more than DZD 6 billion. The wilayas concerned are Sidi Bel Abbes, Boumerdès, Oum El Bouaghi, Khenchela, Laghouat and Médéa.	Two or three TWWR projects are being studied. This does not take into account informal REUSE.	Three large-scale agricultural REUSE projects (Tiznit, Settat and Oujda)	Project in the commune of Naplouse: irrigation of more than 3 000 dunums (= 300 ha) using TWW.	No projects currently under preparation	9 creation/extension operations covering 2 190 ha and 3 rehabilitation operations totalling 712 ha, with a start-up for most of them in 2020-2021.
Annual volumes reused	In 2020, a volume of 18 million m³ of purified water was used for agricultural purposes to irrigate 11 494 hectares, including fruit trees (date palms, olive trees, etc.) and some cereals such as barley, wheat and oats.	Information not available but the volumes are presumably low.	20 million m³/year in 2021. Small-scale projects: 400 to 1000 m³/d (DIAEA, 2014): Potential REUSE estimated at 550 million m³ (horizon 2030);	The volume of TWWR used annually for agriculture in Gaza was approximately 1.0 million m³ of the 77.7 million m³ recuperated. In the West Bank, the volume reused did not exceed this limit out of 8.0 million m³ recuperated.	Cambérène/Patte d'Oie: 1 000 m³/d, Pikine: idem Total 600 000 m³/year	The volume of TWW consumed per crop year varied from 8 million m³ in 2002-2003 to 18.3 million m³ in 2007-2008. For the 2018-2019 crop year it was 12.4 million m³. This variability is mainly due to rainfall.

	Algeria	Bolivia	Morocco	Palestine	Senegal	Tunisia
Areas equipped with formal REUSE	16 000 ha equipped in 2021.	7 000 ha, equivalent to 2 % of the country's irrigated production area, come from the direct and indirect reuse of wastewater.	Potential irrigable area ≈ between 65 000 ha and 130 000 ha (with storage)		Cambérène/Patte d'Oie: 35 ha, 112 farmers Pikine: 25 ha, 80 farmers	Irrigable area of 7 437 ha. The average intensification rate observed over the 2000-2019 period is 41 % (irrigated area/ irrigable area).
Types of other REUSE uses	- Indirect REUSE (discharge of TWW upstream of dams/ percolation into groundwater), - Unplanned/uncontrolled REUSE (informal recovery), - Municipal REUSE (city cleaning and civil protection against fires + green areas), - Industrial REUSE, - Groundwater recharge only at the stage of reflection.	- Mineral washing, - Manufacturing of adobe, - Car washing, - Irrigation of parks and gardens. However, no information was found on the corresponding volumes, most of these practices are informal. Energy production with capture of methane produced in the treatment plant of the city of Santa Cruz.	Significant development of non-agricultural TWWR: - 23 golf courses irrigated with TWW, - 3 green spaces (Tangiers and Tetouan) + the ecological park of Oujda + the green belt of Ouarzazate, - Industrial: main operation = phosphate washing + Emerging projects: -> Forestry (palm groves of Marrakech), -> Groundwater search option.	Ramallah municipality - 2020 (2 WWPPs) for REUSE for green areas, roadsides, public gardens, allotments + road works and street cleaning. Freshwater saving of 300 m^3/d.	TWW is currently only used for agriculture in Senegal.	Mainly environmental REUSE (volumes greater than agricultural REUSE), but poorly characterised. Limited experience of REUSE on urban green spaces. Many cases of REUSE on golf courses. Some cases of industrial REUSE (phosphates in Gabes). Some groundwater recharge operations being tested.
			SLUDGE MANAGEMENT			
Regulation, planning	No regulations. Existence of quality standards NA IANOR 17671 and 17672 on the quality of sludge and sewage sludge composts. No masterplan	No, this does not exist in Bolivia.	National strategy for treatment plant sludge management developed in 2020: The recommendations of this strategy have not yet been concretised.	The Palestinian regulations for sludge treatment and reuse are very strict, none of the service providers have achieved the necessary indicator levels for reuse in agriculture.	Sanitation governed in Senegal by law 2009-24 of 8 July 2009 on the Sanitation Code: - Sludge: articles L79 to L88 There is no national plan but some communes have sanitation master plans.	A national action plan in 2006. Four regional masterplans between 2015 and 2016 (Greater Tunis, North, Centre and South). Investment programmes. Sludge regulation: 1. standard NT 106.20, 2. order 2006 approving the specifications on sludge reclaim for agricultural purposes, 3. decree 2007-13 on sludge management for agricultural purposes.
Tonnage produced annually	250 000 tons/year of dry matter (2012)	There is no monitoring of sludge management in Bolivia. The average is estimated at 50 l/pers./ year	110 000 tons/year of dry matter (2019). Evolution to 500 000 tons of dry matter in 2030.	No information.	More than 100 000 tons of dry matter per year in 2021. Today, sludge management in Senegal is mainly carried out at treatment plants for sewage from septic tanks.	197 000 tons/year of dry matter (2020).
Recovery chains	Agricultural sector. Two biogas production projects by methanisation.	Agricultural production.	No reference for sludge recovery. - Direct storage on site (dominant option), - Landfill (fairly common option), - Use with little or no control by farmers (relatively rare option), - Energy recovery (experimental stage).	Lack of good sludge management practices. Only the municipality of Nablus uses dewatered sludge to produce biogas.	Agricultural recovery after summary treatment. There is a whole chain for the recovery of septage for market gardening activities in the Niayes area. The ONAS and Bill and Melinda Gates Foundation project (2018) in the Niayes area for the thermal treatment of septage.	Three management chains envisaged: green chain (agricultural recovery), red chain (energy or cement recovery) and black chain (landfill). The four regional masterplans of 2015-16 steer towards a given chain depending on the local context. Agricultural recovery tested at the pilot stage with encouraging results, but not yet launched large-scale.
Tonnage recovered	25 % of sludge produced, i.e., 62.5 tons	Very marginal volume, only on one identified irrigated scheme, the subject of the field workshops.	No real chain for sludge recovery in Morocco.	No information.	No information.	2019: 2 500 tons of dry sludge matter recovered in agriculture. 9 WWPPs whose sludge is recovered. -> 450 ha spread.

	Algeria	Bolivia	Morocco	Palestine	Senegal	Tunisia
RESEARCH						
Teams / laboratories	National Polytechnic School (ENP-Algiers), Water Science Research Laboratory National Graduate School of Agronomics (ENSA-El Harrach-Algiers) Tipaza University Centre Djilali Bounaama University of Khemis Miliana Biotechnology Research Centre Ali Mendjli of Constantine.	Research undertaken by institutions, universities, NGOs in coordination with agencies of the Ministry of the Environment or funding and cooperation agencies. Among the most relevant are the departments of agronomy, sanitary engineering and environment of the main universities such as: - Centro de Aguas y Saneamiento Ambiental of Universidad Mayor de San Simón (UMSS), - the Institute of Sanitary and Environmental Engineering of Universidad Mayor de San Andrés (UMSA); Partners: German, Swedish, French, Spanish and Japanese cooperation; the European Union; the UN; and among the NGOs, Aguatuya.	Approximately 40 researchers (excluding PhDs and students). 17 laboratories & departments. 7980 scientific publications (2010-2020) on Google Scholar.	Scientific research mainly led by the water and environment departments of the main universities. For example, of 41 articles: 17 are theses & 2 are doctoral research. + three international research programmes.	IFAN: Fundamental Institute of Black Africa University of Cheikh Anta Diop Graduate Polytechnic School of Thiès including the water engineering department.	National Institute of Research in Rural Engineering, Water and Forests (INRGREF) National Institute of Agronomic Research in Tunisia (INRAT) Centre of Research and Technology on Water (CERTE) International Centre for Environmental Technologies of Tunis (CITET) University of Manouba (UMA) National Engineering School of Sfax (ENIS).
Subjects addressed	- Effect of irrigation on strawberry cultivation; - Life cycle analysis of cucumber production (TWWR irrigation vs. groundwater); - TWWR for irrigation and groundwater protection; - States of the art; - Mapping of soils and TWWR; - Long term impact of TWWR on soils.	- Regulation, - Water quality - Treatment efficiency - Studies related to specific sites. Little information on the treatment and reuse of sludge.	Treatment – reuse of wastewater in agriculture. -> Biological quality of TWW and health risks, -> Physicochemical quality of WW, -> Purification performances, -> TWWR practices in agriculture, -> Socio-economic dimension of TWWR projects, -> Epidemiological investigations, -> Treatment and recovery of sludge, -> Innovation in WW purification technologies, -> Ecotoxicology, -> Models for integrating REUSE into IWRM, -> Impact of TWWR on soil and water quality. + International cooperation/pilot projects for experimentation and research.	The three programmes support 176 research projects in the water sector, 26 of which are related to water reuse and agriculture. The themes are varied: - Evaluation of the efficiency of treatment methods in treatment plants, - Agronomic efficiency of REUSE, - Effect of the reuse of sludge/biosolids on soil quality, - Comprehensive studies on the impact of TWWR on the physicochemical quality of soils and the quality parameters of olive oil.	Study area: peri-urban market gardening areas in Dakar - Health impacts of REUSE in peri-urban market gardening, contamination of agricultural products and groundwater; - Impact of REUSE on soils, heavy metals, salinisation; - Impact of REUSE on groundwater quality. Also applied research projects on extensive treatments (macrophyte lagoon-based, infiltration percolation).	INRGREF: TWW and sludge characterisation, fertiliser value, environmental risk, micropollutants and emerging pollutants, microbiological health risk, irrigation systems. INRAT: economic, institutional and social aspects of REUSE CERTE: water treatment, innovations in disinfection, phytodepuration, nanofiltration, impact of sludge spreading UMA: water treatment, biotechnology ENIS: water treatment, environmental impact of REUSE

2.3 Intermediary conclusions

Algeria

Algeria is facing increasing **water stress**. Every year, it loses 20% of its renewable water resources on average (the filling rate of operating dams throughout the country is falling). This is alarming given that urban and agricultural water consumption is constantly rising. **This situation recently prompted the public authorities to think about alternative solutions**, and in particular to reconsider the question of reusing non-conventional water.

In this respect, the **Minister for Water Resources** recently advocated the reuse of wastewater and the desalination of sea water. According to him, for the time being, non-conventional resources constitute 'palliative resources' to the water stress Algeria is facing.

In 2017, the annual volume of wastewater generated by the Algerian population was 1.6 billion m^3/year, distributed throughout the country's 1 541 communes, of which 1.2 billion m^3 were collected in 1 125 communes managed by the ONA.

As for **treatment and purification facilities**, Algeria has made **significant progress in terms of basic infrastructure**. The number of purification plants increased from 28 WWTPs with a treatment capacity of 98 million m^3/year in 1999 to 177 in 2016, and reached 200 in operation in 2021 with a capacity of 1 000 million m^3. The actual production is currently 400 million m^3.

Of the 200 WWPPs in operation in 2021, 17 (10 aerated lagoon-based and 7 activated sludge) are used for TWWR for irrigation purposes. In 2020, a volume of 18 million m^3 of treated water was used for agricultural purposes for the irrigation of 11 500 hectares, including fruit trees (date palms, olive trees, etc.) and some cereals such as barley, wheat and oats.

The **informal reuse** of treated wastewater remains significant, although it is poorly documented.

The use of TWW for irrigation purposes under concession requires close coordination between different stakeholders involved at all levels, and is governed by regulations.

The technical control, the management of irrigated schemes and the sanitary control as well as the quality of the purified water and agricultural products are ensured by the **territorial directorates of each wilaya** under the supervision of different ministries: water resources, agriculture, health, environment and trade.

The TWWR governance process consists of three interconnected stages, namely the concession study, the sanitary control and the use of the water. Each stage involves a number of actors.

In **rural areas not connected to the public sewage system**, i.e. **20% of the total population in 2015**, the inhabitants mainly use autonomous sanitation through septic tanks. In the Ghardaïa region, unplanned REUSE initiatives are carried out by local actors such as farmers and civil society.

Algeria currently has **no regulations on sludge management**. However, quality values for sludge and sludge composts have been established by the Ministry of Water Resources and have been classified as **national standards by IANOR**.

The absence of regulations on the agricultural recovery of sludge has led to almost 60% of the sludge generated by urban wastewater treatment plants being sent to landfill and 15% to storage. According to the ONA, only 25% of the 250 000 tonnes of sludge produced in 2012 was recovered for agricultural purposes.

According to surveys conducted by the Ministry of Water Resources between 2018 and 2020, the areas that could be irrigated by TWW were 45 000 hectares from 81 purification systems (WWPPs and lagoons) in operation and under construction.

By way of example, SEAAL (water and sanitation company of Algiers) and ONID (national irrigation and drainage office) have developed a joint strategy to respond to the current emergency in the Mitidja plain. This strategy is an institutional innovation in response to a difficult water context: in irrigated agricultural sectors, substituting TWWR for agricultural water withdrawals from dams in order to exclusively direct the small volume of water available in dams towards drinking water.

The SWOT diagnosis of Algeria highlights real potential for agricultural REUSE linked to the development of sanitation on the one hand (increase in the available TWW resource) and to strong pressure on conventional water, especially the low filling of dams (other resources becoming scarcer). The main problem is institutional: lack of coordination between the various stakeholders at different levels, lack of involvement of civil society, low recovery rate.

Bolivia

The recent Political Constitution of the State (CPE) approved in February 2009, determines **access to water as a fundamental human right for life**, as a strategic resource under the control of the State.

Although Bolivia **does not have a specific regulatory framework for water reuse**, it does have a regulatory framework for the conservation, protection and use of water resources. The regulatory framework for the planning, management and use of water resources in the country is very dispersed. The current regulations of law 1333 on the environment are very restrictive in terms of quality standards, which represents a real difficulty for the promotion of reuse.

Each sector has its own regulations in this area, which **does not allow for overall water planning in the territories**.

In recent years, some strategic tools and regulations have been proposed that consider reuse in the country as an alternative to increase agricultural production under irrigation.

With regard to wastewater treatment, **only 22% of the more than 200 existing WWPPs are in good condition**. Most wastewater is not treated at all and the sanitation coverage is only 30%, which is much lower than the 90% coverage for drinking water. Natural systems (lagoon-based) and anaerobic technologies are the most widely used for wastewater treatment in the country.

The sustainability of the WWPPs is threatened by the connection of **industrial effluents** to the sewage systems (untreated micropollutants) and by the **amount of the sanitation fee**, which in most cases does not cover the operation and maintenance costs.

The case of the Knowledge Node for Decentralised Sustainable Sanitation in Bolivia (NSSD) (2009-2015) is noteworthy. This initiative sought to promote knowledge and the implementation of **alternative decentralised sustainable sanitation systems** in Bolivia (semi-decentralised WWPPs and dry toilets).

Most wastewater reuse in the country is for agricultural purposes. It is estimated that more than 7 000 ha, equivalent to 2% of the country's irrigated production area, are under direct and indirect wastewater reuse. About 78% of agricultural reuse is concentrated in Cochabamba and La Paz. **TWW from about 40% of the country's WWPPs is reused indirectly**, with the effluent being mixed with natural rivers and reused downstream. Direct reuse of effluent is practiced in 8% of WWPPs. The discharged water undergoes some degree of additional treatment for reuse in only 14% of WWPPs.

Similarly to treatment, the issue of reuse tariffs is not developed. These **TWWR systems are self-managed**, which means that the infrastructures, water rights, organisation, operation and maintenance are handled by the farmers themselves. Consequently, any payments or contributions in kind or in labour for the operation and maintenance of the irrigation systems are focused exclusively on repair and corrective maintenance and are not considered as fees.

With regard to **water quality** for reuse, as mentioned above, no specific standards exist. However, **liquid discharges from WWTPs** have to comply with the admissible limits for 25 parameters. In addition, the **classification of watercourses** and water bodies according to their quality and suitability for use (and reuse) must be carried out in strict compliance with 80 parameters and their respective maximum admissible values. Furthermore, reuse is only envisaged for the production of tall crops and not for the production of vegetables.

The country's experience in terms of sludge management and reuse is still limited; there is no accounting on sludge production. Most of the sludge, after the drying bed, is reused in agriculture, but without prior assessment of its quality and pathogen content.
With regard to studies and documentation on reuse in the country, their examination shows that most of the documents deal with the national reuse situation in a general manner with information on the regulations and technical tools for the environment and water resources.

The SWOT diagnosis of Bolivia highlights an essentially unplanned agricultural REUSE, managed by local irrigation committees with flexible operation; the institutional difficulties of the French-speaking Maghreb countries are not encountered. The principle of evaluating the quality of surface water and not that of treated wastewater is a real asset for integrating REUSE into IWRM. The downside of this unplanned use of TWW is the poor management of the sanitary risk.

Morocco

Morocco has been involved in **water planning and mobilisation** since 1960. The institutional framework is based on water resource management on the scale of catchment areas by **specialised agencies** (ABHs), and the general legislative framework is constituted by law 10-95 of 16 August 1995, updated by the new water law 36-15 of 10 August 2016 for 'integrated, decentralised and participatory management of water resources'. In the context of climate change, Morocco has anticipated a number of adaptation measures (water saving, use efficiency, flood control, etc.).

Significant efforts have been made to **mobilise ground and surface water resources.** Large **hydraulic infrastructures** have been set up at a sustained pace, particularly inter-basin water transfer systems to meet sectoral needs, essentially for agriculture.

The **2020-2027 priority programme** aims to achieve objectives in two vital sectors that are highly threatened by climate change: securing drinking water supply in rural areas and meeting irrigation needs. In particular, it advocates **saving water through localised irrigation and increasing supply by using non-conventional water**, including treated wastewater.

The **liquid sanitation sector** has undergone a notable evolution in recent years: (i) a connection rate to the network of around 76% in 2019 compared to 70% in 2005; and (ii) a purification rate of 66% with marine outfalls and 55% without outfalls in 2019 compared to 7% recorded in 2005. The stock of purification plants includes 156 completed WWTPs and 8 marine outfalls; 79 WWTPs are under construction. The volume of treated wastewater is approximately 400 million m3 (excluding outfalls). According to the 2019 National Mutualised Sanitation Programme (Plan National de l'Assainissement Mutualisé 2018, PNAM) dashboard, the **intensity of treatment** is increasing: between 2014 and 2019 the percentage of primary treatment went from 17% to 6%, secondary treatment from 42% to 51% and tertiary treatment (including full lagooning) from 41% to 43%.

Despite a strong national will to develop agricultural REUSE (numerous national plans), **it is struggling to do so: no large-scale project has yet seen the light of day in Morocco**. Only small pilot projects (400 to 1 000 m3/day for a maximum area of approximately 1.5 ha) have been carried out and have made it possible to develop technical reference systems and to strengthen scientific skills, which are fairly well documented.

While the reuse of TWW for agricultural purposes is in a situation mixed between blockage and attempted start-up (20 million m^3/year in 2021), **other uses**, such as watering golf courses and green spaces (43 million m^3/year) and phosphate washing (industrial use piloted by OCP - 10.3 million m^3/year), have proven to be operational and remain candidates for development strongly supported by the Moroccan government.

Sludge management is not sufficiently integrated into the 'water' chain, although initiatives have intensified in the last decade, encouraged by the PNAM. One example is the technical assistance provided by AFD to establish good sludge management practices adapted to the purification systems and the soil and agro-climatic context of the intervention zones.

The **SWOT diagnosis** of Morocco highlights that REUSE for agriculture is neglected compared to urban or industrial uses. The main reason is economic. Given agricultural users' ability to pay, and in the absence of significant subsidies (notably to cover the CAPEX and OPEX of tertiary treatments), the projects do not reach breakeven. The research activity on REUSE, on the other hand, is a strength on which the authorities can rely to develop the practice.

Palestine

With the scarcity of water resources and the loss of access to water related to the Israeli occupation, Palestine considers treated wastewater as one of the sources of water that can be used for different purposes such as agriculture. **Wastewater must be recognised as part of the total water cycle.**

The Palestinian Water Authority (PWA) considers REUSE as one of the five strategic objectives 2017-2021 for the water sector. This was already the case in the previous strategic objectives 2012-2016.

More than two thirds of the wastewater collected in the West Bank and Gaza is currently treated in WWTPs. The total volume of wastewater generated in Palestine is 114 million m^3/year but only 47.9 million m^3 of treated wastewater is produced each year by the country's 22 WWTPs.

If all the wastewater generated was reused, it would be possible to reduce the gap between supply and demand by 14%. However, not all of the treated wastewater meets the REUSE specifications and standards established between 2010 and 2012, in particular due to the deficient operation of some treatment plants.

One of the main challenges for the Palestinian water authorities is the **management of 'transboundary water'** in the West Bank (15 million m^3/year): where there is no treatment plant, water can cross the borders into Israel, where it will be treated (at the expense of the Palestinian government) and reused by Israeli farmers (Paris Agreement). There is a real issue at stake for Palestine to treat and reuse this wastewater locally.

The **funding agencies** (KFW, AFD, JICA, USAid) are very active in sanitation in general and REUSE in particular.

There are already **REUSE operations** after tertiary treatment in Nablus (2 KFW and USAid pilots, agricultural use), Jericho (informal REUSE, agricultural use), Ramallah (green areas), Jenin (planned REUSE, on 500 ha) and Gaza (for less than 5% of wastewater). Most of the other large agglomerations in Gaza and the West Bank also have REUSE projects. There are also about 15 small treatment plants that practice REUSE, often after extensive treatment.

There is **no experience of sludge management** on an operational scale; all of the practices and projects are either at the pilot or research project stages.

Scientific research in the water sector in general is primarily carried out by the water and environment departments of the main universities (Alquds, Birzeit, AnNajah, and to a lesser extent Bethlehem University and the Arab American University of Jenin). The main actor in research is Birzeit University. Research themes included the impact of REUSE on crops and soils and alternative treatments (e.g. planted filters).

Farmers' **acceptance of REUSE** was also surveyed among 115 farmers in the West Bank, showing that 75% of them were willing to cultivate with TWW, the main decisive factor being the absence of conventional resources.

The **SWOT diagnosis** of Palestine highlights the urgency of deploying REUSE, on the Gaza side to develop an excessively scarce resource and fight against the territory's food dependency, and on the West Bank side to develop local irrigated agriculture and avoid paying pollution fees to Israel. The main obstacles come from a lack of political will and a governance structure that is still ill-defined.

Senegal

The sanitation situation is still precarious in Senegal, even though sanitation networks and treatment plants are being developed. Non-collective sanitation through latrines and septic tanks is high, generating septage rather than treated wastewater. Open defecation still concerns 30% of the rural population.

Informal REUSE started in 1970 following the rupture of a raw sewage pipe. It mainly concerns market gardening, with proven negative health impacts on the population.

The country currently has a **legal, institutional and regulatory framework** for REUSE.

However, only **three 'pilot' cases of planned REUSE** have been identified, supported by the WHO and the FAO. These sites are located in the northern periphery of Dakar (**Niayes sector of Patte d'Oie and Pikine**, with flows of 1 000 m^3/d for each, and in the Thiès area). The water is mainly used for market gardening. Tertiary sand filtration treatments are implemented.

The project has enabled the annual supply of about 600 000 m^3, half of which, from the Cambérène station, supplies the farmers of Patte d'Oie on approximately 35 ha. The other half, from the Niayes station, supplies farmers of Pikine on about 25 ha. The Thiès station supplies farmers in Fandène on more than 15 ha.

Farmers are interested in REUSE to cope with the rising costs of conventional water, for which they are competing with urban uses that are increasing due to demographic changes.

The management of REUSE is complex from an **institutional, organisational and regulatory point of view** as it involves the Hygiene Department (Ministry of Health), the Sanitation Department (Ministry of Water and Sanitation), the Horticulture Department (Ministry of Agriculture and Livestock), the Urban Planning Department (Ministry of Urban Planning and Spatial Planning), and finally, the municipality. Due to the multitude of actors involved in the sector, it is impossible to develop it sustainably without concerted efforts to organise local governance.

From a technical point of view, the **ONAS** ensures the management of the sanitation facilities, although there is a trend towards delegation from the public service to the private sector. There is little agricultural technical support that takes into account the specificity of the irrigation source.

The main **reuse of sludge** currently concerns **septage** from non-collective or semi-collective sanitation (latrines). Agricultural recovery takes place after a summary treatment. In this context, there is currently a whole recovery chain for septage in market gardening activities in the Niayes area, which have already been studied for informal REUSE and for the two pilot sites of Patte d'Oie and Pikine.

The Gates Foundation is supporting a project for the **thermal treatment of septage** to disinfect it and improve its use from a health point of view.

The **SWOT analysis** of Senegal highlights the political will to develop REUSE to support agriculture in peri-urban areas and to limit groundwater pollution. Farmers are also in favour, but are faced with significant urban expansion and uncertain sanitary conditions due to the lack of wastewater treatment and monitoring of its quality.

Tunisia

There were 122 treatment plants in 2020. This infrastructure, the result of a massive equipment campaign in the 1990s, is now ageing: **54 treatment plants are over 20 years old** and about 20 are over 30 years old. A major **rehabilitation/extension programme** is being implemented by the ONAS. 287 million m^3 are treated annually.

Agricultural REUSE began in 1965 in Tunisia. According to the latest available report on REUSE, there are **31 irrigated schemes** with an irrigable area of 7 437 ha. This area has increased by 20% since 1998 (6 200 ha).

In the 2018-2019 season, only 22 irrigated perimeters (IPs) were functional with an area of 6 387 ha (86%). The reasons for **non-functionality** are: lack of interest in some IPs located in the north of the country, which is relatively endowed with rainwater, the quality of TWW, power cuts, and non-functional networks and equipment.

The **REUSE regulatory framework** is in place, with a 1989 decree, a 1994 order, and a quality standard that was revised in March 2018. However, at present, while physico-chemical analyses are carried out in the majority of IPs using TWW, bacteriological analyses are less frequent. Sanitary measures (protective equipment for farmers, vaccination, prohibition of direct grazing) as defined in the REUSE specifications are often not respected. No monitoring of salinity or soil is carried out in the majority of IPs using TWW.

With regard to sludge, Tunisia's regulatory framework aims to **protect public health and soils** under the country's specific climatic conditions. **Restrictions** on use are applicable for market gardening. It is also forbidden to use liquid sludge and unsanitised sludge.

Still on the topic of sludge, a first general study was carried out in 2006 in the form of an **action plan** that covered the various technical, financial and institutional aspects of sludge management in treatment plants. It was followed in 2015-2016 by **four regional master plans** (Greater Tunis, North, Centre and South) which defined:

- the different treatment/recovery chains;
- a plan for the necessary infrastructure for 2035;
- a priority investment programme;
- and accompanying measures.

The value chains defined are the **green chain** (agricultural recovery), the **red chain** (energy recovery in the cement industry) and the **black chain** (burial).

The focuses of REUSE research in Tunisia, led by six main organisations, have covered the following main areas:

- Techniques to **improve the quality of TWW** upstream of its reuse;
- **Agricultural techniques and practices to optimise TWWR** in agriculture (irrigation systems, storage, fertilisation, tillage, etc.);
- **Environmental impacts;**
- **Health impacts** for users and consumers;
- More marginally, aspects related to **governance**, including socioeconomic, institutional and social aspects.

The **SWOT analysis** of Tunisia shows that in the face of the country's hydrological situation and the increasing sensitivity of receiving environments, the State is aware of the importance of REUSE. A new legal framework and structural planning studies are being developed. However, this ambition is constrained by a stock of treatment installations requiring major rehabilitation and a crisis of confidence that the authorities will have to contain to reassure users and recover operating costs.

3. ANALYTICAL SUMMARY OF THE NATIONAL SITUATIONS

This chapter takes up and organises the lessons learned from the 'country' synthesis reports from the perspective of the four COSTEA REUSE themes. Firstly, the four themes are explained. A complete table of analysis by country is then presented. Finally, a comparative analysis of the situation between countries is produced, highlighting common points and specificities.

3.1 Explanation of the principle

The previous chapter presents an overview of the REUSE situation by country.

This chapter presents an analysis thereof, focusing on the four themes that form the backbone of the COSTEA REUSE approach, and whose stakes were made explicit during a COSTEA REUSE workshop in Lyon in November 2018.

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Theme 1: Unplanned REUSE, rural sanitation, sludge management

- The reuse of raw wastewater is still in the majority in the world (90% of wastewater volumes reused). This practice, which is prohibited in each of the target countries, is not concerned by COSTEA's REUSE approach. On the other hand, 'informal' REUSE, and/or 'indirect' REUSE, where TWW discharged into the receiving environment is reused downstream of the point of discharge, merit better understanding, particularly by decision-makers, and greater analysis in order to assess the benefits and risks.
- The environmental impact of REUSE on surface or underground aquatic environments (removal of pollution by the discharge, potential substitution of volumes) should be taken into account in projects and operations.
- Wastewater management must necessarily take account of the production of sewage sludge or septage. This by-product, even more than wastewater (regardless of the level of treatment), represents both an environmental and health risk and a nutrient resource (organic matter and fertilising substances, particularly N and P). As the organic matter content of soils is an important agronomic parameter for the sustainability of irrigated systems, sludge management can be a relevant option.

Theme 2: Governance, communication, awareness-raising

- The social dimension is reflected at the national level in the overall institutional framework, in the establishment of standards and in the distribution of competences between the various ministries, agencies and offices (agriculture, sanitation, health, environment, etc.).
- At the local level, it is the cornerstone of the trust of the actors among themselves and in the TWWR system. The theoretical framework and its practical application on the ground are inseparable.
- Depending on the issues and the degree of urgency, REUSE governance can be vertical, or, conversely, it can be part of slower but more inclusive participatory approaches. It can be unified or differentiated, in which case consultation platforms are important. The involvement of public-private partnerships (PPPs) is a possibility to be considered.
- The training and capacity building of actors at different scales is also a major step and a key component of social acceptability approaches.

Theme 3: IWRM, economic aspects

- Reuse, whether agricultural, environmental, for groundwater recharge, for planned or unplanned use, takes on its sense as a fully-fledged component of integrated water resource management on a territorial scale. Decision-makers are not always aware of this, and furthermore, IWRM/REUSE prerogatives do not often belong to the same directorates in ministries.
- The study of the current role and potential of REUSE alongside more conventional resources over several hydrological cycles, seen in particular from the angle of adaptation to climate change (substitution for resources that are becoming increasingly scarce, recharging and desalination of aquifers), can provide input for public policies on water management.
- It is often the economic reality that often weighs most heavily in coordinated or uncoordinated strategies for resource allocation, and in particular the price of energy, which is essential for the proper functioning of the treatment processes, as well as that of analytical control.
- The cost-effectiveness of a REUSE project determines its attractiveness for the various actors. An in-depth study of the setting up and functioning of existing operations allows an analysis of the distribution of initial investments, local or international public aid, added value, etc. Pricing and collection methods, amortisation periods, and environmental and social externalities should be taken into account.

Theme 4: REUSE in the plot, equipment, management of sanitary and environmental risks

- TWWR for irrigation has an important technical dimension for farmers, whether for a possible stage of local refinement of the water's quality (tertiary treatment) or for the supply of water to the plot. Conventional irrigation equipment is not always adapted, especially for effluents loaded with suspended matter and nutrients (clogging).
- Nutrient inputs should be monitored and compared with plant needs, so that they can be supplemented with mineral fertilisation if necessary, and to avoid risks of excess that would be harmful to the natural environment.

- Health and environmental risks include microbiological risks (bacteria, viruses, parasites, etc.), micropollutants (metallic, organic or emerging) and salinity. Feedback from the results of research programmes or analysis campaigns also sheds light on the consequences of these hazards.
- It should be noted that in the logic of the multi-barrier management of health risks developed by the WHO, the combination of the 'tertiary treatment and water quality' component and the 'irrigation technique used' component makes it possible to compound the effectiveness of successive barriers and thus to progress in controlling risks.

3.2 Comparison in the target countries

The second table breaks down the approach of the four COSTEA REUSE themes by highlighting the key ideas to be considered in the case of each country.

3.3 Common features and specificities

Theme 1: Unplanned REUSE, rural sanitation, sludge management

- For this first theme, the countries can be divided schematically into two groups depending on the purification capacities in place: a group equipped in an almost exhaustive and functional way with its main WWTPs (the three French-speaking Maghreb countries) and a group of countries still under-equipped or deficient (Bolivia and Senegal). The case of Palestine is intermediate: many of its main WWTPs are operational, the last ones are under construction or in the advanced planning stages.
- The situation of unplanned or informal REUSE is contrasting depending on the country. It is generally unreported and poorly documented.
- The first group has a ban on informal REUSE, but this ban is not complete in practice, except in Tunisia. They already have (in the Tunisian case) or are planning (Algeria, Morocco, Palestine) REUSE projects for most of their treatment plants.
- For the second group, informal uncontrolled REUSE is in the majority, which represents a significant health risk. It is difficult for the public authorities to intervene when habits are established, as user-farmers can react strongly. It should be noted that after treatment and dilution in the environment, the health risk is reduced.
- More specifically, in Bolivia, the high number of treatment plants conceals malfunctions, low purification efficiency, and the discharge of poorly treated, low quality water; 81 informal REUSE sites are noted. In Senegal, in the Niayes area, market gardening using informal REUSE is developing; there are two experiments with complementary treatment to limit the risks, supported by the FAO and the WHO.
- It should be noted that Algeria seems to have moved from the second to the first group after a cholera episode in 2018.
- Rural sanitation is in its infancy in the target countries but there are some successful 'model' projects with an integrated REUSE component in Morocco or Palestine. This was discussed in stage 3 (participatory workshops).
- With regard to sludge, the situation is similar in the countries of the first group, which are generally considering planning tools, but have not made any progress from an operational point of view. The source exists, some experiments have taken place but there is no systematic recovery. The subject inspires mistrust, the volumes stored are accumulating, landfilling is not sustainable, and it will ultimately be necessary to tackle the problem.
- In the case of Senegal, non-collective or semi-collective sanitation is still the norm. Treatment units are being set up to process the septage from septic tanks and reduce the health risk but they are often bypassed and the sludge is marketed without treatment.
- Provided that the trace element content is within the norms, and that an organic substrate is present in the mix, composting sludge seems to be a highly relevant solution, which would also allow the organic matter content of soils to be maintained. This is crucial in irrigated agriculture in hot climates (mineralisation dynamics of organic matter).

Theme 2: Governance, communication, awareness-raising

- It should be noted that the issues of regulation and governance were the subject of a specific COSTEA REUSE deliverable (stage 4).
- All of the countries have official texts governing REUSE. Similarly to theme 1, there are two groups of countries: for the four Mediterranean countries, the legal texts are accompanied by decrees, orders or application standards that detail them. For Bolivia and Senegal, the corpus is simpler (law only).
- The institutional set of actors is particularly complex in the three French-speaking Maghreb countries and Senegal, with many ministries involved as well as local authorities and the agricultural profession. Coordination bodies or mechanisms do exist but they are not very operational.
- In the operations identified, users' associations are generally responsible for the practical organisation of irrigation (Senegal not yet).
- In some countries, there are agreement models between actors that could serve as a more widespread model (e.g. Morocco), even if they are not always implemented.
- There are specific national plans for REUSE in the three French-speaking Maghreb countries (Tunisia's plan is under development). For the other three countries, REUSE is integrated into broader planning documents, such as national water resource management plans.
- The REUSE issue is important in the occupied territories (West Bank) because Israel charges for the discharge of TWW into the valleys that lead into its territory. In this case, on the Palestinian side, water is not a resource but a source of costs.

Table 2

T1 – Unplanned REUSE, rural sanitation, sludge management						
Key Ideas	Algeria	Bolivia	Morocco	Palestine	Senegal	Tunisia
KI 1.1	There are no official figures on uncontrolled REUSE. Prior to the cholera outbreak in the summer of 2018, untreated wastewater flowed freely through canals into small rivers, from which local farmers drew their irrigation water in many regions of Algeria.	There are no official figures on unplanned REUSE in Bolivia.	7 000 ha of agricultural land are reportedly irrigated with raw waste water (RWW) before WWTP.	The strategy (2014-2016) for the agricultural sector set as a priority target 'the provision of 15 million m^3 of non-conventional water, including REUSE'. However, until 2020, the volume of REUSE for irrigation did not exceed the limit of 2.0 to 3.0 million m^3 in the West Bank and Gaza.	The practice of REUSE in Senegal remains mostly informal until now. It has been documented since 1970, when the first case was identified following the rupture of a wastewater pipe.	There are no figures or monitoring on unplanned REUSE.
KI 1.2	The formal reuse of wastewater for agricultural purposes started in 2007 and is increasing.	Water treatment is mainly centralised. There are some experiences with semi-decentralised WWTPs but this is rare. In rural areas there is a predominance of septic tanks. There are no studies on the use of septage from these tanks.	When farmers (located upstream of the WWTPs) have not been integrated into TWWR projects, they are obliged (in their opinion, having been deprived of the resource) to forcefully extract water from the pipes carrying RWW to the WWTP.	No planned TWWR was recorded before 2015/2016.	Wastewater is still mainly used for market gardening.	To date, most of the treatments concern plants of relatively large cities (+ 10 000 population equivalent). Rural sanitation is in its early stages.
KI 1.3	Tertiary system planned in 16 WWTPs, some in operation and some under construction with the aim of extending TWWR to market garden crops.	The roles and responsibilities of actors in the management of sanitary risk are not clearly established.	The diagnosis carried out made it possible to differentiate three modes of use that are similar to an unplanned or non-controlled TWWR site: direct / indirect / mixed use.	There are currently no large-scale agricultural REUSE operations, although several projects are underway. Operational agricultural REUSE is currently limited to small-scale pilot projects.	There are opportunities to develop REUSE, as is the case in Dakar, in the peri-urban agricultural areas of St. Louis and M'Bour.	Despite the long history of treatment plants and the regulations in place, operational references for sludge management are very rare. Most of the sludge is stored or landfilled.
KI 1.4	Rural sanitation mainly consists of septic tanks.	Sludge management is practically inexistent. The Cliza pilot project is interesting because it includes a sludge management dimension. The reuse of treated sludge is anecdotal and only concerns agriculture.	Extensive treatment in rural areas is still rare, although first experiences with reed filters are to be noted.	Informal REUSE experience in Jericho: the new WWTP with tertiary treatment is far from having connected the whole agglomeration. TWW discharges are low, but already mobilised, with each farmer pumping individually for a price of 15 cts/m^3.	In rural areas, the majority of wastewater treatment is by septic tank, which limits the potential for REUSE operations.	With a national action plan in 2006 and four regional master plans in 2015 and 2016, sludge reuse should be on track. In reality, however, it is struggling to get off the ground.
KI 1.5	Currently, sludge is mainly disposed of in landfills, which is prohibited by law / very little recovery.		Despite a constantly increasing number of treatment plants and more and more sludge produced, no management chain is really in place, and planning is still in progress, depending on the agricultural and pedoclimatic contexts.	The quality of effluents is not always compatible with agricultural TWWR (lack of energy to operate the installations and hydraulic overloads).	In several secondary cities, there are treatment plants for sewage sludge, which is used in agriculture as an alternative fertiliser.	
KI 1.6	Establishment in 2013 of a cooperation programme between Algeria and the European Union on the management of sludge from wastewater treatment			There has been no reuse of sludge in Palestine. Standards and regulations are very strict. 1 trial use > WWTP in Nablus to produce biogas methane. Dewatered sludge ends up in landfill.	There is also an emerging parallel market for untreated sewage sludge, which is hazardous from a health point of view.	

T2 – Governance, communication, awareness-raising						
Key Ideas	**Algeria**	**Bolivia**	**Morocco**	**Palestine**	**Senegal**	**Tunisia**
KI 2.1	REUSE has become a priority in the new water policy and investments have been allocated to the rehabilitation of old plants and the construction of new ones.	Institutional fragmentation and little capacity for coordination within the national and local levels but also between the local and national levels. TWWR is not analysed across sectors.	To ensure the good governance of TWWR projects -> establishment of partnership and management agreements for the treatment- TWW reuse system, with multiple stakeholders. The commitments of most stakeholders are 'statements of intent' rather than actual commitments.	The Government embarked on a water reform process in 2010 (enacted in 2014 - Water Act) including legislative measures.	No specific strategy. The public authorities only seem to be involved in the production of treated wastewater. The reuse of this water is handled by NGOs or through experimental projects.	The REUSE framework is institutionally complex, with a large number of actors. There is insufficient coordination capacity at the national and local levels. There is a regional coordination body ('REUSE Committee'), but its interventions and power to act are still limited.
KI 2.2	The Council of Ministers of 30 May 2021 adopted a national strategy for the development of non-conventional water resources aimed at dealing with water shortages.	There are associations of irrigators who manage small schemes developed by themselves with their own resources and which consist of small diversions of watercourses, all of which are gravity fed. There are few, if any, large-scale schemes financed by public funds with strong state intervention.	Farmers do not explicitly commit themselves to pay for TWW in these agreements.	Before the Water Users' Association Act (2018), farmers already formed cooperatives to manage water projects.	The multiplicity of institutional actors and the lack of a formal coordination framework between the four ministries in charge of TWWR often makes it difficult in practice.	The regulations are largely focused on the safety side of REUSE, with treatment requirements that are difficult to meet, to the detriment of its development. Not all of the required microbiological analyses are carried out due to lack of budget.
KI 2.3	Although there is a coordination committee for the annual allocation of surface water in which the ONID, ANBT, ANRH, ABH and the agricultural sector participate, the volumes of water subscribed for by farmers through their associations, where they exist, are generally not met due to lack of water: the coordination mechanism is not effective with regard to the users.	Pricing for agricultural water does not exist and has not become the norm. It is not currently possible to charge for water that is perceived as being soiled. Farmers instead feel that they are rendering a service by agreeing to reuse it.	Participatory irrigation management well established in Morocco: organisation of irrigators in agricultural water users' associations (AWUAs) > these associations participate in the development, operation and maintenance of irrigation systems.	Governance structure in Palestine -> poor coherence between actors, overlapping and unclear responsibilities, non-viable legal instruments, insufficient resources and infrastructure. -> REUSE = under the Ministry of Agriculture, -> Water quality monitoring = mixed between 1. the Ministry of Health 2. the Environmental Quality Authority 3. the Ministry of Agriculture 4. service provider. -> Treatment facility = controlled by the PWA and the EQA.	Market gardeners have long been reluctant to practice TWWR, considering this water to be soiled. They adopt and accept the practice for economic reasons (cost of the water).	The institutional framework for rural sanitation is not yet clearly established. At this stage, competences and management responsibilities are not well distributed between the ONAS and the Ministry of Agriculture.
KI 2.4	The farmers fully support the principle of irrigation from purified wastewater (PWW). The lower salinity of PWW, the significant nutrient inputs and the possibility of expanding the irrigated area are all reasons put forward. Questions may be raised as to the farmers' commitment to comply with the stringent standards and sanitary controls imposed by PWW irrigation.	Although few figures were made available to the consultants on the technical and economic efficiency of TWWR from the farmers' point of view, the stakeholders agree that it is very low, hence the difficulty in meeting the costs linked to the use of irrigation;	Farmers' acceptance is contrasted in Morocco depending on the situation: -> Irrigated area: TWWR project success difficult because the price per m^3 of conventional water is competitive with that of TWW. -> Rainfed farming areas: interest in REUSE because TWW would generate higher yields and therefore a much higher economic gain than that generated by the current situation. -> Raw water REUSE areas: farmers already used to TWWR. Participation possible subject to good information and subsidy mechanisms.	Acceptability and willingness to pay (several studies): - N°. 1: more than 50% of persons surveyed willing to pay for TWW for irrigation (Ghanem 2012). - N°. 2: average acceptance of REUSE, 81% of 30 farmers (Abu Sultan 2016). - N°. 3: 75% of farmers are willing to use TWW (Hamdan, 2021). - Etc.	Land tenure issues between landowners and land users are complicated, and involve municipalities.	Analyses are carried out by a large number of actors (agriculture, environment, health), without pooling and with mutual distrust. A common database is being developed to pool analysis data, amongst other things.

T2 – Governance, communication, awareness-raising						
Key Ideas	**Algeria**	**Bolivia**	**Morocco**	**Palestine**	**Senegal**	**Tunisia**
KI 2.5	According to a survey conducted in 2007 on farmers' acceptance of TWWR, three strong expectations stand out: - The principle of a strategic vision for the use of PWW in agriculture, incorporated in IWRM, and shared by all stakeholders - The principle of proceeding gradually and cautiously when introducing this irrigation process. - The principle of strict compliance with standards in the use of TWW, through stringent control by the public authorities.		Training and support for farmers is provided by the ONCA (agricultural consultancy) and ONSSA (food safety).	In Palestine, REUSE for irrigation is limited due to health aspects, socio-economic conditions, religious considerations and perceptions of the public and of farmers.	The farmers who reuse treated wastewater lack accompaniment.	The farmers generally accept the use of treated wastewater well, provided that the quality of the water is good. The technical extension centres (CTVs) within the CRDAs raise awareness of REUSE among farmers on an ad hoc basis.
KI 2.6				Farmers are willing to pay up to 50% of the conventional fee for treated water. The average sale price of conventional water (2021 study) was USD 0.45, while that for TWW was USD 0.25.	There is no formal collective organisation in the sense recognised by the State in the agricultural areas concerned. However, it should be underlined that the users do organise themselves amongst themselves.	There are communication initiatives both towards users and the general public, based on mediatised success stories, ex: Ouerdanine irrigated scheme, GDA Sidi Amor.
KI 2.7						Good mobilisation of civil society on water pollution problems can be observed (e.g., pollution of the sebkha of Moknine, pollution of the bay of Khnis, discharge of the Miliane wadi in Rades, discharge of purified water in Raoued, etc.), which could have a favourable influence on REUSE.
KI 2.8						

T3 – IWRM, economic aspects						
Key Ideas	**Algeria**	**Bolivia**	**Morocco**	**Palestine**	**Senegal**	**Tunisia**
KI 3.1	IWRM = a relatively new concept in Algeria initiated between 2010 and 2014 by the Ministry of Water Resources in the Algerian coastal basin.	There are actors at different relevant scales to implement an IWRM approach, with management instruments at each scale (national, water basin, sub-basin). However, these bodies are not very operational because in practice, the central level refuses to recognise responsibility at their levels.	Integration of REUSE into IWRM: Master Plan for Integrated Water Resource Development at the scale of water basins (PDAIRE).	While the pricing may seem simple, implementation is daunting because it is governed not only by socioeconomic factors but also by cultural and historical determinants.	Senegal is currently undertaking its second IWRM plan on a national scale.	There is no basin agency in Tunisia.
KI 3.2	Implementation in 2017 of a new policy for integrated water resource and environmental management for 2035 > Implementation of 273 structuring projects by 2035, 32% of which are for REUSE.	Strategic water basins have been selected for priority work.	Low cost recovery for the implementation of complementary treatment > users do not conceive of paying for TWW	Complicated cost recovery for service providers: -> the wastewater pricing structure for service providers needs to be reformed to optimise cost recovery.	TWWR is mentioned in the IWRM plan (Plan GIRE) as part of an axis dedicated to water recovery for growth and food security. However, there are no quantified targets.	TWW is integrated in the national and regional water resource assessments.

T3 – IWRM, economic aspects						
Key Ideas	Algeria	Bolivia	Morocco	Palestine	Senegal	Tunisia
KI 3.3	There are few scientific studies on the economic impact of TWWR.	There are no mechanisms to manage the health risk in case of water quality problems.	Margin generated by REUSE in agriculture (water price, yield & fertiliser gain) modelled in 2000 for a wheat crop, compared to 'rainfed' production.	Cost-benefit analysis conducted on several REUSE projects in Palestine (2016), with significant variability: The C/B ratio was 5.04 for Alteireh, 2.55 for Anza and 1.94 for Al-Taybeh and Rammun.	IWRM approach poorly perceived in rural areas with privatisation of boreholes historically managed by community associations.	A sale price for treated wastewater was set at 20 dinar millimes per m3 , a very low price that does not cover the costs (let alone tertiary treatment). A 2021 circular prescribed a rate that at least covers energy costs until tertiary treatment is adopted. As a result, the basic rate is now waived in several irrigation schemes.
KI 3.4	The TWWR economic model consists of delivering volumes of treated water to farmers at a symbolic price corresponding to the conventional water rate applied locally (approximately 0.02 euros/m3). This practice covers neither the investment costs nor the maintenance costs of the treatment, conveyance and pumping facilities, given the small volumes of treated water available.	Water quality is poorly monitored.	No study carried out on farmers' ability to pay for TWW in Morocco. But many surveys have been conducted: the prices per cubic metre assessed vary from 0.5 to 1 DH/m^3 (equivalent to 0.05 to 0.1€ /m^3).	Funding agencies' approaches vary: - for operational projects, beneficiary farmers are asked to contribute both cash and in-kind; - for pilot projects, farmers get the water for free. Hence a reluctance to pay, especially since with Israeli taxes on cross-border water, the farmers feel they are providing a service by reusing.	In economic terms, the resource has no difficulty in competing (CAPEX and OPEX) with conventional water, which is scarce or salty in the area. However, there is currently no stabilised economic model for REUSE in Senegal.	Increasing electricity prices penalise the operation of WWTPs (water aeration in particular) as well as that of irrigated schemes (pumping costs).
KI 3.5			It is impossible for the cost of TWW (per farmer) to cover the costs of the additional treatment, operation + quality monitoring of TWW. > The only solution therefore lies in State subsidy to cover the gap between the real cost and the price paid by the users. > The national programme for the reuse of purified wastewater (PNREUE) has stipulated that the tariff for TWW must be less than or equal to the price of conventional water, which is itself heavily subsidised.	The lack of storage facilities leads to inter-seasonal wastewater losses and increased cross-border taxes.	A consensus on water pricing was reached between the ONAS and farmers during the development of the Niayes FAO project, at around 50 CFA francs/m^3 compared to an average of 250 CFA francs for agricultural water in Senegal. This cost does not cover the expenses but is accepted and avoids the destruction of these canals to access untreated water.	The use of treated wastewater remains low because the crops produced (mainly extensive olive trees and fodder crops) only generate a small margin.
KI 3.6			In small-scale treatment-reuse projects, depreciation and environmental monitoring costs are not taken into account in the prices established for the different waters sold.			There are opportunities for better use of the water through own-consumption of fodder (e.g. cattle and sheep breeding), short circuits (e.g. dairy products), or the development of intensive tree crops between rows of currently unirrigated olive trees.

T4 –REUSE in the plot, equipment, sanitary risk management						
Key Ideas	Algeria	Bolivia	Morocco	Palestine	Senegal	Tunisia
KI 4.1	As a reminder, wastewater treatment plants in Algeria are totally financed by public funds through the ONA. In several communes of the country, the plants are at a standstill following a power cut for non-payment of energy bills or as the latter require a change of spare parts that were not provided for in the budget.	Only 22% of the country's WWTPs are considered to be in good working order, while almost half (45%) are in poor condition or shut down.	The national legislation stipulates that all projects must undergo an environmental assessment with an Environmental and Social Management Plan (ESMP).	Strict REUSE instructions in terms of irrigation methods: - No spraying within 50 metres of roads and paths, making it effectively impossible, - Generalised drip irrigation for arboriculture in REUSE, - Underground drip irrigation practiced on alfalfa in Jenin.	Significant health and environmental impacts of the informal use of RWW/ TWW in the peri-urban market gardening areas of Dakar.	In many cases, irrigation with treated wastewater is done by gravity, which limits its efficiency and can cause undesirable effects (e.g. rising groundwater). However, the risk of clogging drippers is avoided.
KI 4.2	In terms of health risk, some studies show that vegetables irrigated by TWWR are much less contaminated by metals than similar vegetables bought on different Algerian markets.	The urban population doubled between 2001 and 2020, which is also reflected in the volumes produced, in the order of 275 hm^3 in 2020.	Water sector managers, health management institutions (Ministry of Health and its hygiene services) and food safety institutions (ONSSA) agree that treated wastewater cannot be reused in agriculture without tertiary treatment with disinfection and filtration. The multi-barrier logic advocated by the WHO reaches its limits with the lack of involvement and training of farmers.	Although it is mandatory for each service provider to monitor effluent quality parameters prior to REUSE, most do not have the laboratories or the financial means to carry out routine periodic testing.	No use of localised irrigation techniques with treated wastewater. Mainly sprinkler irrigation.	Real awareness raising on the use of personal protective equipment carried out by the Technical Extension Centres (CTVs) of the Ministry of Agriculture. But risk reduction measures are insufficiently implemented.
KI 4.3	Little research data on irrigation techniques applied in Algerian TWWR schemes.	65% of the Bolivian population has access to sanitation compared to 91% who have access to drinking water.	The PDA (Agricultural Development Programme) subsidises the purchase of localised irrigation equipment.	The REUSE operations or projects underway are based on tertiary treatment with filtration and disinfection. The vast majority of WWTPs studied require additional treatment to suit a wider range of crops.	No agricultural network, no conveyance from the plant.	Despite more than 60 years of experience, there have been no cases of outbreaks of waterborne diseases as a result of the use of treated wastewater.
KI 4.4		Formal TWWR does not allow irrigation for plants with short stems.		When the salinity of TWW is too high, it can be mixed with freshwater, but which is often not available. Gaza is in this case, and the salinity of TWW limits the cultivation possibilities.	Insufficient control mechanisms to ensure exclusive agricultural use (carters selling water to households).	There is no warning system in case of the deterioration of water quality, and there is no alternative resource that can be mobilised. Except in serious cases (e.g., a case of cholera detection), the water service is maintained even if it is degraded.
KI 4.5		TWWR irrigation is mainly gravity fed in order to keep O&M costs to a minimum.			Lack of training on hygiene measures.	

- Farmers' acceptance is generally good but differs according to the availability of conventional resources. Where water is scarce, there does not seem to be any cultural or religious blockage.
- Senegal has the particularity of using the water for its fertilising properties, which is the main criterion justifying the use of TWW by farmers.
- Support and awareness-raising for farmers are implemented in Morocco and Tunisia by various services of the Ministry of Agriculture (ONCA, ONSSA in Morocco, CTV in Tunisia).
- Tunisia has been the subject of initiatives to raise awareness among the general public on the use of treated wastewater.
- Tunisian civil society is increasingly mobilised on environmental issues, and in particular on the impact of TWW, which is favourable to REUSE.

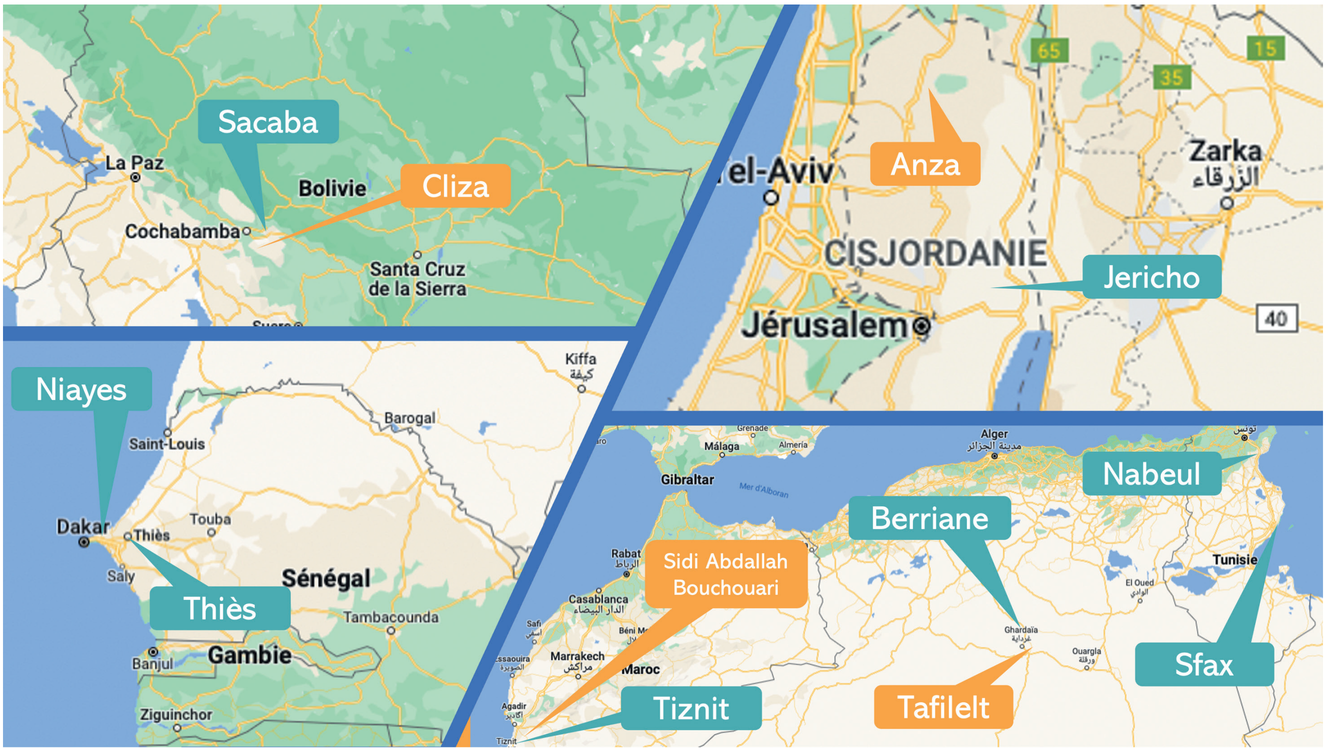
Theme 3: IWRM, economic aspects

- Integrated water resource management (IWRM) is a relatively new concept, which is being implemented in Algeria, Morocco, Bolivia and Senegal, with the creation of water basin agencies. However, there is a lack of resources for these structures, and the central level (ministries) has a strong influence.
- REUSE is generally integrated into IWRM. For example, in its IWRM 2035 plan, Algeria foresees the implementation of 235 structuring projects, 32% of which concern REUSE.
- The sale price of treated wastewater is generally low and does not cover the possible costs of tertiary treatment. In some cases (Algeria, Tunisia), an excessively low sale price is detrimental to the practice: the treated wastewater no longer has any value. The ordinary costs of irrigated schemes, such as pumping and maintenance costs, are generally not covered.
- In Tunisia, a decree has recently been issued to circumvent the excessively low selling price, requiring the energy costs to be covered.
- The situation is as follows: the sale price of treated wastewater must be lower than that of conventional water, which is itself subsidised. In the particular case of Algeria, the price of conventional water is very low (€0.02/m^3) and identical to that of TWW. It is higher in Morocco (€0.05/m3 to €0.1/m^3), and in Tunisia (€0.06/m^3 to €0.25/m^3).
- The only solution is therefore state subsidy to cover the gap between the real cost and the price paid by the users.
- Overall, there is little historical evidence on the economic impact of agricultural REUSE in these countries.
- A cost-benefit analysis carried out in Palestine on three sites showed a cost-benefit ratio varying between 2 and 5: the costs systematically exceed the economic benefits. Social externalities (job creation and fertiliser savings) and environmental externalities (preservation of surface and groundwater quality) should be taken into account. The study also demonstrates the interest of multi-use, in this case through the cement industry, which consumes water throughout the year.
- The acceptable price for treated wastewater is usually half that of conventional water, provided that the service is correct (quantity).
- Billing recovery is complicated in Palestine.
- The recovery of water is contrasted. In particular, there is reflection on crops with higher value-added in Tunisia.

Theme 4: REUSE in the plot, equipment, management of sanitary and environmental risks

- Tertiary disinfection treatments are among the first links in the chain of health risk management. They are rare to date, but integrated in the new projects of the four Mediterranean countries. They generally consist of sand filters + UV.
- Morocco is thus pushing towards the generalisation of tertiary filtration and disinfection treatments before agricultural REUSE, regardless of the crop.
- If there is a sudden deterioration in the quality of TWW, there is no warning system.
- Irrigation methods with treated wastewater are contrasted. Gravity is used in many cases to limit costs, such as Tunisia in an intercropping system of olive trees/fodder crops. It is localised in the case of Palestine.
- There are regulatory restrictions on crops (e.g. ban on market gardening in Tunisia, ban on short-stemmed plants in Bolivia).
- The informal use of wastewater is widespread in Algeria, Bolivia, Morocco and Senegal at least. It leads to a lack of control and greater risks. This is illustrated by the market gardening in Senegal.
- In Algeria, a surprising study result was that vegetables irrigated with TWW were less contaminated by metals than similar vegetables purchased from different markets that were probably irrigated with other water of inferior quality.
- In the example of Tunisia, irrigation using treated wastewater did not induce waterborne diseases, unlike raw wastewater or even conventional water that can be contaminated by discharges.
- An Environmental and Social Impact Assessment (ESIA) is required before the implementation of a TWWR irrigation scheme in Morocco and Tunisia. An Environmental and Social Management Plan (ESMP) is required. The monitoring of soil and groundwater quality demanded in these assessments and plans is rarely carried out.
- Awareness-raising and support for farmers with regard to health risks are undertaken in Morocco and Tunisia.

Figure 2: Location of the sites in each country (blue: peri-urban sites – orange: rural sites)



4. FEEDBACK FROM THE PARTICIPATORY WORKSHOPS

4.1 Algeria

The two sites of wadi el Bir (centralised approach) and the Tafilalet eco-neighbourhood (decentralised approach) were the subject of local workshops.

The national feedback workshop confirmed the following observations:

- There is a lack of coordination between the different stakeholders involved in REUSE. The institutions in charge of water treatment and those in charge of conventional irrigation agree on the need to find new partners as several management initiatives have previously failed. The emergence of one or more concessionaires between the ONA and ONID is an option to be studied.
- Scientific research, which has developed significant REUSE expertise, is currently on the side lines of decisions taken by water sector institutions; as a result, the texts are not always effective.
- Technical and regulatory expertise for monitoring water and soil quality is insufficient, which does not allow compliance with national TWWR standards to be guaranteed.
- Indirect REUSE (the case of water infiltration in the wadi el Bir aquifer) diversifies the approaches to certain problems, such as that of inter-seasonal storage.

4.2 Bolivia

The two sites of Sacaba (centralised approach) and Cliza (decentralised approach) were the subject of local workshops.

The national feedback workshop confirmed the following observations:

- The actors have clear roles within their sector but they are not aware of the responsibilities of other actors involved in the reuse system.
- There are no regulations to monitor the quality of reused treated wastewater and the health safety of users.
- Studies and experiences on the subject are limited in Bolivia. There is a need to strengthen knowledge and skills on the recovery of sludge and treated wastewater for agriculture.
- Water pricing is not adapted. The low user contribution does not cover operation and maintenance costs.
- The salinity of TWW and its potential effects on crops is a matter of concern for farmers.

COSTEA
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REUSE Structuring Action

IRRIGATE SCHEME OF WADI EL BIR

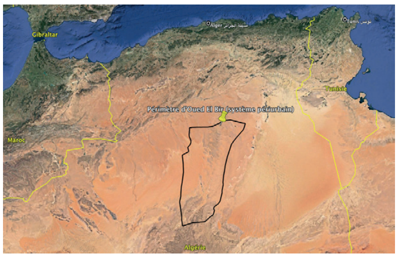
GHARDAIA-ALGERIA

M. Farah HAMAMOUCHE
Tarik HARTANI

INTRODUCTION

This irrigated scheme was created in 2013 as part of the APFA programme. From their installation until 2018, the active farmers used RWW to irrigate. They pumped water directly from the wadi into which raw effluent was discharged. The WW left the WWTP untreated due to an institutional dispute over the electrification of the WWTP. It was not until six years after the official inauguration of the WWTP that it was able to fulfil its treatment role. In the meantime, there was the cholera epidemic in northern Algeria (summer 2018). The tightening of controls by the national police at local level and the introduction of heavy sanctions at national level against RWW users, led the farmers of Wadi El Bir to abandon this reuse. The active farmers turned to groundwater as an alternative solution. 32 boreholes tapping the water table were created during 2018, just a few metres from the wadi into which the wastewater was discharged. This configuration implies that some of this water percolates into the water table before being used by the farmers (indirect REUSE by recharging the water table with wastewater).

IDENTITY CARD



Wastewater treatment plant type: aerated lagoon system

Tertiary treatment: no

TWW volume: 3 000 m³/d

Storage: 0 m³

Irrigable area: 300

Nb. of farmers: 100, of which only 34 are active

Crops: date palm, olive, arboriculture and market gardening

Type of irrigation: drip

ANALYSIS

- Large volumes of permanent water.
- TWW, a source of water complementary to groundwater.
- Groundwater recharge with TWW.
- Reduced pressure on groundwater.
- Increased pumping rate and lower groundwater salinity.
- Reduced use of chemical inputs and increased agricultural yields.

- Design problems resulting in poor water quality.
- Lack of spot testing of water quality.
- Lack of equipment and space for sludge treatment and storage.
- Administrative constraints and inapplicability of REUSE regulations at local level.
- Lack of coordination between the actors involved in TWWR.

RECOMMENDATIONS

- Guarantee a place to store and treat the residual sludge from the WWTP so that it can be used for agricultural purposes.
- Bring the WWTP up to international standards.
- Create a management and awareness body (responsibility of the authorities).
- Define management responsibilities.
- Train farmers in REUSE practices in agriculture.
- Draw inspiration from successful REUSE experiences (the Hennaya irrigated scheme in Tlemcen

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REUSE Structuring Action

TAFILALET ECO-NEIGHBOURHOOD

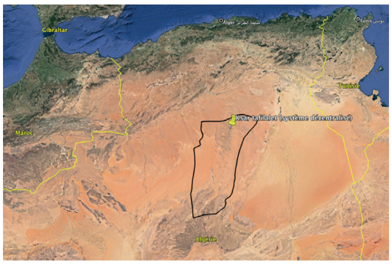
GHARDAIA-ALGERIA

M.Farah HAMAMOUCHE
Tarik HARTANI

INTRODUCTION

The idea of creating an ecological neighbourhood was born in 1996 with the aim of solving the housing crisis. This popular initiative is based on an ecological and social conscience, while preserving the way of life of the Mozabite community.
The members of the Amidoul Foundation wanted to reinforce the principles of the circular economy and sustainable development.
Part of the public lighting has been converted to solar energy.
An experimental treatment plant for some of the domestic wastewater was set up in 2013, with the aim of irrigating a green space forming a green belt around the village.
The members of the Amidoul Foundation designed the mini planted filter station in an artisanal manner. The system has been connected to 150 homes (i.e. 14% of the volume produced by local residents).The collected wastewater is conveyed by gravity to the 1st settling tank.

IDENTITY CARD



Wastewater treatment plant type:
filter planted with reeds with 3 filter tanks

Tertiary treatment: no

TWW volume: 36 l/s

Storage: 0 m^3

Irrigable area: 1.2 ha

Nb. of homes: 150/1050

Crops: none

Type of irrigation: drip

ANALYSIS

- Natural, inexpensive treatment technique.
- Free experimental trial -> built for the benefit of local residents with no charges.
- Circular economy -> 0 energy, 0 waste, 0 maintenance.
- Creation of a microclimate.

No technical studies.
- Sizing problem when designing the mini plant.
- Poor quality TWW.
- Proliferation of mosquitoes in summer.
- Fear of water-borne diseases among residents.
- Insufficient water to extend the irrigated area.
- Lack of financial support from the government.

RECOMMENDATIONS

- Use local aromatic plants to reduce unpleasant odours.
- Install an analysis laboratory in the Ksar to monitor water quality on a regular basis.
- Set up a small forest nursery to generate money to maintain the green space.
- Replicate this initiative on other sites (tourist cottages in the Ben Isguen oasis).
- Learn from the experience of large WWTPs and other decentralised reuse sites (Touggourt).

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ENSEMBLE, POUR RELEVER LES DEFIS DE L'AGRICULTURE IRRIGUEE

REUSE structuring action

EL ABRA-HUERTAMAYU/SACABA
BOLIVIA

Paola Riveros Haydar
Sergio Alvarez Carrión

INTRODUCTION

This reuse system, classified as urban because of its type of treatment technology, is located in the Sacaba, Cochabamba. The ABRA WWTP was designed to treat domestic water for vegetable irrigation. However, it now also treats industrial water. The WWTP began to operate in 2017 and is currently managed by Sacaba Municipal Water and Sewage Company EMAPAS. Regarding irrigation, the area is located in the Huerta Mayu community. The irrigation management is done by the Huerta Mayu Irrigation Association, which has experience in irrigation prior to the development of the ABRA WWTP. Most of the irrigation water in the area comes from deep wells and shallow wells. Reuse is mainly for soil preparation.

IDENTITY CARD

Wastewater treatment plant type: Aerobic treatment technology (sediment tanks and trickling filters, a sludge drying bed, and a disinfection house)

Tertiary treatment: chlorine disinfection (Currently not working).

TWW volume: 11232 m³/d

Irrigable area: 12 ha. With rotations 41 ha.

Nb of farmers: 79 families.

Crops: Lettuce, onions, beets. Also potatoes, beans, corn for fodder.

Type of irrigation: Flood irrigation with water pumped from deep and shallow wells, as well as reuse.

ANALYSIS

- Capacity of the WWTP to increase water supply in the future.
- Treatment reduces the negative impact of wastewater.
- Stakeholders indicate that they have defined roles and responsibilities within their areas. Treatment is managed by the municipal company EMAPAS, while an established irrigation association manages irrigation. However, at the reuse system level, not all responsibilities are clear (e.g., maintenance of the aqueduct and filters located at the WWTP-irrigation zone).

- Farmers still did not use sludge on their plots. There is little experience sludge treatment and more studies are needed.
- Water salinity and odors negatively affect the river and its surroundings.
- Stakeholders are not satisfied with odors and salinity of treated water.
- Industrial wastewater entering the WWTP prevents compliance and enforcement of treatment standards. Irrigation management monitoring is only visual.
- O&M tariff is partially subsidized by the municipality. However it does not guarantee future sustainability.
- Current negative perception of buyers. Farmers require support (secured market) if crop change is proposed.
- Reuse is minimal due to low water quality (salinity and odor). Farmers are planning to irrigate only with deep well water.
- Irrigation is also done using shallow wells (possibly contaminated) using motor pumps. Also in dry periods, some farmers mix wastewater with well water.
- Personal protective equipment use and the implementation of health risk reduction measures in irrigation is not standardized.

RECOMMENDATIONS

1) **Sludge reuse:** It is necessary to develop sludge treatment and reuse to reduce pathogens and odors. This action should be carried out by Municipal Water and Sanitation Company of Sacaba EMAPAS-GAM with the support of the neighbors.
2) **Satisfies stakeholders:** The quality and quantity of water for irrigation should be increased by improving treatment. This action will be the responsibility of EMAPAS and GAMS and will require national and cooperative resources.
3) **Water quality:** It is necessary to socialize industrial discharges regulations through workshops and meetings with the social sector; increase investment through resource and project management and restructure the tariff structure through a specific study.
4) **Operators' health:** The issue of health risks needs to be addressed in greater depth. A medium- and long-term evaluation and monitoring of measures to reduce health risks and the use of protective equipment should be carried out.

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AFEID AFD

REUSE structuring action

VILLA EL CARMEN/CLIZA
BOLIVIA

Paola Riveros Haydar
Sergio Alvarez Carrión

INTRODUCTION

This reuse system, classified as rural due to its treatment technology. The WWTP began operating in 2014, with opposition from the neighbors due to previous bad experiences. The WWTP is based on a decentralized treatment approach and circular economy; O&M is carried out by Aguatuya by Aguatuya, a NGO contracted by the municipality. Agriculture systems that previously relied on rain have been able to produce year-round thanks to water. Since 2019, there is also an experimental sludge treatment pilot plant in the same area which can treat 40 m3 of sludge per batch, and so far, only primary and secondary sludge have been tested. A challenge for the plant is to expand coverage of the sludge treatment service to other nearby areas.

IDENTITY CARD

- **Wastewater treatment plant type:** A combination of an anaerobic system UASB and a biofilter

Tertiary treatment: No

TWW volume: 207,318 m3/year or 6.57 l/s

- **Irrigable area:** Approximately 9 ha are irrigated.
- **Nb of farmers:** 10 to 15 irrigators/18 families
- **Crops:** High stem irrigation, mainly corn 62%, alfalfa 18%, potato 15% and 5% broad bean.
- **Type of irrigation:** flooding irrigation with motor pumps.

ANALYSIS

The amount of water is sufficient for the supplementary irrigation of current users

- There is a good relationship between local stakeholders in both treatment and irrigation.
- The sludge treated by the sludge pilot plant is a good fertilizer for crops and contributes to soil improvement.
- Reuse water is an additional source of water for irrigation in addition to rainfall.
- Irrigators are satisfied since plots that were not used for planting are now cultivated.
- Reused water has improved corn production.

The treatment plant is at 100% of its capacity and does not guarantee an increase for future users or water in the dry season.

- Users currently use the treated water free of charge; corn production has improved, with the reuse of treated wastewater; is marketed at interdepartmental level.
- The irrigation association is in the process of being created. They currently lack a structure, legal status and their experience in irrigation management with reuse is still limited.
- Treatment O&M costs are currently included in the drinking water tariff. Details of treatment costs should be explicitly included for users.
- The irrigation infrastructure is precarious, as water is pumped with motor pumps from an earthen canal to the plots for flood irrigation.
- No health problems have been reported so far. However Irrigators do not always use the necessary safety equipment for irrigation, nor do they have standardized practices to reduce potential health risks.
- Potential future soil salinity issues require monitoring

RECOMMENDATIONS

- **Water Quantity:** Construction of a reservoir, to store treated water in order to balance supply and demand, both irrigators and users should be participants in this initiative.
- **Water Tariff:** Including an explicit treatment fee for users could help future adjustments and contribute to the sustainability of the system.
- The formation of an irrigation association, with internal regulations for water reuse considering its sustainability, would help to analyze a possible tariff depending on the crops to be produced and the quality of the treated water required.
- **Operators' health:** Improve reuse water production practices and monitor the use of personal protective equipment by irrigators to reduce health risks. Producers must be sensitized and trained on the proper management of treated wastewater irrigation

SCP

4.3 Morocco

The two sites of Tiznit (centralised approach) and Sidi Abdallah el Bouchouari (decentralised approach) were the subject of local workshops.

The national feedback workshop confirmed the following observations:

- The gap between discharge standards and quality standards of water for irrigation hinders agricultural TWWR.
- Cost recovery is low, subsidies for agricultural TWWR projects are needed, in the same way as for conventional water; why not via a specific fund?
- Cost-benefit analyses taking into account positive externalities are crucial tools upstream of the planning process for TWWR projects.
- The multi-barrier approach to risk management developed by the WHO is being called into question, particularly for market gardening: how can the implementation of barrier measures be guaranteed when the product reaches the consumer?
- The problem of intrusion of industrial discharges remains crucial, and it is strongly recommended that the promulgation of the implementing provisions of the water law be accelerated.

4.4 Palestine

The two sites of Jericho (centralised approach) and Anza-Jenin (decentralised approach) were the subject of local workshops.

The national feedback workshop confirmed the following observations:

- Public health considerations are paramount and water quality must be monitored and guaranteed throughout the TWW chain, both within and outside the WWTP: treatment, pumping, distribution; the PWA only monitors quality within the plant.
- Water pricing and cost recovery is also a major issue emphasised by all of the stakeholders; according to them, farmer users should not contribute to treatment, which remains the responsibility of the collectivity (polluter pays principle).
- Sewage sludge is still too often considered as waste to be eliminated whereas recovery chains do exist (in Jericho, for example, for the manufacture of an enriching agent by an industrialist).

4.5 Senegal

The two sites of Niayes and Thiès (centralised approaches) were the subject of local workshops.

The national feedback workshop confirmed the following observations:

- The treatment plants are not all up to standard, which does not allow the production of treated wastewater of satisfactory quality for reuse in agriculture.
- There is still no clear regulatory and normative framework for TWWR; the texts implementing the Water Act on this subject have not been issued.
- REUSE planning should be developed and expanded, especially in the context of climate change; the TWWR component should be integrated into the design of wastewater treatment plants.
- REUSE users and practitioners are not secure in their land resources, especially in urban and peri-urban areas under pressure from urbanisation.
- The production and management of septage matter from non-collective or semi-collective sludge treatment plants has led to the emergence of a flourishing economic activity, which can be taken as an example.

4.6 Tunisia

The two sites of Sfax Sud and Nabeul Souhil (centralised approaches) were the subject of local workshops.

The national feedback workshop confirmed the following observations:

- The TWW treatment (ONAS) and distribution (Ministry of Agriculture, CRDA) infrastructures are too often in poor condition, which handicaps the operation of TWWR irrigation schemes already in place; rehabilitation campaigns are underway.
- Urban proximity is a threat to agricultural land and the territorial coherence of irrigated schemes.
- The lack of inter-seasonal storage limits the potential for reclaim; in coastal areas, the development of storage facilities would also make it possible to limit discharges into the sea and thus the risk of contamination of the coastline.
- Good agricultural added value of water is a success factor for TWWR in both schemes, but does not guarantee the financial health of the GDA.
- There are successful examples of sewage sludge management for agronomic use (e.g. Nabeul SE4), which should be able to be replicated.

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TOGETHER, TO MEET THE CHALLENGES OF IRRIGATED AGRICULTURE

AFEID AFD

REUSE Structuring Action

Site of Tiznit

MOROCCO

SOUDI Brahim
ZAHRAOUI Khaoula

INTRODUCTION

Following the drought of the current agricultural year, treated wastewater is being pumped and reused by a dozen farmers. Although the quality of the TWW allows for unrestricted use, this first phase of REUSE concerns fodder crops and olive trees. In this context of water shortage, exacerbated by the drought, REUSE will have a highly substantial agro-socio-economic impact. Scaling up irrigation with TWW will maximise these impacts and develop flourishing peri-urban agriculture.

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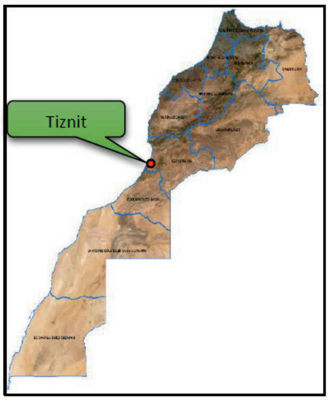

Wastewater treatment plant type: complete natural lagooning (A + F + M)

Tertiary treatment: yes (maturation lagoons) + additional treatment: disinfection by UV + filtration

TWW volume : 5000 m³/d

Storage: 1500 m³ storage tank

Irrigable area: 400 ha in the long term (50 ha in the short term)

Nb. of farmers: 11 members in this current first phase

Crops: Olive trees and fodder crops (alfafa, fodder corn and berseem)

Type of irrigation: gravity-fed irrigation pending rehabilitation of the network in order to convert to the localised irrigation planned in the project

ANALYSIS

Assets

- Project prioritised by ministerial departments to ensure successful implementation.
- Signature of a partnership agreement defining the roles of the stakeholders.
- The authorisation for re-use was issued by the ABH but has now expired. A new request for renewal has been sent to them.
- Commitment by farmers to an agreement with an agricultural dairy cooperative (aggregator).

Gaps to be filled

- Poor definition of the actual commitments and contributions of the stakeholders (these are only declarations of intent).
- How the operating costs of the project will be covered is not defined.

RECOMMENDATIONS

- Draw up an operational management protocol that clearly defines the contributions and commitments of the actors involved.
- Clearly define the operating procedures for additional treatment and the related facilities, as well as the procedures for carrying out analyses to monitor TWW quality.

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REUSE Structuring Action

Site of Sidi Abdallah Bouchouari

MOROCCO

SOUDI Brahim
ZAHRAOUI Khaoula

INTRODUCTION

From a socio-economic point of view, this project would generate a number of impacts, including: the resilience of the argan ecosystem to climate change, which is reflected by a shortage of water, and an improvement in farmers' incomes, bearing in mind that the carob tree (the main crop in the region) is a fairly resilient tree species whose produce has a high commercial value.
This 'small-scale sanitation' model, once operational, would be worth replicating, as its impact in terms of adapting to climate change and improving people's incomes is undeniable.

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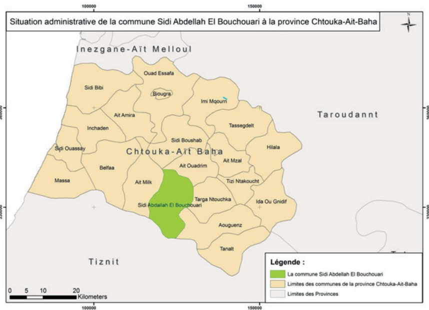

Wastewater treatment plant type: Septic tank + filters planted with reeds

Tertiary treatment: included in the system

TWW volume: 100 m³/d planned

Storage: no

Irrigable area: 8 ha

Nb. of farmers: 12 members of an agricultural cooperative

Crops: carob tree with intercropping

Type of irrigation: localised irrigation

ANALYSIS

Assets

- Strong commitment from the commune.
- Significant support from the water department.
- Existing cooperative has indicated a need for TWW.
- Financial support from the PNAM is planned.
- The WWTP is an educational and research platform that enables technical information to be documented with a view to facilitating replication and scaling up.

Gaps to be filled

- Funding for the extension of the collection network (connection rate is low).

RECOMMENDATIONS

- Increase the connection rate by applying a promotional incentive tariff.
- Replicate this pilot project in neighbouring communes.
- Set up a provincial processing, extraction and conditioning unit as part of an economic interest grouping (EIG) bringing together neighbouring cooperatives.

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AFEID AFD AGENCE FRANÇAISE DE DÉVELOPPEMENT

REUSE structuring action

JERICHO WWTP
PALESTINE

Malek Abualfailat
Naser Qadous

INTRODUCTION

Jericho city is situated 300m below see level. The total population is approximately 25,000. The sewage water is collected and treated to secondary level in an activated sludge WWTP. The plant has the capacity to treat 6600 CM daily, currently it receives 2200 CM, the whole volume is reused (during summer) in irrigating 760 dunums of date palm trees.
Initially, there was an objection of reusing the TWW in agriculture due to religious issues and health concerns, while after some pilots from farmers, and due to scarcity of water, reuse increased day after day. The treatment plant operator (the municipality) has utilized the Take or Pay (ToP) payment scheme at 1 ILS/CM.
This model showed that although Jericho WWTP has utilized unplanned reuse scheme, where every individual farmer has his own carrier line connected directly to the effluent but it succeeded to partially cover the irrigation water gap for the farmers and assist them to sustain their orchards.

Treatment:
Method: Activated Sludge

Level: Secondary with chlorination

Volume: 2,200 m³ daily

Storage: No Storage facilities

Irrigated area: 76 ha

No. Of Users: 7 farmers

Crops: Date Palm trees,

Irrigation method: Drip Irrigation

ANALYSIS

The General health aspect: Water quality is satisfactory compared to required standards. Workers in the WWTP are getting necessary vaccines, use protective garment during work.

The environment: The WWTP has a positive impact on the environment and economy. Eliminated loose, leaking cesspit in most of Jericho houses, no health issues

Accessibility and governance: The roles and responsibilities between the different stakeholders are very clear

The WWTP is generating revenues to the benefit of the municipality.

The Sludge Management: Sludge is being sun-dried in dry beds, and after extended period collected and moved to a nearby industry to be crushed and mixed with soil.

Irrigation water is distributed through simple piping system, no adequate fresh water is accessible to flush the pipes subject it to clogging.

Farmers are not using protective garment

RECOMMENDATIONS

- Enhance Treatment and reuse of sludge especially as Jericho is a hot area with low precipitation rate.
- Connecting more houses to the Wastewater network in Jericho would provide more TWW.
- Provide water storage facility to save non-used water saved during rainy months
- Systematizing and institutionalizing the water distribution system, not only rely on unplanned irrigation water distribution system.

SCP

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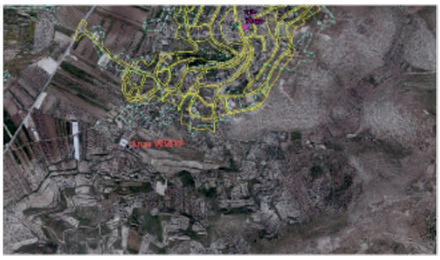
REUSE structuring action

ANZA/ JENIN
PALESTINE

Malek Abuallailat
Naser Qadous

INTRODUCTION

The WWTP of Anza uses the activated sludge technology. Currently producing 120 CM/day of high-quality treated effluent, which are totally reused . The whole water is used since finishing the scheme in 2015. In the first few years of operation water was used to irrigate newly established olive groves, and some alfalfa fields at a pilot scale. Currently water is used to irrigate alfalfa, almonds, apricots, olives and Luffa.
Every house pay $4.7 per month for sewage collection and the treatment. There are 400 houses connected to the system. The total operational cost for the WWTP is $1875 per month. Solar panels were installed recently, consequently reducing the operational costs. Such pilot represents a good example of solving the environmental pollution of cesspits, as it collects sewage water, treat it and use it in agriculture. It forms a case to learn from.



Activated Sludge system

Secondary treatment:

TWW volume: 120 m³/d

No Storage facilities

Irrigable area: 3 ha

Nb of farmers : 7-12

Crops: Alfalfa, almonds, apricots, olives and Luffa.

Type of irrigation: Drip Irrigation

ANALYSIS

- Clear roles and responsibilities
- Quality of water is acceptable
- No Environmental or health complaints
- Village council covers costs of WWTP
- All volume of treated effluent is used

- **General health** measures are not taken as it should be, no vaccination for the operator of the treatment plant is taken regularly.
- **Sludge** is not treated or reused, rather carried to the close solid waste dumping site.
- The water **Quantity** is not sufficient it covers 25% of the farmers need in the village.
- **The control on irrigation** is primitive depending on farmers experience.

RECOMMENDATIONS

- Development of Tariff system
- Enabling the water users' associations
- Reviews on the Palestinian standards for the treated effluent reuse
- Enhance Self-monitoring
- Treated effluent standards unifications
- Sludge management

SCP

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TOGETHER, TO MEET THE CHALLENGES OF IRRIGATED AGRICULTURE

REUSE Structuring Action

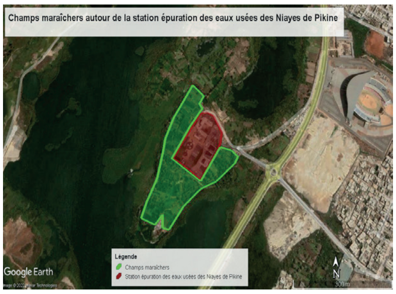
SITE OF NIANYES PIKINE SENEGAL

ALPHA BA
YOUGA NIANG

INTRODUCTION

Niayes is Senegal's oldest and first REUSE site. It is also the largest in terms of farmers (over 350) and surface area (over 100 hectares). This is where the first REUSE experiments were tested in Senegal, and where several NGOs have been involved in supporting farmers. Indeed, all of the REUSE test projects of the State of Senegal have been carried out on this site. The practice of REUSE on this site is not the result of planning by the public authorities but took place by chance when producers who had set up in the area were using the water of the lake for market gardening.

IDENTITY CARD



Wastewater treatment p type: activated sludge

Tertiary treatment: no

TWW volume: 935 m³/d

Storage: Not defined m³

Irrigable area: 64 ha

Nb. of farmers: 358

Crops: Market gardening

Type of irrigation: Sprinkler

ANALYSIS

- A market for the produce exists and many women are involved in bringing the produce to market.
- Producers agree to pay for the water but demand improvements in quality and quantity.
- Existence of a formal producers' structure on site to defend their interests and interact with the ONAS.
- The site has land tenure security with a decree classifying the site as an urban community reserve.

- Water quality and quantity unsatisfactory in relation to farmers' needs.
- No sanitary control system for produce.
- Underlying tensions between the various stakeholders.
- Progressive salinisation of the land.
- Negative effects of excess water discharged into the lake, with the disappearance of fishing activities.
- Neglect of septage by farmers with the decline in quality.

RECOMMENDATIONS

- ✓ Review the capacity of the plant, which receives more wastewater than its actual capacity.
- ✓ Improve the quality of treated water by passing to a tertiary level.
- ✓ Put the urban community reserve mechanism to use for other REUSE sites in Senegal.
- ✓ Finalise the setting up of a connection system for farmers with a view to moving towards invoicing for water.
- ✓ Set up a sanitary monitoring system for farmers and produce.
- ✓ Work on an exhaustive assessment of the site's potential in terms of REUSE.

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TOGETHER, TO MEET THE CHALLENGES OF IRRIGATED AGRICULTURE

REUSE Structuring Action

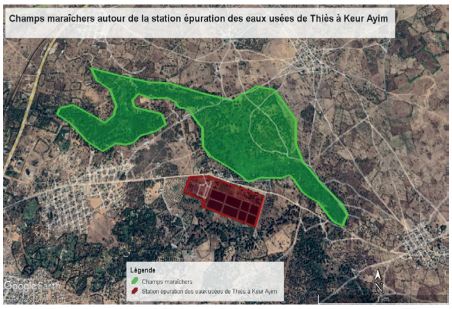
WASTEWATER TREATMENT PLANT OF THIES SENEGAL

ALPHA BA
YOUGA NIANG

INTRODUCTION

The Thiès site is served by the Thiès plant which treats wastewater from the households of this town. Built in 2007, this plant has a capacity of 3 000 m3/day and has not yet reached its treatment capacity. It uses a lagoon-based system for tertiary treatment. It is the only site in Senegal currently practising tertiary treatment. Unlike the other sites, which must use the Cambèrent plant laboratory to analyse water quality, this site also has an on-site laboratory for the regular monitoring of treated water quality. This system enables the site to discharge water that complies with WHO standards for treated wastewater. The site is home to approximately one hundred farmers covering an estimated area of around thirty hectares. It should also be noted that the ONAS had not planned to practise REUSE on the site, but rather to discharge the treated water into the valley bottoms to recharge them.

IDENTITY CARD



Wastewater treatment plant type: activated sludge and lagoon

Tertiary treatment: yes

TWW volume: 3000 m³/d

Storage: 5000 m³

Irrigable area: 39 ha

Nb. of farmers: 124

Crops: market gardening

Type of irrigation: sprinkler

ANALYSIS

- Plant currently operating at 2/3 capacity.
- Availability of quality treated water in large quantities for producers on the site.
- No negative impacts of REUSE observed by practitioners in the area.
- The fact that the water is free makes REUSE products more competitive in the area, and there is a market with the town of Thiès.

- Surplus treated water discharged for groundwater recharge.
- No mechanism in place to monitor produce derived from REUSE in the field.
- Insecurity and risk of land loss for producers on the site.
- Lack of producer organisation and official functional relations with the ONAS.

RECOMMENDATIONS

- ✓ Set up a mechanism to secure the land practising REUSE.
- ✓ Help the producers to better structure themselves collectively.
- ✓ Initiate discussions with producers about the possibility of charging for water.
- ✓ Establish a framework for ongoing exchanges between producers and the ONAS.
- ✓ Set up a national association of REUSE practitioners to disseminate the practice.

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TOGETHER, TO MEET THE CHALLENGES OF IRRIGATED AGRICULTURE

REUSE Structuring Action

SFAX EL HAJEB

TUNISIA

Houssem Braiki
Fadhel Ghariani

INTRODUCTION

The scheme was created in 1987. Intensifying the use of TWW will help to improve resilience to the effects of climate change by filling a significant part of the water deficit expected by 2050. The scheme makes good use of TWW despite its poor quality, thanks to the integration of fodder crops and milk production, as well as processing (cheese-making). It has the potential to be extended if the quantity and quality of TWW so allow.

IDENTITY CARD

Wastewater treatment plant type: low-rate activated sludge

Tertiary treatment: no

TWW volume: 49 500 m³/d

Storage: no storage

Irrigable area: 452 ha

Nb. of farmers: 7

Crops: fodder and arboriculture

Type of irrigation: improved surface irrigation

ANALYSIS

The climate context and the scarcity of conventional resources are favourable to REUSE.

The integration of fodder crops intercropped with olive trees and milk production followed by processing (cheese-making).

Saving on inputs.

The very poor quality of the TWW.

The standard at the WWTP inlet is not met.

Outdated infrastructure and absence of storage facilities.

Urban encroachment threatens the scheme.

Insufficient resources allocated to awareness-raising.

Financial unviability of the GDA

RECOMMENDATIONS

- Upgrading of the infrastructures.
- Groundwater recharge project to increase the availability of the resource and its use.
- Pilot project to expand into high value-added crops.
- Communication and awareness programme.

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TOGETHER, TO MEET THE CHALLENGES OF IRRIGATED AGRICULTURE

REUSE Structuring Action

NABEUL SOUHIL

TUNISIA

Houssem Braiki
Fadhel Ghariani

INTRODUCTION

Created in 1982, the Souhil scheme is the second TWWR scheme in the country. Tree cultivation ensures that the resource is put to good use through the production of essential oils (neroli), mainly for export. Increased use of the resource will reduce the impact of discharging TWW into the sea. Sludge is also recovered within the scheme.

IDENTITY CARD

Wastewater treatment plant type : SE3: low-rate activated sludge SE4: medium-rate activated sludge

Tertiary treatment: SE3 (no) – SE4 (yes)

TWW volume: SE3 3500 m³/d – SE4 16 538 m³/d

Storage (m³) 600, 500 and 4500

Irrigable area: 302 ha

Nb. of farmers: 432

Crops: citrus, tobacco, olive

Type of irrigation: improved surface irrigation

ANALYSIS

Crops with good added value.
Good quality TWW.
Good level of cost recovery.
Good governance of the scheme.

Insufficient quantity of water (storage, water turns).
Outdated irrigation infrastructure.
Absence of storage and discharge of unused TWW into the sea.
Lack of awareness-raising resources.
Need to rejuvenate plantations.
Threat of urban encroachment.

RECOMMENDATIONS

- Programme to upgrade infrastructure.
- Setting up of inter-seasonal storage.
- Pilot project to expand into high-value crops.
- Use of renewable energy.
- Evaluation and optimisation of sanitary and environmental monitoring and control activities.
- Productive alliance programme for the bigarade flower value chain.
- Communication and awareness-raising programme.

5. CONCLUSIONS OF THE FINAL FEEDBACK SEMINAR

5.1 OSS and FAO Interventions, opportunitiEs for synergies

In North Africa, two international organisations have launched initiatives on the use of non-conventional water:

- The Sahara and Sahel Observatory (OSS) coordinated the **regional initiative 'Water stress in North Africa' with AFD**. The objective of this regional initiative was to feed, for a period of 18 months (2021-2022), the public policy dialogue in the region (Algeria, Egypt, Libya, Morocco and Tunisia) and to encourage knowledge sharing on a regional scale on the issues of water stress and solutions to face these challenges. This initiative addresses good practices in conventional water demand management as well as the prospects for complementary responses provided by non-conventional water (including REUSE) and fossil water.
- The FAO is coordinating **the Maghreb initiative for the reuse of non-conventional water in agriculture (IMENCO)** with the Arab Maghreb Union. The objective is to strengthen planning procedures and regulations, pricing structures, technology, tools and institutional capacities to promote non-conventional water reuse (drainage water and REUSE). It aims to set up pilot projects of excellence in the five countries of intervention (Algeria, Morocco, Mauritania, Libya, Tunisia) with an investment plan of $7.5 million over five years. These sites, five for REUSE and five for drainage water, were selected in each country following national status reports, institutional dialogues and cost-benefit analysis studies.

The OSS initiative provides a general vision of the issues of access to water in the region, while the FAO initiative is distinguished by its willingness to strengthen investments to finance activities locally. COSTEA's REUSE structuring action is complementary to these regional approaches. It responds to two OSS recommendations to limit scientific information gaps, namely:

- Strengthen the use of non-conventional water resources as they are precious and sustainable alternative sources and can contribute to reducing the water deficit;
- Develop benchmark studies based on the analysis of local, regional and international experiences in the use of treated wastewater and agricultural drainage water in irrigation.

The 12 cases studied in the framework of this COSTEA structuring action help to illustrate the good practices and difficulties encountered at the scale of irrigated schemes. They provide valuable feedback to enrich the learning process on the implementation of REUSE in North Africa as targeted by the OSS and FAO approaches. These 12 cases were chosen for their exemplarity in each country. However, they all bear witness to operational difficulties that they could share within the regional network that IMENCO aims to set up. It should be noted that for the common countries (Algeria, Morocco, Tunisia) none of the COSTEA REUSE sites correspond to one of the FAO REUSE sites; there is therefore complementarity.

In the perspective of a phase 3 on REUSE, COSTEA could continue its work with these 12 sites. This phase focused on facilitating local dialogue between stakeholders to develop a diagnosis. The next phase could focus on setting up a network of living labs on REUSE in cooperation with the FAO, the University of Manouba and the OSS to encourage the transfer of technology and know-how.

5.2 Recommendations

Theme 1

1/ Integrate REUSE planning into the sanitation planning process

The design of treatment plants rarely takes into account the potential for using treated wastewater. The choice of sites for the installation of treatment plants is primarily based on environmental and sanitary objectives for collecting and treating wastewater. The potential for the reuse of discharges should be integrated into the scenarios proposed in the preliminary design studies.

2/ Organise the transition to planned and regulated REUSE

REUSE is developing informally in many countries. This makes it possible to circumvent legal and institutional obstacles. This practice is poorly quantified and the strengthening of controls and bans is not enough to curb it. States should identify these informal REUSE sites and draw up compliance proposals with the actors, without hindering operations that are often satisfactory from an economic and social point of view, without any major health impact.

3/ Develop new purification technologies

The treatment processes mastered by sanitation actors are generally not well adapted to the rural context with a more dispersed population and low volumes to be treated. Experiments are needed to try out low-cost treatment processes and to test new energy sources (renewable, sewage sludge). On the basis of successful projects (e.g. Sidi Abdallah el Bouchouari), autonomous sanitation systems could be standardised, promoted and supervised.

4/ Promote sewage sludge management and recovery

This aspect of sanitation is little taken into account. There are few standards and strategies at country level and the chains are poorly developed. Yet the storage of sludge at WWTPs is an obstacle to the operation of certain plants. A revision of regulations and infrastructures is necessary as well as capacity building for operators. The increase in the price of fertilisers is leading farmers to look favourably on this potential resource (e.g. Wadi Souhil in Tunisia). With regard to the recovery of septage from non-collective or semi-collective sanitation, the technical stabilisation stage is necessary within specific treatment units, which can then lead to real economic value chains, as is the case in Senegal.

Theme 2

1/ Put in place a legislative and regulatory framework adapted to the uses

The regulatory situation is very different from one country to another, but the need for measures is consensual. The regulatory arsenal is non-existent for some countries or incomplete for some uses. Implementing provisions of laws have not always been published to operationalise the planned REUSE in the countries. A revision is sometimes necessary to make non-harmonised standards between discharge and TWWR requirements evolve; effluent quality is sometimes too restrictive for certain uses. These findings also apply to sludge recovery. The Bolivian approach of regulating the quality of water taken from water bodies is pragmatic from a health and operational point of view: it avoids focusing on TWW.

2/ Improve the coordination of stakeholders

The poor organisation of stakeholders is an important reason for the blockage of REUSE projects. This concerns both inter-institutional relations at the local and national levels and multi-scale interactions. At national level, the creation of a REUSE agency or a specific committee is proposed. From one country to another, the distribution of roles and responsibilities and dialogue modalities can take different forms. They should be defined in texts, established in conventions, and implemented. The involvement of civil society and users is important to anchor projects in the territories. The involvement of private actors, especially operators for the distribution of TWW, is suggested in some cases. Better connections with research are also needed to facilitate the transfer of scientific work to institutional actors (for regulation) and operational actors (for practices and monitoring).

3/ Support REUSE users

REUSE requires the adaptation of sanitary and agronomic practices. Farmers and users' associations need to be guided through these changes to respect specific hygiene measures and train them on the choice of suitable crops and irrigation equipment. Capacity building activities (visits, training, manuals, etc.) should be planned. The organisation of REUSE farmers at the level of irrigated schemes or at national level is an opportunity for networking which encourages the dissemination of good practices.

4/ Communicate and raise awareness on this still unknown alternative

REUSE is a practice that is still unknown and which sometimes suffers from a less than favourable social perception. The countries' efforts in terms of communication and awareness-raising to explain the depletion of water resources and the search for alternatives such as REUSE are not sufficient. Resources need to be allocated to build the confidence of potential users and end consumers. The introduction of awareness-raising days, media campaigns or the highlighting of exemplary sites via 'trophies' are examples that should be developed.

Theme 3

1/ Place the REUSE resource in the global context of the available water resources

Treated wastewater is an available resource for environmental, social and economic issues on the scale of water bodies. It is part of the water cycle and thus contributes to the needs of a territory and its stakeholders as a complementary or substitute resource. It is relevant to integrate REUSE into planning processes for both territorial integrated water management plans and climate change adaptation plans.

2/ Support the development of projects

The development of REUSE projects depends on substantial investments to obtain water that complies with quality standards and a distribution network adapted to the users. These investments require financial support for both the urban and rural contexts. Multi-use projects are conducive to economic benefits for a territory and thus justify public support. Other investment models need to be tested and evaluated, such as, for example, public-private partnerships, financial contributions from users and/or revised water charges. The existence of currently informal operations should be analysed in context, and preserved as much as possible.

3/ Improve the recovery of the operational costs and the economics of REUSE

Few REUSE operations are financially balanced. Farmers have a low capacity to pay for water, and operators cannot afford to pay for maintenance and electricity costs alone. Financial analyses and the concerted development of a pricing system are necessary, albeit not sufficient, conditions upstream of project planning.

- Public authorities should subsidise the creation of irrigated schemes, but also, in decreasing amounts, their operation in the first years;
- Operators should:

i/ provide the required service in terms of water quantity and quality to guarantee user satisfaction,

ii/ seek to diversify the uses of treated wastewater,

iii/ minimise production costs with treatment technologies adapted to the uses and controlled pumping costs with new energy mixes.

- Farmers should make better use of water through water conservation measures, the adoption of new crops with higher added value, and possibly collective units for processing products. At the scheme level, principles of solidarity between farmers (large- vs. small-scale) can be discussed in the design of the tariff system.

Once again, indirect REUSE operations (dam lakes, wadis, aquifers) should be favoured when possible, as they allow both storage and complementary self-purification at a low cost, and the empowerment of downstream users.

Thème 4

1/ Program the upgrading of sanitation infrastructures

Inadequate infrastructure is a limiting factor affecting both the quality and availability of the resource. The rehabilitation and extension of treatment plants is necessary to improve the viability of the infrastructure and REUSE projects. The use of renewable energy and low-cost techniques should be favoured. Efforts to professionalise operations are also desirable to better control treatment processes and their maintenance.

2/ Improve the monitoring of environmental and sanitary data

The impact of REUSE on surface water, groundwater, soil or the quality of agricultural products is poorly documented in the different countries. Risk control, which is essential for confidence, is uncertain on some schemes. Efforts in terms of analysis and data sharing need to be optimised to ensure that the practice is secure. This also means strengthening manpower and skills at the local level. The WHO's Sanitation Safety Plan (SSP) approach is a relevant tool to adopt.

3/ Support research approaches and their funding
The development of REUSE is confronted with needs for knowledge that are still significant, particularly in terms of health and agronomic issues.

- The lack of long-term epidemiological studies and the emergence of new contaminants raise doubts as to the safety of the practice. Tertiary treatment limits these uncertainties to the detriment of the financial balance of the projects. This raises the question of whether there is a match between the impact on health and the appropriate treatment needs.
- Agricultural REUSE implies developing adapted irrigation equipment to better respond to the specificities of wastewater and minimise maintenance. It calls for better monitoring of nutritional inputs with fertigation. It also requires identifying crops and varieties that are more tolerant to salinity.

5.3 Photos

The seminar took place over a day and a half at the Vincci Nozha Beach Hotel in Hammamet.

The Tunisian Minister of Agriculture and the Governor of Nabeul spoke at a welcoming event. Some 50 participants attended. There was a succession of presentations and roundtable discussions.

The delegation then visited the Nabeul SE4 treatment plant, from which TWWR and sludge recovery are practiced.

The afternoon field trip continued with a visit to the INRGREF research station in Wadi Souhil.

Finally, the irrigated scheme of Wadi Souhil was the last stop of the visit.

6. PROSPECTS

At the end of the work in 2021 and 2022, a COSTEA REUSE synthesis was drawn up.

This synthesis contains five key messages from the 18 months of collective work.

1/ REUSE should be planned into the water cycle as a fully-fledged component of integrated water resource management.
In this way, REUSE is secured through an adequate treatment of wastewater, according to the intended uses and their required quality, and the environmental sensitivity of the surroundings. REUSE planning is not incompatible with an indirect reuse of the water, after it has passed through the natural environment. In this case, self-purification phenomena can be taken into account in addition to treatments by purification processes (barrier effect). In this respect, Bolivia has an interesting regulatory framework that classifies all water bodies (including treated wastewater) into categories according to the quality of the water.

2/ Sewage sludge and septage should be considered as a source of recoverable by-products and agricultural inputs rather than a constraint to be managed.
Although septage is perceived as a difficult issue to manage, it is in fact an opportunity and an asset for territories. In the example of Senegal, there are several secondary towns with treatment plants for septage that is recovered and used in agriculture as a substitute fertiliser at the centre of a real economic value chain. The development of the sludge value chain requires a systemic territorial approach that involves stakeholders at the local level and at each stage of the chain in order to progress towards services that are complete, safe from a sanitary point of view, and functional.

3/ It is essential to consolidate a governance framework conducive to the development of REUSE by strengthening procedures and the political, institutional and legal framework.
Conflicting policies and a lack of institutional support often explain the failure of REUSE projects. The main success factors to be considered in the definition of this framework are (i) the prioritisation of REUSE in water policy to promote a more efficient use of water resources; (ii) the coordination of stakeholders, and their involvement through the designation of a coordinator; (iii) the national and international harmonisation of standards; (iv) the consideration of the socio-cultural dimension at different scales; (v) effective risk management.

4/ The cost-effectiveness of REUSE should better integrate the social and environmental benefits.
Conventional economic and financial methods almost systematically make REUSE projects unjustifiable, as the favourable environmental and social impacts are rarely taken into account, or are underestimated. The sustainability of projects of REUSE in its three components (economic but also social and environmental) can be approached through life cycle analysis methodologies or cost-benefit analyses.

5/ Controlling the health and environmental risks linked to REUSE requires REUSE project stakeholders to develop key components to anticipate risks and propose solutions adapted to the uses and territories.
Achieving health and environmental objectives requires the monitoring and evaluation of the system, the definition of the responsibilities of the monitoring and control institutions and services, documentation of the status and functioning of the treatment, and independent confirmation of its proper functioning. A risk analysis type approach is relevant for the development of health safety standards for water users and agricultural products.

ANNEXES

FRAMEWORK ADOPTED FOR THE 'COUNTRY' SYNTHESIS REPORTS

SUMMARY

1 INTRODUCTION
1.1 Objectives
1.2 Terminology

2 NATIONAL STATE OF PLAY
2.1 Institutional framework
2.2 Integrated water resource management
2.3 Sanitation situation
2.4 REUSE situation
2.5 Sludge management situation
2.6 Prospects

3 EXISTING BIBLIOGRAPHY
3.1 National structuring studies
3.2 Scientific research
3.3 Specific studies linked to the projects
3.4 Summary

4 ANALYSIS OF THE NATIONAL SITUATION FROM THE PERSPECTIVE OF THE FOUR THEMES
4.1 T1: uncontrolled reuse, sludge management, extensive treatment
4.2 T2: governance, acceptability, consultation, training
4.3 T3: integrated water resource management and economic impact
4.4 T4: efficiciency of the equipment and practices
4.5 Analysis of the country's situation, possible ways forward

5 MULTICRITERIA ANALYSIS GRID FOR THE CHOICE OF STUDY SITES
5.1 Presentation of the grid
5.2 Identification of potential case study sites in phase 3
5.3 Verification of the available information

MULTICRITERIA ANALYSIS GRID FOR THE CHOICE OF SITES

			LEV 0	LEV 1	LEV 2	LEV 3
THEMES	CRITERIA	SCORE	-	*	**	***
T1 REUSE AND ENVIRONMENT	1.1 Informal, unplanned REUSE		no	ongoing and problematic	ongoing without problem	successfully underway, documented
	1.2 Environmental impact on surface- or groundwater		unknown	little information and neutral	unfavourable and problematic	favourable and observed
	1.3 Agronomic recycling of sludge		no	planned	implemented with difficulty	successfully implemented
T2 GOVERNANCE AND SOCIAL	2.1 Local governance scheme		absent	informal	defined but dysfunctional	defined and functional
	2.2 Verification of the application of standards		no	irregular	regular but not shared	regular and shared
	2.3 Acceptance and commitment of users		blockage	mistrust predominant	trust predominant	trust and commitment
T3 IWRM AND ECONOMICS	3.1 IWRM (needs-resource approach by water basin)		absent	planned	defined but poorly applied	defined and functional
	3.2 Water pricing		absent	existing, not covered	exists, covered, not viable	exists, covered, viable
	3.3 Marketing of agricultural produce		absent	real, low-paying	remunerative, limited innovation	remunerative and innovative
T4 TECHNIQUE AND HEALTH	4.1 Tertiary treatment equipment		absent	exists, not operational	exists, encounters difficulties	exists and fully operational
	4.2 Irrigation equipment		gravity	Improved gravity-fed	sprinkle and localised	idem and doses controlled
	4.3 Health impact		unknown	poorly documented	documented and problematic	documented and unproblematic

PROGRAMME OF THE FINAL FEEDBACK SEMINAR OF HAMMAMET

Tuesday 14 June
PRESENTATION AND DISCUSSION OF THE OUTCOMES OF THE REUSE STRUCTURING ACTION

The first day is devoted to the content of the REUSE structuring action: the main conclusions, the experiences to be shared, the difficulties encountered and the recommendations.

MORNING

8h30-9h
Opening
Words of welcome MARHP, AFD, COSTEA

9h-9h30
Introductory session
Presentation of the participants and agenda

9h30-9h50
REUSE strategy 2050
Presentation of the DGGREE

9h50-10h30
Presentation of the sites
Poster session of the 12 pilots studied

10h30-11h
COFFEE BREAK

11h-12h30
Country presentations
Presentation of the main national conclusions and discussion

12h30 – 14h
LUNCH

AFTERNOON

14h-15h30
Cross-cutting views
Presentation of cross-sectional analyses and discussion with participants

15h30 – 16h
COFFEE BREAK

16h-17h30
Institutional benchmark
Presentation of the transversal analysis and discussion with the participants

17h30-18h30
Feedback and what has been learned from the 18 months of the COSTEA REUSE SA
Collective discussion on successes, obstacles, suggestions.

19h30
DINNER

Wednesday 15 June
REFLECTIONS ON THE FOLLOW-UP TO COSTEA REUSE & FIELD VISIT

The second day is dedicated to the follow-up of the REUSE structuring action, including the possible connections with the parallel OSS/FAO approaches. A visit to one of the SA sites studied is planned for the afternoon.

MORNING

8h30-9h00
Regional REUSE initiatives
FAO and OSS presentations

9h00-10h15
Thematic discussions
Identification of knowledge gaps on water REUSE (in 4 thematic groups)

10h15-10h45
COFFEE BREAK

10h45-11h30
Thematic presentations
Plenary presentation and discussion of knowledge gaps

11h30-12h15
Follow-up to the SA
Collective discussion on the follow-up of the COSTEA REUSE SA

12h15-12h30
Conclusions

12h30-14h
LUNCH

AFTERNOON

14h
Departure for the visit
Visit of the WWTP and the irrigated area of Nabeul
Meeting with local actors
Visit of the INERGREF experimental site

17h
Return to Tunis
Transfer by bus to a hotel in the capital

19h30
DINNER