



Economic impact of the reuse of raw wastewater in irrigation: meso-economic survey on the largest perimeters of Morocco

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ABSTRACT

In Morocco, wastewater is continuously discharged without pretreatment downstream of urban centers and widely reused in agricultural irrigation, especially where water resources are limited and soils are deficient in organic matter. This constitutes a potential risk for the health of the population. Thus, this work has set as an objective to calculate the cost of damage caused by waterborne diseases in order to estimate how much they weigh (monetary burden) on one of the largest perimeters of Morocco where the reuse of raw wastewater is very responsive (Meknes, Khemisset, Tiflet and Sidi Allal El Bahraoui). For this purpose, we opted for a meso-economic analysis that would provide aid to public health policy decisions in a given region. To calculate the cost of damage caused by waterborne diseases in the provinces of Meknes and Khemisset, the same method used by the World Bank and the World Health Organization (WHO) in 2001 was used: Cost of damage caused by waterborne diseases = Cost of treatment (direct cost) + Cost of time spent caring for sick children (indirect cost). Then we compared the cost of damage caused by waterborne diseases with the cost of wastewater treatment in the two provinces. The results obtained clearly show that waterborne diseases are a real health problem, and weigh heavily on both provinces, particularly in the province of Meknes, despite the decrease in their incidence over time. The monetary quantification of the damage caused by waterborne diseases cannot be completely accurate because of the under-reporting of cases (the use of traditional medicine which escapes any reporting system).

Keywords: Wastewater; Irrigation; Cost; Damage; Waterborne diseases; Meso-economic

1. Introduction

Morocco has the most competitive economy in North Africa [1], also is a country where the availability of water is an essential factor in the development of the agricultural sector which is the basis of the Moroccan economy. However, environmental degradation in general, and water stress in particular, like in other Mediterranean

countries, threatens the health of its population and risks mortgaging its economic development [2].

According to the UN, Morocco is already considered to be under water stress with only 500 m³ of freshwater per capita per year, compared to 2,500 m³ in 1960 [3]. Even with this degradation of water resources, large areas continue to be irrigated with wastewater discharged without pretreatment into waterways, thus threatening the health of

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the population through the consumption of products from this agriculture [4–6].

At this level, ecological economics is the discipline that allows for discussion useful for the formulation of specific recommendations to decision-makers [7].

This work consists in calculating, via a meso-economic study, the cost of the damage caused by waterborne diseases in order to estimate how much they weigh (monetary burden) on the cities of Meknes, Khemisset, Tiflet and Sidi Allal El Bahraoui. This axis constitutes one of the largest perimeters of Morocco where the reuse of raw wastewater is very answered (+3,000 Ha) [8].

2. Method

The definition of pollution for economists is not the same as that used by biologists. In economics, it is analyzed as an external cost that manifests itself when one or more individuals suffer a loss of well-being [9].

To calculate the cost of damage caused by waterborne diseases, we have opted for a meso-economic analysis that allows us to follow the trajectories of economic facts from beginning to end, or from upstream to downstream. This type of economic analysis avoids dichotomies and simplistic oppositions [10].

In general, the purpose of meso-economic studies is to provide decision support for public health policy in a given region, and thus facilitate the implementation of corrective mechanisms [11].

This type of study, which is considered an integral part of the health care decision-making process, has grown significantly in recent decades, since it provides information on the costs of illness and clinical interventions, as well as their economic benefits [2,4]. It thus provides evidence to support the development of health policies, better delivery of health services and appropriate allocation of resources [12].

$$\text{Average length of stay (AKOS)} = \frac{\sum_{n=1}^{\infty} \text{days of hospitalization during a year}}{\text{the number of patients hospitalized during the same year}} \quad (1)$$

Table 1 clearly shows that patients hospitalized with typhoid spend an average of 7 d; those hospitalized with Hepatitis A spend an average of 5 d; and patients hospitalized with Gastroenteritis spend an average of 4 d.

3.1.1. Editing the monetary cost of a hospitalization

And therefore the cost of hospital treatment (direct cost) of the main waterborne diseases at the level of Meknes and Khemisset (Table 5) during the years 2015, 2016, 2017 and 2018 = the cost of a hospitalization × number of hospitalized patients during the same years.

3.2. Indirect cost: cost of time spent caring for sick children

In addition to medical costs (direct costing), one parent spends time caring for sick children. This time has an opportunity cost, in terms of leisure or work. For each case of waterborne disease, WHO and the World Bank (2001) estimated that one parent would spend 1-d caring for the child.

To calculate the cost of damage caused by waterborne diseases in the cities of Meknes, Khemisset, Tiflet and Sidi Allal El Bahraoui, the same method used by the World Bank and the World Health Organization (WHO) in 2001 was used:

Cost of damage caused by waterborne diseases = Cost of hospital treatment (Direct cost) + Cost of time spent caring for sick children (Indirect cost) [2].

3. Results and discussion

3.1. Direct costing: hospital treatment

This terminology is used to describe the costs and effects associated with health and health service use. This category includes all material resources (medications, medical devices) and human resources (salaries of health system professionals) directly related to the diagnosis and treatment of the patient [13].

The calculation of the cost of direct damages (cost of hospital treatment) is based first on the calculation of the average length of stay (ALOS) recorded in the hospitals of the two provinces (Table 1) for the main waterborne diseases (typhoid, Hepatitis A, acute gastroenteritis), then by referring to the General Nomenclature of Professional Acts (GNPA) [14], the monetary cost of a hospitalization was calculated (Tables 2–4).

This Nomenclature is adopted by all Moroccan health structures for invoicing, and is imposed on practitioners to determine the price of medical procedures and care provided during a hospital stay.

The ALOS is frequently used as an indicator of efficiency [15]. A shorter stay decreases the cost per discharge and shifts inpatient care to the less expensive setting. ALOS is the average number of days' patients spend in the hospital. It is usually calculated by dividing the total number of patient days in a year by the number of inpatients in the same year [16].

The value of this day is based on the average monthly salary in rural areas (i.e., 3,954 DH/month), and in urban areas (i.e., 6,124 DH/month). On average, a day of lost work would therefore be equal to nearly 132 DH in rural areas, and 204 DH in urban areas (Tables 6 and 7) [16].

And thus, the total cost of time spent caring for sick children (indirect cost) = Total number of cases of waterborne diseases affecting children × Value of a lost workday. Thus the estimate of the total cost of damage (Table 8) caused by waterborne diseases during the 4 y (2015, 2016, 2017 and 2018) in the two provinces = cost of treatment (Σtotal_1) + cost of time spent caring for sick children (Σtotal_2) [2].

Comparing the total cost of damages caused by waterborne diseases in the two provinces (Table 9) with the Average Annual Health Expenditure per capita (AAHE/capita) which is around 1,578 DH [17].

The present results clearly demonstrate that waterborne diseases are a real health problem, and weigh heavily on both provinces, particularly in Meknes, despite the decrease in their incidence over time.

Table 1

Calculation of the average length of stay (ALOS) for waterborne diseases in the provinces of Meknes and Khemisset between 2015 and 2018

	Meknes				Khemisset			
	2015	2016	2017	2018	2015	2016	2017	2018
Typhoid	160/22 = 7.27	260/37 = 7.02	260/37 = 7.02	260/37 = 7.02	89/13 = 6.84	86/12 = 7.16	86/12 = 7.16	86/12 = 7.16
Hepatitis A	82/16 = 5.1	74/15 = 4.93	74/15 = 4.93	74/15 = 4.93	32/6 = 5.33	24/5 = 4.8	24/5 = 4.8	24/5 = 4.8
Gastroenteritis	124/30 = 4.13	111/28 = 3.96	111/28 = 3.96	111/28 = 3.96	78/19 = 3.94	61/15 = 4.06	61/15 = 4.06	61/15 = 4.06

Table 2

Cost of hospitalization for typhoid according to GNPA

	Services	Services invoiced according to GNPA
Typhoid	Stay: Accommodation	250 DH/D for the first 3 d of hospitalization
	Catering	150 DH/D beyond 3 d of hospitalization
	Medical visits	For an ALOS = 7 d: (250 DH × 3) + (150 DH × 4) = 1,350 DH
	Antibiotic therapy	
	Infusion	300 DH
	Biological assessment	300 DH
		Total: 1,950 DH

Table 3

Cost of a hospitalization for Hepatitis A according to GNPA

	Services	Services invoiced according to GNPA
Hepatitis A	Stay: Accommodation	250 DH/D for the first 3 d of hospitalization
	Catering	150 DH/D beyond 3 d of hospitalization.
	Medical visits	for an ALOS = 5 d: (250 DH × 3) + (150 DH × 2) = 1,050DH
	Antibiotic therapy	
	Biological assessment	300 DH
		Total: 1,350 DH

These results corroborate perfectly with the results of the survey conducted on the cost of environmental degradation in Morocco in 2014, which places water pollution as the primary vector of environmental degradation. The same survey confirms that water pollution weighs heavily on the Moroccan economy (1.26% of GDP).

If decision-makers would focus on prevention upstream (creation of WWTPs, awareness raising, accompanying farmers in the creation of wells), the state could save and/or limit the cost of damage caused by waterborne diseases in the four cities.

Without risk awareness, it will be very difficult to promote behavioral change towards safer practices, knowing that reuse of raw sewage is a clandestine practice, in addition, safety regulations are often too theoretical [4].

The monetary quantification of damage caused by waterborne diseases cannot be completely accurate due to under-reporting of cases (the use of traditional medicine that escapes any hospitalization and reporting system).

3.3. Comparison between the total cost of damage and the total cost of wastewater treatment

In Morocco, the drinking water consumed is then discharged into the sewerage system according to a given

restitution rate. The restitution rate used in Morocco is 80% [18].

Thus, the total cost of wastewater treatment = (Number of inhabitants × Restitution rate × Treatment cost per m³ in DH)

Note that the average cost of wastewater treatment in Morocco depends on the type of treatment adopted by the treatment plants [18].

Table 10 shows that the “natural lagoon” is the least expensive type of treatment, yet it is the most existing in the WWTP of Morocco [18].

Comparing the results (Tables 11–13), it is clear that the cost of damage caused by waterborne diseases far exceeds the cost of wastewater treatment. Therefore, Moroccan decision-makers must be convinced of the need to shift from the “treat and dump” model to the “treat and reuse” model in order to valorize the by-products derived from useful wastewater.

The reuse of wastewater treated by WWTPs will have a positive impact on Morocco given its arid climate, poor rainfall distribution and the scarcity and overexploitation of its water resources [19].

4. Conclusion

This type of study is an aid to decision making and can in no way be considered imperative. It is true that water,

Table 4
Cost of a hospitalization for Acute Gastroenteritis (A.G.E.) according to GNPA

	Services	Services invoiced according to GNPA
A.G.E.	Stay: Accommodation	250 DH/D for the first 3 d of hospitalization
	Catering	150 DH/D beyond 3 d of hospitalization
	Medical visits	for an ALOS = 4 d: (250 DH × 3) + (150 DH × 1) = 900 DH
	Antibiotic therapy	
	Infusion	300 DH
	Biological assessment	300 DH
		Total: 1,500 DH

Table 5
Calculation of the cost of hospital treatment (direct cost) for waterborne diseases in the provinces of Meknes and Khemisset between 2015 and 2018

	Typhoid	Hepatitis A	A.G.E.	Total (DH)
Meknes				
2015	$1,950 \times 36 = 70,200$	$1,350 \times 22 = 29,700$	$1,500 \times 38 = 57,000$	156,900
2016	$1,950 \times 37 = 72,150$	$1,350 \times 19 = 25,650$	$1,500 \times 34 = 51,000$	134,400
2017	$1,950 \times 34 = 66,300$	$1,350 \times 18 = 24,300$	$1,500 \times 32 = 48,000$	138,600
2018	$1,950 \times 31 = 60,450$	$1,350 \times 18 = 24,300$	$1,500 \times 33 = 49,500$	134,250
Khemisset				
2015	$1,950 \times 22 = 42,900$	$1,350 \times 19 = 25,650$	$1,500 \times 32 = 48,000$	116,550
2016	$1,950 \times 18 = 35,100$	$1,350 \times 15 = 20,250$	$1,500 \times 30 = 45,000$	10,0350
2017	$1,950 \times 18 = 35,100$	$1,350 \times 13 = 17,550$	$1,500 \times 31 = 46,500$	99,150
2018	$1,950 \times 17 = 33,150$	$1,350 \times 14 = 18,900$	$1,500 \times 29 = 43,500$	95,550

Table 6
Calculation of the indirect cost (cost of time spent caring for sick children) for waterborne diseases in the provinces of Meknes between 2015 and 2018

Meknes								
	2015		2016		2017		2018	
Total number of cases of waterborne diseases affecting children	Urban: 4,554	Rural: 1,404	Urban: 4,303	Rural: 1,194	Urban: 4,122	Rural: 1,043	Urban: 4,088	Rural: 1,022
Value of a lost workday in DH	Urban: 204	Rural: 132	Urban: 204	Rural: 132	Urban: 204	Rural: 132	Urban: 204	Rural: 132
Total cost of time spent caring for sick children in DH	929,016	185,328	877,812	157,608	840,888	137,676	833,952	134,904
Total in DH	1,114,344		1,035,420		978,564		968,856	

as a vector of socio-economic development, is a matter for everyone. However, in Morocco, the action of several departments (the Ministries of Agriculture, Interior, Health, Finance, etc.), which could be an asset, turns out to be an obstacle, because in the end this shared management of water leads to an unstable policy and often a more complex management that weighs heavily on the health system.

Thus, good management of water resources requires a transversal policy. This transversal policy means, on the one hand, an interministerial collaboration with a single ministry as a reference that must manage water issues.

In the context of the continuous scarcity of water resources, overexploitation of groundwater, climate change and population growth with the risk of waterborne diseases, the reuse of treated wastewater remains a considerable

Table 7

Calculation of the indirect cost (cost of time spent caring for sick children) for waterborne diseases in the provinces of Khemisset between 2015 and 2018

	Khemisset							
	2015		2016		2017		2018	
Total number of cases of waterborne diseases affecting children	Urban: 169	Rural: 222	Urban: 145	Rural: 202	Urban: 123	Rural: 198	Urban: 97	Rural: 160
Value of a lost workday in DH	Urban: 204	Rural: 132	Urban: 204	Rural: 132	Urban: 204	Rural: 132	Urban: 204	Rural: 132
Total cost of time spent caring for sick children in DH	34,476	29,304	19,788	26,664	25,092	26,136	19,788	21,120
Total in DH	63,780		46,452		51,228		40,908	

Table 8

Estimation of the total cost of damages caused by waterborne diseases in the provinces of Meknes and Khemisset between 2015 and 2018

	Meknes				Khemisset			
	2015	2016	2017	2018	2015	2016	2017	2018
Total ₁ (DH)	156,900	134,400	138,600	134,250	116,550	100,350	99,150	95,550
Total ₂ (DH)	1,114,344	1,035,420	978,564	968,856	63,780	46,452	51,228	40,908
Total cost of damage (DH)	1,271,244	1,169,820	1,117,164	1,103,106	180,330	146,802	150,378	136,458

Table 9

Report of the total cost of damage caused by waterborne diseases in the provinces of Meknes and Khemisset between 2015 and 2018/Average Annual Health Expenditure per capita

	Meknes				Khemisset			
	2015	2016	2017	2018	2015	2016	2017	2018
Total cost of damage (DH)	1,271,244	1,169,820	1,117,164	1,103,106	180,330	146,802	150,378	136,458
Average Annual Health Expenditure (AAHE) per capita (DH)				1,578				
Ratio of cost of damages/AAHE	806	741	708	699	114	93	95	86

Table 10

Cost of wastewater treatment according to the type of treatment in Morocco

Type of treatment	Natural lagoon	Aerated lagooning	Bacterial beds	Activated sludge
Average wastewater treatment cost/m ³	0.15 DH/m ³	0.3 DH/m ³	0.5 and 0.6 DH/m ³	2 DH/m ³

Table 11

Estimated cost of wastewater treatment in the province of Meknes between 2015 and 2018

Meknes				
Year	2015	2016	2017	2018
Population per capita	844,871	856,536	868,174	879,731
Type of wastewater treatment	Natural lagoon			
Estimated cost of wastewater treatment per m ³ in DH	0.13	0.13	0.13	0.13
Restitution rate	0.8	0.8	0.8	0.8
Estimated total cost of wastewater treatment in DH	87,866	89,079	90,290	91,492

Table 12

Estimated cost of wastewater treatment in the province of Khemisset between 2015 and 2018

Khemisset				
Year	2015	2016	2017	2018
Population per capita	541,734	541,564	541,408	541,229
Type of wastewater treatment	Natural lagoon			
Estimated cost of wastewater treatment per m ³ in DH	0.13	0.13	0.13	0.13
Restitution rate	0.8	0.8	0.8	0.8
Estimated total cost of wastewater treatment in DH	56,340	56,323	56,306	56,288

Table 13

Comparison between the cost of wastewater treatment and the cost of damage caused by waterborne diseases in the provinces of Meknes and Khemisset between 2015 and 2018

	Meknes				Khemisset			
	2015	2016	2017	2018	2015	2016	2017	2018
Total cost of damage (DH)	1,271,244	1,169,820	1,117,164	1,103,106	180,330	146,802	150,378	136,458
Cost of wastewater treatment in DH	87,866	89,079	90,290	91,492	56,340	56,323	56,306	56,288

opportunity to ensure both water and health security and to adapt to global changes.

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