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A critical analysis of water economics in public water and sanitation services in Morocco

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Abstract

Purpose – The objective of this article is to propose a panel of management performance evaluation indicators at operator level. This panel would be the tool to be made available to an observatory that should be set up by regulation. The proposal comes at the right time given that Morocco is planning a major reform of the sector very soon. A framework law has already been promulgated for this purpose (Law 51-21 relating to the reform of public establishments).

Design/methodology/approach – The proposed panel is the result of (1) a review of the literature dealing with public management theories, in particular those relating to industrial and commercial public services and whose character is captive. The management of the latter requires a great deal of caution to preserve their economic balance and consequently their sustainability. (2) A review of experiences of countries is chosen because of contextual their similarities with Morocco like France having a similar legal background, Tunisia and Algeria chosen for geographical and economic similarities. The British experience is also discussed for what it represents as a liberal model in the management of public water and sanitation services, as opposed to the German model also studied and which stands as the only country where the management of public services has almost always been a communal prerogative. The analysis of these models has made it possible to identify management evaluation practices that could be adapted to the Moroccan context. (3) Research work by practitioners and reports from specialized international institutions (International Water Association [IWA]). (4) A critical analysis of a multitude of management and activity reports from 12 autonomous authorities and 4 private delegates covering 16 million inhabitants of the urban environment. A total of 15 indicators are developed. They aim to assess the effectiveness of management in terms of saving drinking water and preserving the natural environment from the pollution of water resources.

Findings – Approximately, 15 indicators for assessing water resource management in public water and sanitation services are proposed. These indicators relate to the efficiency of pipe networks, the performance of storage systems and losses in users' homes. Indicators specific to liquid sanitation systems, particularly with regard to the control of wastewater overflows into the public highway and their treatment before discharge into the natural environment, are also proposed.

Research limitations/implications – The application of the results of this research could be confronted with its appropriation by the operators. Indeed, the investment involved in setting up the proposed evaluation system, as well as the conflict of interest that may arise in the process of formalizing and standardizing the system at the national level, may slow down the process of setting it up.

Practical implications – In practice, the implementation of a system for evaluating the performance of water resource management in public drinking water and liquid sanitation services would make it possible to optimize the volume of water to be mobilized. Substantial savings are expected both at the level of the resource itself and at the level of the investments that accompany the realization of the mobilization and distribution infrastructures. These savings will be very useful for the creation of other similar services and to serve more people.

Social implications – The distribution of drinking water and liquid sanitation is a vital human need. These services are extremely captive. They are key factors in the socioeconomic development of the territory and the

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citizen. The impact is transversal and affects the lifestyle of the populations. On the one hand, it favors the sedentarization of the populations and on the other hand, preserves their health by fighting against the diseases of water origin. In addition, the comfort that it provides in the daily life of users is highly coveted when they are delivered in a modern way and arranged with modern technologies.

Originality/value – The regulation of public drinking water and liquid sanitation services in Morocco is the weakest link in the sector. The Ministry of the Interior is legally responsible for setting up a standard system for evaluating the management of these services to fill this gap (organic law 113-14 on municipalities). Unfortunately, this initiative is not yet underway. The opportunity to apply the results of this research is well timed. Morocco plans to launch a global reform of the sector starting in 2022–2023 (Law 50-21 on the reform of public institutions).

Keywords Drinking water, Sanitation, Management indicators, Performance, Water resources, Water loss

Paper type Research paper

1. Introduction

Drinking water and liquid sanitation public services in Morocco constitute a communal prerogative (Organic law 113-14, 2016). Communes have the choice of either managing it themselves or delegating the management to another public or private operators. Three fundamental principles must be respected while exercising the management. The constitution of the Kingdom of Morocco stipulates, indeed, equal citizen access to services, continuous service supply and fair territory (Constitution of the Kingdom of Morocco, 2011).

These principles can only be truly guaranteed through two main axes for durable water resource management, e.g. resource saving and its protection against pollution. Indicators are set up to evaluate the performance of these two management aspects, which are still regarded as insufficient to figure out the reality.

During 2005–2020, distribution system efficiency continues to fluctuate between 69.30 and 77.9%. The linear index of drinking water losses in the network evolved from 25.9 to 14 m^3/day/km (consolidated results) (Ministry of the Interior. Morocco. DRSC, 2018; Water and sanitation operators in Morocco, 2005–2020).

In terms of liquid sanitation achievements at the end of 2019, significant progress has been made under the National Sanitation Program (NSA, PNA in French language). The current situation is cited by the Department of the Environment (Ministry of Energy Mines and Environment, Morocco, 2020):

(1) Connection rate: 76% compared to 70% in 2005;

(2) Wastewater treatment rate: 52.9% compared to 8% in 2005. It is around 80% for private delegation and autonomous communal operators. But most treated wastewater is discharged into the sea or into the public hydraulic domain (615 Mm^3). Only 71 Mm^3 are reused. Of which, 17% are reused in the phosphate industry.

The NSA was completed in 2020 (initial targets: 75% urban connections and 60% pollution drawdown). The State's strategy has been focused since 2018 on the mutualization of urban and rural sanitation as well as the reuse of wastewater treated under a new program called National Mutualized Sanitation Program – NMSP or PNAM in French language).

The expected objectives of the NMSP by 2040 are as follows:

(1) Accelerate the pace of implementation of the NSA to achieve a 95% connection rate and an 80% treatment rate including sea outfalls by 2040.

(2) Clean up the chief towns of communes in rural zones to reach a 50% connection rate by 2030 and 80% by 2040.

(3) Promote the reuse of treated wastewater to mobilize 474 Mm^3/year by 2030 and 573 Mm^3/year by 2040.

This ambitious challenge requires the implementation of a standard performance evaluation system to upgrade all operators in the water and liquid sanitation sectors.

Since 2018, there have been significant institutional and regulatory changes in these sectors:

(1) Ministry of the interior had started a process of modernization of the management of public water supply and sanitation services in terms of governance, harmonization of the operator's requirements specification and digitalization of procedures.

(2) The usual operators (autonomous communal operators and private delegates) will be replaced by regional multi-service limited companies in which the State will have a shareholding to strengthen and promote the good governance of these services (law n°50-21 on the reform of public establishments and companies). The regions of Casablanca-Settat (7,408,213 inhabitants) and Souss-Massa (2,896,152 inhabitants) have been selected as pilot projects. This process should be launched in January 2022.

It is understood that the economic and financial equilibrium of these services is highly sensitive to the mobilization of water resources and to the capacity of users to recover the real costs.

This being the case, regulatory and steering mechanisms must be put in place quickly to accompany the implementation of this strategy. The evaluation of management performance is an essential component of this. This is the context in which this article is intended. It proposes a panel of contextual indicators based on the examination of a very wide range of data and information from the activity and management reports of operators over the last 15 years (2005–2020). Scientific articles in the field of public and social management with literature on practices in different contexts were also an important source for the choice and construction of indicators. This amalgam of knowledge combined with the experience accumulated in these fields led us to design 15 indicators adapted to the Moroccan context dedicated to the management of water resources and their preservation against pollution.

In addition, to successfully deploy the new strategy, it is essential to have technical regulation tools, the weak link in the current system. The panel of indicators proposed rightly responds to this threefold problem, i.e. saving water, protecting the resource and regulating the public service. It is therefore timely. However, it should be shared with all stakeholders to ensure that it is progressively anchored in the current system and avoids being rejected.

2. Methodology

The methodology adopted for the realization of this article is similar to the case study and the research-intervention advocated by a panoply of theoretical authors in management sciences Capgra, Nikolas, & Pascal, 2011). This method consists in the production of knowledge in interaction with the field. Indeed, the lead author has been professionally involved in the governance bodies of water and electricity utility operators in Morocco since 2015 and below. The daily handling of field data and management reports prepared annually by the operators (the latter are published on their websites), the author was able to develop some expertise in public management.

We have therefore tried to dissect the system in place by highlighting the general context of water resource management in public water and wastewater services. We have identified the institutional, regulatory and technical constraints that hinder the effective management of water resources, the main component of this sector. This article has focused essentially on the management modes of autonomous management and private delegation. These two models are mainly concentrated in the Moroccan urban environment and cover the needs of more than half of the country's population.

On the theoretical level, the notions of corporate social responsibility (CSR), socially responsible investments (SRIs) (M'zali, Hervieux, & M'Hamdi, 2017), ESG criteria (environment, social and governance) (Derujinsky-Laguercir, Kern, & Lorino, 2011) and performance evaluation dashboard (balanced scorecard) (Kaplan & Northon, 2007, have been a source of concepts and theories used in public management. Scientific research (Guerin Shneider, 2001) and work by practitioners in the field (IWA, 2003) have made it possible to identify the divides and distortions between theory and practice in the sector studied. These practices are identified from the management reports of the operators of the services in question, which are drawn up annually. About ten reports per type of operator were examined. These reports relate the main management results of drinking water and wastewater services in general and those relating to water resources in particular.

A benchmarking exercise was also carried out to identify international and regional best practices. A review of experiences of countries is chosen because of contextual similarities with Morocco as France having a similar legal path, Tunisia and Algeria having the geographical and economic similarities and Jordan known for its chronic water stress. The liberal model of England and that of Germany known as the most successful in Europe and based on the municipalization of the management of these services were also diagnosed. The analysis of these models allowed us to identify management evaluation practices that could be adapted to the Moroccan context.

The result is a panel that addresses the whole issue of water resource management evaluation. About 15 key performance indicators were constructed from the research carried out either by adapting the method of determining the variables to the conditions of the physical environment of Morocco or by extending the evaluation system in place to other aspects that have demonstrated their relevance in other theoretical or practical models and that are omitted in the system applied by the operators in place.

3. Current situation

The context for the management of public water and liquid sanitation services in Morocco is characterized by

(1) The country is classified by the World Resources Institute (WRI) with high basic water stress. The water resource is increasingly scarce;

(2) A sustained effort of drinking water infrastructure in terms of water resource mobilization and liquid sanitation is essential to cover the entire territory;

(3) A multitude of stakeholders in the water and liquid sanitation sector (Table 1).

(4) Insufficient institutional, regulatory and technical means to regulate these services effectively.

By their characterization of industrial and commercial public services and their qualification as territorialized local services, liquid sanitation and the distribution of drinking water have a dual dimension:

(1) A sociopolitical dimension because of their creation and the determination of the mode of their management is an attribution of the elected officials;

(2) A socioeconomic dimension since they are a lever for the economic and social development of the citizen and the territory.

They are part of the social and solidarity economy structures regarding the interterritorial equalization practiced for cost recovery (at least in the case of Morocco). Finally, they require a vision of sustainable development in the management processes. The institutional and

	Superior Council for Water and Climate	Ministry of the Interior			Department of Water		Department of the Environment	Ministry of Agriculture, Rural Development and Maritime Fishing	Ministry of fiance		Ministry of healht	Civil society and users
		Territorials collectivities	Autonomous communal operators	Private operators	ONEE	HBA		ONSSA	Budget Department	Public Establishments Department		
Institutional establishments for consultation and strategic orientations	Sanitation-Drinking Water	Sanitation-Drinking Water	-	-	-	-	-	-	-	-	-	-
Mobilization/Production	-	Drinking Water	-	-	Sanitation-Drinking Water	Drinking Water	-	-	-	-	-	-
Planification	-	Sanitation-Drinking Water	-	-	Sanitation-Drinking Water	-	-	-	Sanitation	-	-	-
Distribution	-	Sanitation-Drinking Water	Sanitation-Drinking Water	Sanitation-Drinking Water	Sanitation-Drinking Water	-	-	-	-	-	-	Sanitation-Drinking Water
Control	-	Sanitation-Drinking Water	-	-	-	Sanitation	Sanitation	Drinking Water	Sanitation-Drinking Water	Sanitation-Drinking Water	Drinking Water	-
Financing	-	Sanitation-Drinking Water	-	-	Sanitation-Drinking Water	Sanitation	Sanitation	-	Sanitation-Drinking Water	-	-	Sanitation-Drinking Water

Note(s): ONEE = National Office of Electricity and Drinking Water; ONSSA = National Office of Health and Food Safety; HBA = Hydraulic Basin Agency

Source(s): Original

Table 1. Institutional stakeholders in drinking water and liquid sanitation services

technical mechanisms to be put in place to preserve their sustainability must therefore be constructed within the framework of a compromise between local governance and regulation. These latter concepts can be defined as follows (Demoustier & Richez-Battesti, 2010):

(1) Territorial or local governance is a complex phenomenon of stability (compromise and negotiation) and instability (divergence and conflict) in which heterogeneous actors must mobilize around a common objective. In other words, it implies that the public institution no longer has a monopoly on territorial organization. Instead, the decision-making system includes the participation of actors with different interests. In the specific case of the management of drinking water and liquid sanitation services, the theoretical fields to be mobilized to approach territorial governance refer to several disciplines whose analytical frameworks and tools are various. On the other hand, administrative limits can make it difficult to implement a coherent territorial public action. In a context where the administrative territory does not encompass the whole functional system, no one has the power to act on the whole system (shared resources and diffuse impact). New modes of organization are needed to build a shared vision and to take decisions and initiate actions with several actors as reported (Dionnet & Guérin-Schneider, 2014).

(2) As reported by Demoustier and Richez-Battesti (2010), the mode of regulation is defined by Boyer (1995) based on Aglietta (1976) as "the contradictory dynamics of

transformation and permanence of a mode of production" and Orléan (1994) as "the series of institutions, rules of the game and market and nonmarket conventions that involve situated rationalities".

The indicator assessment, performance of drinkable water distribution system which is applied in drinkable water distribution service without a legal basis, demonstrates an average value of 77.9% consolidated by the communal operators and private operators (DRSC, 2020). A deposit of 55 Mm^3 [1] of drinking water is lost every year with regard to an optimal feasible distribution performance of 82%. The amendments made to this indicator between 2005 and 2020 are 5.3 points for private operators and 11.7 points for communal operators. Nevertheless, these values remain biased due to the absence of standardization of calculation methodology and performance indicators. In this respect, we notice that in the 2020 database, a one point improvement performance would help to gain 8.4 Mm^3 of drinking water every year. In order to reduce water losses, the Grouped Rural Water Supply Program (PAGER) in its new version (2020) has set a target of 78% efficiency by 2027 at national level.

3.1 Multiplicity and interference of stakeholders: factors against water resource management

The functional institutional scheme of water in Morocco is characterized by a multitude of stakeholders. The attributions are redundant, posing many constraints to the smooth running of the service. Indeed, as the Economic, Social and Environmental Council (Economic, Social and Environmental Council, 2014) points out in a more macroscopic view of the role of stakeholders in the water sector in general, the multiplicity of stakeholders makes the overall interoperability scheme extremely complex, generating major risks and consequently inefficient:

(1) The urban development perimeter [2] does not always coincide with the management perimeters. This leads to inconsistencies in the establishment of master plans and implies a lack of visibility for the commune on the resource;

(2) In the case of management delegated to the private operator, the absence of an institutionally strong delegating authority (group of communes) means that the small territorial communes risk being stifled by the others, which are demographically and economically more important. The manager injects his/her investments where they are more profitable, and where social pressure is strong. Interference is even more constraining for the stakeholders when two managers intervene in the same area.

3.2 Terminological ambiguities and formulation of performance indicators

3.2.1 Drinkable water service. The nomenclature used and the parameters for calculating the indicators differ from one operator to another. This difference is reflected in the variables used to calculate the indicators. In the case of autonomous communal operators, the requirements specifications do not indicate indicators for measuring performance. Three examples stand out:

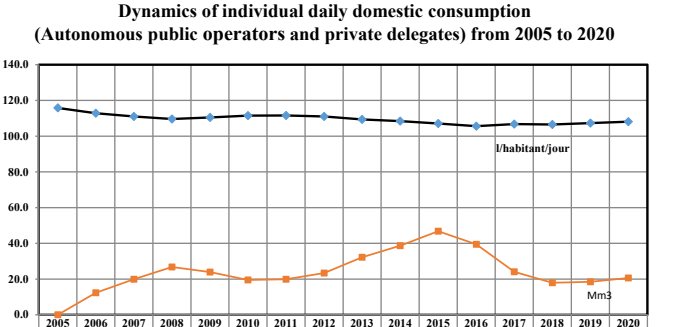
(1) The designation of "access to the service" is disparate. The terms "access rate", "service rate" and "connection rate" are used to indicate the spatial coverage of the network. For some operators, they may also mean the availability of water at the household.

(2) The efficiency of the network is calculated according to different approaches. It is defined as the ratio of the volume of water sold to the volume of water mobilized (volumes produced and volumes purchased). The volumes sold, since they are not defined in advance, give rise to confusion about the volumes that are not invoiced but

used in full knowledge of the facts (volumes consumed free of charge, volumes used for the needs of the service, etc.). Many specialists also mention the need to accompany the yield with other indicators (Guerin Shneider, 2001). Moreover, its interpretation is always difficult. This difficulty lies in the qualification of the management perimeter, totally urban, semiurban or rural. In the case of Morocco, the frequent annexation of rural villages and peripheral neighborhoods of the cities gives reason to this opinion. The indicators, subscriber density and Linear Consumption Index (LCI), should be included in the matrix to judge whether the area is rural, urban or intermediate (Renaud, 2009). The use of efficiency as an exclusive indicator of the state of the network in France has been discussed and questioned (for a very long time), thanks to these external contributions (Guerin Shneider, 2001). It should also be noted that the International Water Association (IWA) has not retained yield as an indicator in its report on performance indicators for water services (IWA, 2003). It seems that their motivation is consistent with the above findings.

(3) The linear loss index (LLI) is calculated using the same approach without being compared to a standardized reference value. It is commonly accepted that the LLI is the right tool to assess the state of a water distribution network in terms of leakage, provided that it is standardized and normalized. Although the technical yields of the networks managed by the public operators and private operators have improved significantly and are tending towards 80%, the loss indices are high enough to make this result superfluous. The consolidated efficiency of these operators has risen from 69.3% in 2005 to 76.6% in 2020. Based on 2020 data, an improvement of 1 point in efficiency will save 8.4 Mm^3 of drinking water per year [3]. The LIL (Linear Index Loss) in distribution has been improved by 11.3 points from 2005 until 2019, i.e. an average of 0.75 points/year (Figure 3). This result is the immediate consequence of periodic leak detection campaigns and recurrent investments in the rehabilitation of distribution networks.

(4) The trend in water consumption by users is down. This is of the order of 6.62% from 2005 to 2020 (all operators and all categories of consumers combined). It went from 115.8 in 2005 to 108.1 l/inhabitant/day in 2020 (Figure 1). Indicators of the temporal evolution of consumption at the user's tap will be relevant insofar as a decrease or increase that persists will inevitably have an impact on the entire production–distribution process.



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Average annual consumption l/capita/day (Volume sold/pop served)	115.8	112.8	111.0	109.6	110.5	111.5	111.6	111.0	109.4	108.4	107.1	105.6	106.8	106.5	107.3	108.1
Gain in volume sold compared to 2005 (Mm3)	0.0	12.3	19.9	26.8	23.9	19.5	19.9	23.4	32.2	38.7	46.8	39.5	24.1	17.9	18.5	20.6

Figure 1.
Dynamics of individual daily domestic consumption (autonomous public operators and private delegates) from 2005 to 2020

Source(s): Original

3.2.2 Liquid sanitation. The wastewater managed by the autonomous communal operators and the private operators totaled 615 Mm^3 in 2020. This volume represents approximately 76.8% of the discharges at national level (800 Mm^3 of annual wastewater are collected; of which, 750 are of domestic origin in accordance to the report of the Ministry of Energy Mines and Environment, 2020).

In an interview given to the newspaper "Finance New" by the Minister of Energy, Mines and Environment published on 21 March 2021, treatment rate is at 90,5% for both communal operators and private operators. All this water is rejected either in the sea or in hydraulic public land. Only 71 Mm^3 are reused at national level; of which, 17% are reused in the phosphate industry (Diao, 2021).

The most known project is that of Marrakech city which recycles part of the used water for golf irrigation, the irrigation of palm grove and green municipal places. It has to be underlined that the reuse of raw sewage has always been a common practice. In 2009, it was estimated that about 70 Mm^3 of raw sewage was reused to irrigate an area of at least 7200 ha in the outskirts of some big cities like Marrakech, Meknes, Oujda, Fès, etc.) as per Cordom & AL (2015). These waters could regrettably escape the authorizations of reutilization. This shows that the reuse of used water is relatively accepted.

3.3 Absence of national norms

3.3.1 Resorting to benchmarking for indicator qualification. In 2006, Water and sanitation Management Laboratory (WML), (GEA in France) of National School of Rural Engineering, Water Resources and Forestry in France, established a frame of reference concerning LLL depending on the covered area (rural or urban) (Table 2). The correlation is made by considering subscribers' size per kilometer network according to a report of Dreal-Cera (2013). In this frame of reference, the consolidation of the last 15 years' results qualifies the performance of communal operators and private operators as poor. Obviously, the values exceed the reference in the urban area of WML. The national average is 14.8 m^3/day/km (results 2020). By applying this ratio on the total network length of communal operators and private operators' area, we are surprised by the big amount of water lost: 418,000 m^3/day [4] (regarding an optimal LIL average of 3.3 m^3/day/km). In order to line up with the diagram norms in Figure 2, these loses have to be brought back to 120 m^3/day.

> NB: The mathematical correspondence between production and LLI is not obvious. When it is about estimated or measured variables, the bias are numerous. The marked difference in the values of volume loss using the two indicators shows the suitability of the consistency of the two equation indicators.

3.3.2 The liberal system of the British type is applied in a well-defined context. The management of water and wastewater public services in England is carried out in a liberal economic context. After a period of municipalization following the Second World War, complete

Type of area	Rural	Intermédiate	Urban
Criterion	$D \leq 20$	$20 < D \leq 40$	$40 < D$
Excellent	LIL < 0.7	LIL < 1.5	LIL < 3.3
Average	$0.7 \leq$ LIL ≤ 2.5	$1.5 \leq$ LIL ≤ 5.2	$3.3 \leq$ LIL ≤ 12.8
Weak	2.5 < LIL	5.2 < LIL	12.8 < LIL

Note(s): D = density of subscribers/linear of the network in km excluding connections); LIL = Linear index of loss (loss index) in m^3/day/km
Source(s): RNAUD (2009)

Table 2. WLM (GEA) frame of reference for loss index reported by RNAUD (2009)

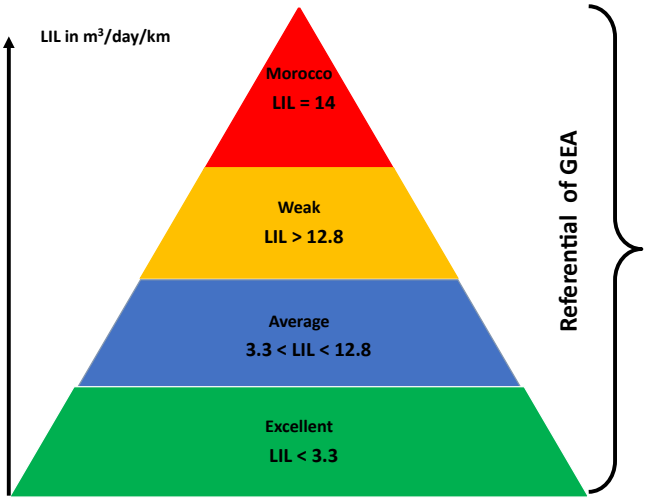


Figure 2.
Linear index of losses (LIL) in Morocco and norms of WML (GEA)

Source(s): Adapted from Water and sanitation Management Laboratory (WML), (GEA in France)

liberalization was introduced in the early 1980s under the Thatcher government (Guerin-Schneider & Grand'esnon, 2013). This model is currently characterized by

(1) Clear, independent and effective regulation. The obligations of the stakeholders are precise, and the objectives are focused on the quality of the service provided and the control of externalities (Ofwat, 2018);

(2) There are few stakeholders. The main actor is the manager who has control over practically the entire trajectory of the water service;

(3) The coverage of the territory is acquired: the manager generally has only renewal to support in investment;

(4) The management perimeters are quite large, which allows for an economy of scale and avoids fee bounce;

(5) A very long experience in the management of water and wastewater public services –type network services. The resulting capitalization and refinement are the technical precursors for the success of the system.

3.3.3 The German model of decentralized municipal public management: based on the principle of subsidiarity. In contrast to the British model, Germany has adopted an approach that favors public management of water and wastewater public services. This model is based on the principle of subsidiarity. Germany is often cited as a successful example of public management of drinking water and liquid wastewater services. These services are among the best examples of good organization and efficiency in Europe (Barraqué & Kraemer, 2014). Their development and level of performance compare well with those of neighboring countries such as Austria, Switzerland and Denmark. Local democracy is strengthened, and user participation is remarkable. Its main characteristics are as follows:

(1) The manager (the elected officials) is confronted with the user at the end of the process during elections, and an account is always in sight;

(2) The difficulty of disaggregating municipal action in general from that dedicated to water and sanitation services is very present. This constraint arises at the level of financing the services in question. The contribution of fees to cost recovery is not easy to isolate. However, the dynamism of the associative fabric amply prevents any excesses;

(3) Private management in Germany is conditioned by the preponderant shareholding of the municipality. This criterion deprives the private partner of control over the management strategy. This model is reminiscent of the configuration of local development society [SDL (Local Development Society) and SDR (Regional Development Society)] introduced by organic law 113-14 on communes, as a potential model for managing industrial and commercial public services in Morocco.

This signifies that drinkable water is wasted four times more that it is authorized for an efficient network in terms of losses.

3.3.4 The case of Maghreb countries and Jordan. The drinkable water system in Tunisia published in the 2019 statistics report of the (SONEDE, 2019) is characterized by a linear index of loss that is 40% less than that wasted in Morocco (9.2 versus 14.6 m^3/day/km in 2019). The average yield of network is also higher (Figure 3). The indicators of water resource management in Tunisia particularly cover all the economic aspects of water. There are 12 established indicators. The consumption ratios, which give information on users' behavior, are also established by the above-mentioned report (SONEDE, 2019).

It should be noted that a substantial progress in the linear index of losses is remarkable for Morocco. However, the effort should be sustained to reach the excellence of the GEA reference system.

In Algeria, individual demand for drinking water was at 120 l/inhabitant in 2011, and the estimated performance was at 55% in 2010 according to (Benbblidia, 2011). Currently, the situation has apparently worsened with regard to the restrictions imposed on the distribution of drinking water throughout Algeria territory. Rationing has effectively marked the year 2021.

In Jordan, uncalculated drinkable water volumes or nonrevenue water constituted (NRW [5]) are quite high. Figure 4 shows the evolution of NRW is always over 40% since 2007 until 2017 as p as per report of (Ministry of Envronnement. Jordan, 2020) titled "Water Sector Green Growth National Action Plan 2021–2025".

The reuse in Tunisia, however, is more developed that in Morocco. If the latter reuses 7% of wastewater manipulated by communal operators and private operators the National Sanitation Office (ONAS) (2020) reports that Tunisia will succeed in reusing 22%, which is equivalent to 63 Mm^3 (Figure 5). As for liquid sanitation, the current indicators in Morocco cover quantitative aspects. Used, collected and treated volumes of water as well as the number of water treatment stations are the only indicators that appear in management reports. We also note the total absence of information concerning sludge management.

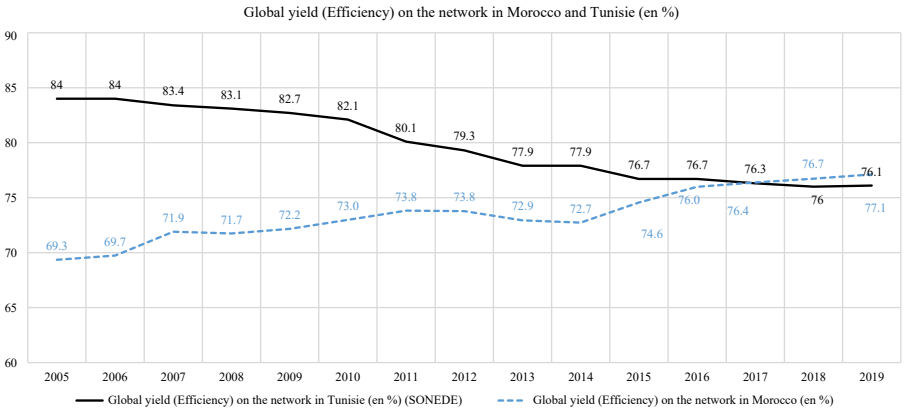
3.4 Urban rain water

Rainwater management often gives rise to conflicts of ownership between stakeholders. Indeed, this conflict is the consequence of four characteristics, namely

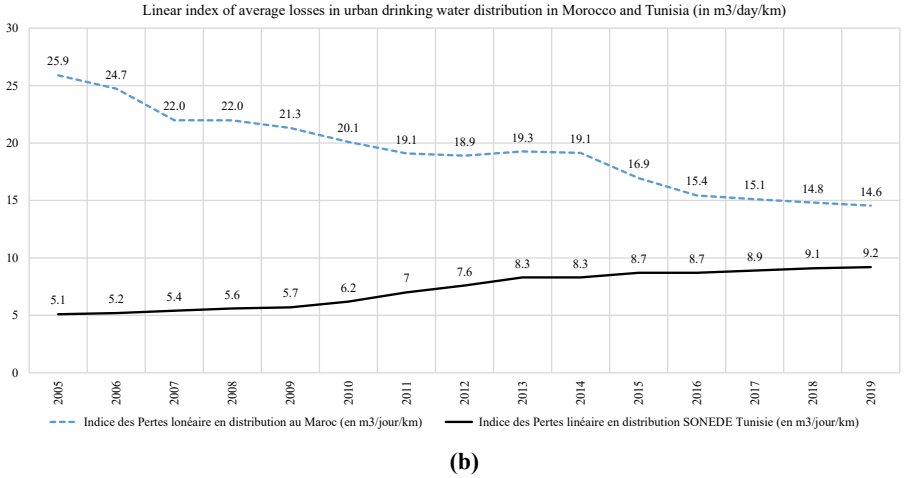
(1) Substantial investments must be mobilized to collect large flows in the rainy season;

(2) Practical difficulty in separating the water coming from the basins outside the operators' management perimeters with that of the roadway and interior basins;

(3) Liquid sanitation costs are recovered in proportion to drinking water consumption (80% in general). Rainwater is therefore not recovered by the applied tariff.



(a)



(b)

Figure 3.
Yield (a) and LIL (b) of water distribution network in Morocco and Tunisia

Source(s): Original

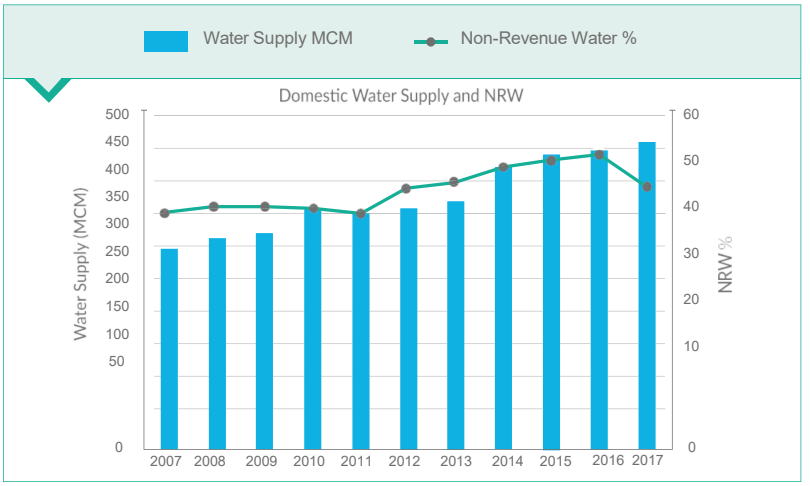
Their reuse is still low. The lack of regulatory and financial incentives seems to be a determining factor in the negligence observed in this respect.

4. Relevance of introducing management performance in drinking water and sanitation services in the Morocco context

The following specifications must be taken into account while adopting the performance indicator approach in public service management of drinking water distribution and sanitation in Morocco.

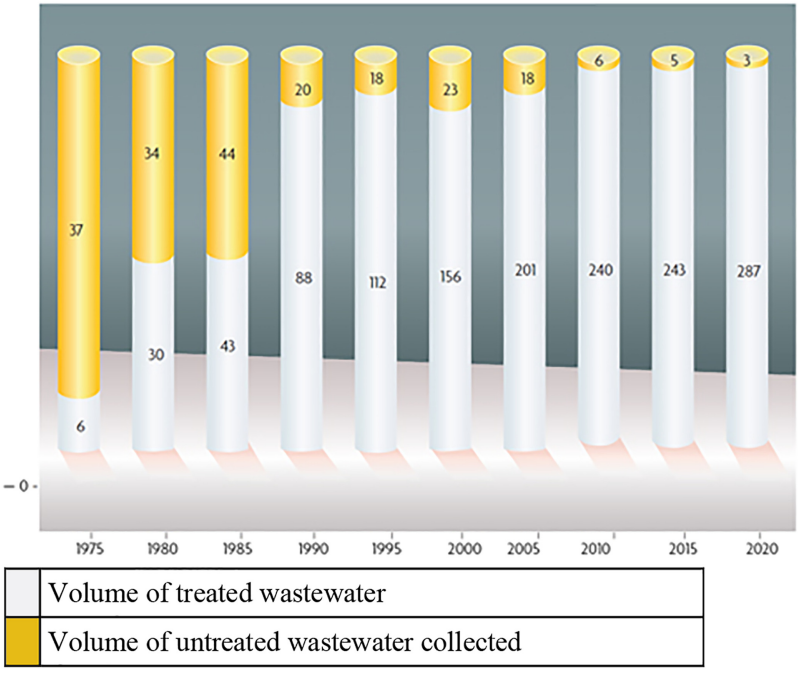
(1) Direct management by the communes: a lot of townships in Morocco themselves manage water services and/or sanitation. When there is lack of means, communes cannot assume the maintenance of performance indicators in a detailed and precise manner.

(2) Urbanization degrees of management perimeter: in a rural area, the density of individual connections is very small. Diameters of canalizations are reduced, and the



Source(s): http://www.moenv.gov.jo/ebv4.0/root_storage/ar/eb_list_page/20022_jordan_water_v02_rc_web.pdf

Figure 4.
Trend analysis of NRW in Jourdan (2007–2017)



Source(s): http://www.onas.nat.tn/Fr/page.php?code = 19

Figure 5.
Evolution of the volume of treated wastewater as per of ONAS in Tunisia (ONAS, 2020)

network is wide in space. Concentrating on connection runaways will have no sense. The dysfunction frequency indicator of public fountains (PFs) is more significant than dysfunction detection frequency in the pipe system. The latter is generally installed in places where road traffic is infrequent; hence, it does not provoke breakage (even if installation conditions are not always optimal).

(3) Traditional systems of drinking water: including indicators for traditional systems of drinkable water is so required. A lot of villages are provided with water through schemes which are composed of well, a small tank and some public fountain. These systems have always existed since the PAGER program started and still function in areas where there are active user associations.

(4) Information and communication: the transparency need and participation in public life are emerging dynamics in Moroccan society. This dynamic has to be taken into consideration while monitoring the dashboard. It is about designing indicators that translate users' expectations with regard to these two aspects. Information campaign or joint bulletin attached to the invoice including details about the services as well as comparisons with neighboring communities, etc. the recent law 31 -13 about access to information supports this suggestion.

(5) Utilities of information and communication between actors: the implementation of indicators is not solely about setting variables. The discussions on setting up performance indicators are always arduous. This is mainly due to the different possibilities of perceiving an indicator and also of the conflicting actors' objectives. Consensus, assessment and clamping are of paramount importance in this process. The phase of normalization is there only the crowning.

(6) On June 27, 2021, the Moroccan government adopted a framework law, no. 50-21, on the reform of public establishments and companies by implementing a state shareholding strategy. The autonomous communal operators are directly concerned by this text. In anticipation of its implementation, there is an urgent need to activate the process that will allow for the establishment of a regulatory system for public services. The approach would necessarily involve the construction of a system to evaluate the performance of these activities.

(7) Previously, the Ministry of the Interior had begun since 2018 a process of modernization of the management of public services of water distribution, sanitation and electricity based on four fundamental axes:

- Improvement of the governance of the distribution sector in particular, clarification of the actors' roles and institutionalization of the organs in charge of this task (Administrative Councils, specific committees, etc.)
- Reform of the rules;
- Harmonization of the specifications setting out the obligations and rights of the main players, namely the municipality, the operator and the user;
- Dematerialization of procedures and digitalization of management processes. This operation was strongly boosted by the appearance of the COVID 19 pandemic.
- Law 50-21: launch of a reform project for public enterprises, particularly those operating in the commercial public services sector. Indeed, a framework law referenced 50-21 on the reform of public establishments and enterprises (EEP) was

adopted by the government of the Kingdom of Morocco in June 2021. Within the framework of this reform, a strategy of state ownership will be put in place, one of the main axes of which is the monitoring of the performance of these entities. It goes without saying that the autonomous communal operators and the national electricity and water office, which are responsible for managing the electricity, water and sanitation distribution sector, are public establishments. They will be grouped into regional development companies provided for by organic law 113-14 relating to the communes, whose main benefit is the enlargement of the management perimeters. Management delegated to the private sector will necessarily be abandoned once the current contracts are closed. Their perimeter will immediately integrate that of the regional companies. This will necessarily allow the promotion of economies of scale and the improvement of cost recovery.

4.1 Proposed panel of indicators

4.1.1 Drinkable water distribution service. 4.1.1.1 The necessity to review mathematical construction efficiency (yield).

(1) Productivity is an environmental and economic indicator before being an indicator of the network state. For some authors, it is primarily an indicator of the waste of the resources (Guerin Shneider, 2001). For others, only the net return (performance indicator of the distribution network) reflects the use of a resource with or without waste (Institute of Delegated Management. Corporate Foundation, 2004).

(2) Several specialists touch upon the necessity of supplementing the efficiency network with other indicators (Institute of Delegated Management. Corporate Foundation, 2004; Guerin Shneider, 2001). In addition to that, the interpretation is always difficult. The difficulty resides in the extent to which the management perimeter is qualified; urban, semi urban or rural. In the case of Morocco, frequent construction of villages and suburban districts in cities makes this idea reasonable. The indicators, the density of subscribers and L CI have to be included in the matrix in order to be able to judge whether it is a rural, urban or intermediate perimeter as per Renaud, (2009). In the study of Guerin Shneider (2001), the employment of output as an exclusive indicator of the system condition in France was discussed and questioned (long ago). Furthermore, we notice that the IWA did not include the network efficiency (yield) as an indicator in its report about performance of water distribution services (IWA, 2003).

(3) Water public service operators demonstrate the performance on their management dashboard. In fact, the network efficiency intervenes in the economic calculation: the yield indeed intervenes in the economic calculation: the more the yield is low, the more the volume produced for a given consumption will have to be important, and the more the proportional loads in the produced volume will be raised. This approach has been particularly theorized in England together with the "economic level of the leaks" as per (Guerin Shneider, 2001). The comparison helps to guide the choices between different technical solutions (realization or nonrealization of leakage research, system rehabilitation or construction of new production infrastructure [. . .]). In Morocco, however, it would be very difficult to ignore the indicator of yield of the network, given its simplicity and popularity to all actors. It is however necessary to see to it to separate between yield in the production (adduction) and yield in the distribution and not to neglect the index of the losses in network.

(4) An examination of the standard formula for calculating the yield raises the following observations:

$$R = \frac{\text{Consumed volume}}{\text{Volume at the head of the network}} \times 100 \quad (1)$$

- An additional distortion of the yield that manifests itself in the processing of the volumes produced by the operator: a surface resource requires more treatment compared to an underground resource. The quantities rejected in the first case are obviously larger. The overall yield would be affected without any change in consumption.
- The supplementary distortion of production is manifested at the level of the processed volumes which are produced by the operator: a surface quantity necessitates further treatment as opposed to ground water resources.
- Distinguishing between technical yield and commercial yield.

Some authors prefer to use net yield which eventually intervenes with uncounted consumed quantities, diverted volumes and service volumes. However, this raises the difficulty of uncounted and diverted volumes. This feature renders the principle of net output in contradiction with the principles of measurability and verifiability. This observation was also raised in a report drawn up by the General Council of Rural Engineering, Water and Forests, the General Council of Bridges and Roads and the General Inspectorate of the Environment addressed to the French Department of Ecology and Sustainable Development and drawn up by a team of experts. In this report, the authors (Cousquer, Dumont, Hanus, Lavoux, & Prime, 2005) encourage the use of the term "primary yield" instead of "net yield" and propose that, in order to preserve the resource, the production yield be adopted.

4.1.1.2 Linear index of losses.

$$\text{LIL} = \frac{\text{Volume put in distribution} - \text{Volume consumed authorised}}{\text{Network length (individual connection off)} \times 365} \quad (2)$$

This indicator, which is recommended by the IWA, is better that the yield so as to translate the network state. It strongly depends on the linear density of connections (number of connections per km of network) and of uncounted authorized volumes that are to be consumed: numerous connections multiply the losses in the downstream of these and the authorized consumed volumes sidestep real losses in the network.

(1) A lot of authors recommend analyzing the following indicators simultaneously: i) primary yield, ii) number of leaks, iii) replacement rate and iv) leakage finding rate.

(2) When the network includes a portion in a rural area, the indicator will be divided into two sub-indicators (rural and urban). A rural network is generally dispersed and extended. LIL is necessarily low in comparison with urban areas.

4.1.1.3 Resource Protection Index (RPI) (3). The Water Resource Protection Progress Index, used by French water services and referenced as P108.3, is determined according to the assessment. This indicator gives information on the development of actions taken in order to protect water resources against major factors of pollution. This has a percentage explanation. It is calculated through a scale-variant from 0 to 100% as below (see Table 3).

The indicator "Water Resource Protection Index" is rarely or never used by the operators in Morocco. The reason seems to be linked with the fact that water resource management belongs to the water department prerogative. The indicator's utility is recommended for operators who produce at least part of the distributed water.

4.1.1.4 Charged consumption unit (sold) (1/day/inhabitant) (consumer segment).

$$\text{CCUc} = \frac{\text{annual charged volume(sold)}}{\text{Served population} \times 365} \text{Per liter/day/inhabitant} \quad (4)$$

The index "c" refers to the considered category.

Given the trend observed in the evolution of real user consumption in Morocco, which fell by 6.6% from 2005 to 2020 (Figure 1), we recommend adopting this indicator in which it is appropriate to divide the population in terms of consumer segments because the trend can be low for one category and high for another. In order not to have biased results, it is not recommended to consider service consumption and that of agents because it is not charged. Everything that is cost-free encourages excess.

The aim is to appreciate water consumption variation of the consumer and to study her tendency with regard to awareness campaigns and pricing system. Eventually, the allocations used for the design of the networks' equipment can be revised.

4.1.1.5 Linear Consumption Index (LCI).

$$\text{LCI} = \frac{\text{VC}}{365\text{LD}}, \text{ in m}^3\text{/day/km} \quad (5)$$

This is the volume consumed per day and per km of the distribution network.

$$\text{With} \begin{cases} \text{VC} = \text{Volume consumed}(\text{m}^3) \\ \text{LD} = \text{Total length of the distribution network}(\text{km}) \end{cases}$$

This indicator, used in Tunisia by the national water exploitation and distribution company (SONEDE, 2019), compares consumption with the density of connections due to their dependence. It does not include losses in the network. Only the authorized [6] volume consumed is retained.

4.1.1.6 Linear Distribution Index (LDI).

$$\text{LDI} = \frac{\text{VD}}{365\text{xLD}} \text{in m}^3\text{/jour/km} \quad (6)$$

$$\text{With} \begin{cases} \text{VD} = \text{Volume distributed (at the head of the distribution network}(\text{m}^3) \\ \text{LD} = \text{length of the distribution network}(\text{km}) \end{cases}$$

Unlike the ILC, this index includes losses in the distribution network.

4.1.1.7 Rate of water resource wastage (RWW). This indicator, recommended by the IWA, should be used in Morocco, in our opinion and based on the realities observed, separately for

No action	0%
Environmental and hydrogeological studies in progress	20%
Opinion of the hydrogeologist given	40%
File submitted to the water basin agency	50%
Government decree fully implemented, land acquired, easements put in place, servitudes put in place, work completed	60%
Protection achieved	80%
Setting up a procedure for monitoring the application of the decree and a control mechanism	100%

Source(s): Original

Table 3. Mode of calculation of the Resource Protection Index (RPI)

rural and urban areas. In the former case, there are mostly public fountain or (and) individual connections that are often anarchic. In urban areas, connections are made by the professional operator on the basis of standards set by the contract specifications.

(1) In urban areas (RWWu),

$$\text{RWWu} = \frac{\text{Real annuel losses}}{\text{Volume introduced in one year}} \times 100 \; in \; \% \tag{7}$$

According to its formulation, and regarding the parameters that constitute it, the RWW seems to be the most suitable to evaluate the water savings made in a public drinking water service. Unfortunately, real losses are only approximated in the field. They are estimated from leaks, breaks, ruptures and overflows. These events are of course unforeseen. The wastage rate is mainly used as a complementary indicator to the yield and the LLL. The losses used are estimated excluding connections.

(2) In rural areas served by

- PFs

In rural areas served by PFs, the rate of wastage of the resource could be approximated by comparing the normal consumption allowed at a PF to the number of users (inhabitants served), with the volume recorded at the same level during the same period.

Water losses at a service's public fountains (LPF):

$$\text{LPLPF} = \sum_{k=1}^{n} \left(\frac{\text{Volume counted on PFi}}{\text{Population served by PFi}} - 25 \right) \text{en litres/day/inhabitant} \tag{8}$$

where

PFi: Public fountain n°i;

n = number of publics fountains.

25 is the average consumption per rural inhabitant served by PF applied in Morocco (in litres/day).

(1) If LPF ≤ 0; (average unit consumption per PF $\leq$ 25 l/day/inhabitant), consumption is globally normal: no waste, but the quality of the service could be affected.

(2) If $0 <$ LPF $< n \times 5$; (average unit consumption per PF between 25 and 30 l/d/capita), the wastage rate is moderate

(3) If LPF $> n \times 5$; (average unit consumption per PF > 30 l/d/inhabitant), wastage is high. In this case, check the state of the PF and if there is no illicit spiking.

Thus, the annual wastage rate in a rural water supply service is as follows:

$$\text{RWWr} = \frac{\text{Actual losses in the network excluding PF} + (\text{LPF} \times 1000 \times \text{Population served})}{\frac{\text{Volume introduced in one year}}{365}} \times 100 \; in \; \% \tag{9}$$

Mixed network losses are estimated from equations (I and II), and the global RWW is in this case merged with the RWWr.

- Individual connections

Individual connections in rural areas usually consist of one water tap installed on the patio of the house or at most a second one in the kitchen. Consumption should not exceed 40 l/day/inhabitant. Beyond that, losses are to be suspected. The wastage rate in this case is confused with the RWWu.

4.1.2 Liquid sanitation service: widening indicator matrix of resource management performance. In Morocco, the regulations as far as the standardization of used water rejection is concerned relate certain specific activities to limited values of rejection. (Domestic used water and industrial activities of sugar, cement, surface treatment, paper pulp, paper and cardboard). In the same respect, a decree related to individual sanitation system was promulgated in 2006 listing the sanitation systems that belonged to this group. Joint application texts should specify the technical arrangements of these systems construction.

In 2015, a new law about water was promulgated (law 36-15) amending the law 10-95 which has arranged a whole section to liquid sanitation, treatment and reject (article 106 to 110). This legal framework is waiting to be completed by executive acts for an appropriate start-up of performance measurement mechanisms.

Nevertheless, at the present stage, it would be possible, through contractual or conventional means, to insert specific indicators for the preservation of the water resource against water pollution. The two aspects to be evaluated are the liquid discharges and the fate of the treatment products. The proposed indicators are universally accepted:

(1) Ratio of the volume of used and treated water (in %): RUT

$$\mathrm{RUT} = \frac{\text{Volume of used and teater}}{\text{Voulme of used and collected water}} \times 100 \tag{10}$$

(2) Performance of treatment (in %)

$$\mathrm{PT} = . = \frac{\text{Polluant load at station exit}}{\text{Poluant load at station inlet}} \times 100 \tag{11}$$

This indicator is the denomination of being in compliance with sewage discharges which refers to regulatory limits of rejected, used and treated water.

(3) Ratio of water volume that is treated and reused (in %)

It portrays the percentage of used water volumes valued with respect to collected volumes by the system.

$$\mathrm{RWR} = . = \frac{\text{Treated and reused water volume}}{\text{Used and collected water volume}} \times 100 \tag{12}$$

(4) Ratio of treated sludge:

$$\mathrm{RTS} = . = \frac{\text{Treated sludge quantity}}{\text{collected sludge quantity}} \times 100 \tag{13}$$

(5) Ratio of reused sludge (in %)

$$\mathrm{RRS} = \frac{\text{Reused sludge quantity}}{\text{Collected sludge quantity}} \times 100 \tag{14}$$

5. Conclusion and recommendations

The performance analysis tools reported in the annual management reports of public water and sanitation operators are mainly used for the operators' own objectives. They could therefore be described as internal indicators. Moreover, their discrepancy and heterogeneity complicate their efficiency for at strategic level. Because of the lack of standardization, at the national level, these indicators do not allow a macroscopic visibility of the public service. At the regulatory level, the governing law 13-14 which is related to communes stated the necessity for local public services to establish performance indicators (article 12). This text should constitute the basis for engagement in this process, especially as a total restructuring of the management of these services is envisaged from 2022.

In this paper, we propose 15 indicators to assess the performance of water resource management in Morocco. Our objective is to cover the aspects of the water economy in distribution network and protection against the pollution of water resources.

In the meantime, the suggested indicators in this research paper can be introduced as evaluative and analytical tools through contracts and specification of requirements established with the operators.

On the other hand, a framework law referenced 50-21 on the reform of public establishments and enterprises (EEP) was adopted by the Government in June 2021. As part of this reform, a state shareholding strategy will be put in place. One of the main axes is monitoring the performance of these entities. This law is a very good opportunity to launch the process of setting up a complete system for regulating and monitoring the performance of water and wastewater services.

List of abbreviations

AFD	French Development Agency
AFEID	French Association for Water, Irrigation and Drainage
CEMAGREF	Agricultural Machinery Center of Rural Engineering, Water and Forestry France (IRSTEA)
CERA	Rhône-Alpes Economic Unit Rhône-Alpes (France)
DREAL	Regional Directorate for the Environment, Development and Housing (France)
COSTEA	Scientific and Technical Committee on Agricultural Water
DRSC	Department of Public Authorities and Licensed Services
ENGREF	National School of Rural Engineering, Water and Forestry
FNCCR	National Federation of Local Authorities, France
IGD	Institute of Delegated Management, France
IRSTEA	National Institute of Research in Science and Technology for the Environment and Agriculture (Former name: CEMAGREF)
IWA	International Water Association
MENA	Middle East and North Africa
ONAS	National Office of Sanitation, Tunisia
PAGER	Global Rural Water Supply Program
NSA (PNA)	National Sanitation Program
NSA	National Mutualized Sanitation Program
SAGE	Water Development and Management Scheme, France
SISPEA	Information System on Public Water and Sanitation Services (France)
SONEDE	National Water Exploitation and Distribution Company, Tunisia
STEP	Water treatment station
WML	Water and Sanitation Management Laboratory in France (GEA)

Notes

1. The total volume manipulated by the communal operators and private operators in 2020 is 839 Mm^3 while that recorded and consumed by the users is of the order of 653 Mm^3.
2. The perimeter of urban planning is fixed by statutory way fixing the spatial extent and the rules of its urbanization. This perimeter covers inevitably the territory of the territorial community.
3. 8.4 Mm^3 = Volume supplied in 2020 by all operators (public and private operators = 839.14 Mm^3) multiplied by 1% network efficiency.
4. The length of the total drinking water network (communal operators and private operators) is of the order of 36 356 km.
5. Water that is supplied to distribution networks but not billed. Unbilled water is the result of a combination of factors, including fraudulent volumes and leaks in the system infrastructure inability to collect payments.
6. Authorized volume includes the quantities of water legally consumed, paid for by users and those delivered free of charge by the service provider for different uses.

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Appendix
Websites of public water and sanitation operators in Morocco and Tunisia

LYDEC	Private delegate of Casablanca	
REDAL	Private delegate of Rabat	https://www.redal.ma/fr
AMENDIS_Ta	Private delegate of Tangier	https://www.amendis.ma/fr
AMENDIS _Té	Private delegate of Tetouan	https://www.amendis.ma/fr
RADEEF	Autonomous communal operator of the city of Fes	http://www.radeef.ma/
RADEEMA	Autonomous communal operator of the city of Marrakech	https://www.radeema.ma/
RADEEM	Autonomous communal operator of the city of Meknes	https://www.radem.ma/
RAK	Autonomous communal operator of the city of Kenitra	https://www.rak.ma/rak/
RADEEJ	Autonomous communal operator of the city of El Jadida	https://www.radeej.ma/
RADEES	Autonomous communal operator of the city of Safi	http://www.radees.ma/
RADEEL	Autonomous communal operator of the city of Larache	http://www.radeel.ma/
RAMSA	Autonomous communal operator of the city of Agadir	http://www.ramsa.ma/
RADEEO	Autonomous communal operator of the city of Oujda	https://www.radeeo.ma/
RADEET	Autonomous communal operator of the Tadla region	https://www.radeet.ma/
RADEEC	Autonomous communal operator of the Chaouia region	https://www.radeec.ma/
RADEETA	Autonomous communal operator of the city of Taza	https://www.radee-ta.ma
SONEDE	National Company for the Exploitation and Distribution of Water (Tunisia)	Accueil (sonede.com.tn)
ONAS	National Office of Sanitation (Tunisia)	http://www.onas.nat.tn/

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