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Contribution To The Optimization Of The Treatment Of Solid Household Waste In A Semi-Arid Zone

Diagnostic model and projections for communal spaces in the Province of Fquih Ben Salah (Morocco)

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Abstract: On the aim of contributing to the protection of the environment in a semi-arid climate, the research work aims to study the prospective optimization of the treatment of solid household waste in a model area, the Province of Fkih Ben Salah, in the continental center of Moroccan territory. Indeed, an exhaustive inventory was made in 2018 of the municipal units in this area of a total volume of solid household waste of 386 Tons per day, for which the rate of net product is 98.97%, i.e. the unit average of 0.73 kg/inhabitant/day. By the year 2033, the volume of the total produced in this waste is projected at 446 T/day, an expected increase of 15% over the period from 2018 to 2033. This volume of waste is then likely to be reduced to the minimum rate of 24%,

Index Terms **- Environment, projection, solid, household waste, semi-arid.**

I. INTRODUCTION

On a global scale, a gradual increase in the production of solid household waste has been noted, which is highly dependent on the increase in the population of inhabitants, in relation to the growing improvement in the standard of living of households (Kaza et *al.*, 2018). This calls on all countries to establish specific and efficient policies relating to sustainable development, including among their priorities the judicious management of household waste from their citizens (UN, 2022). With this in mind, the Moroccan public authorities have been actively committed by implementing, since the benchmark year 2014, a specific legal basis in its capacity as a national charter for the environment and sustainable development, which has become more effective since 2017 in the genesis of the National Sustainable Development Strategy “SNDD” (MTEDD, 2022a; 2022b).

II.MATERIALS AND METHODS

2.1 Presentation of the study area

The study area is identified with the province of Fquih Ben Salah, which is located in the continental center of Moroccan territory and has an area of 2247 km2 (see maps in Figure 1).

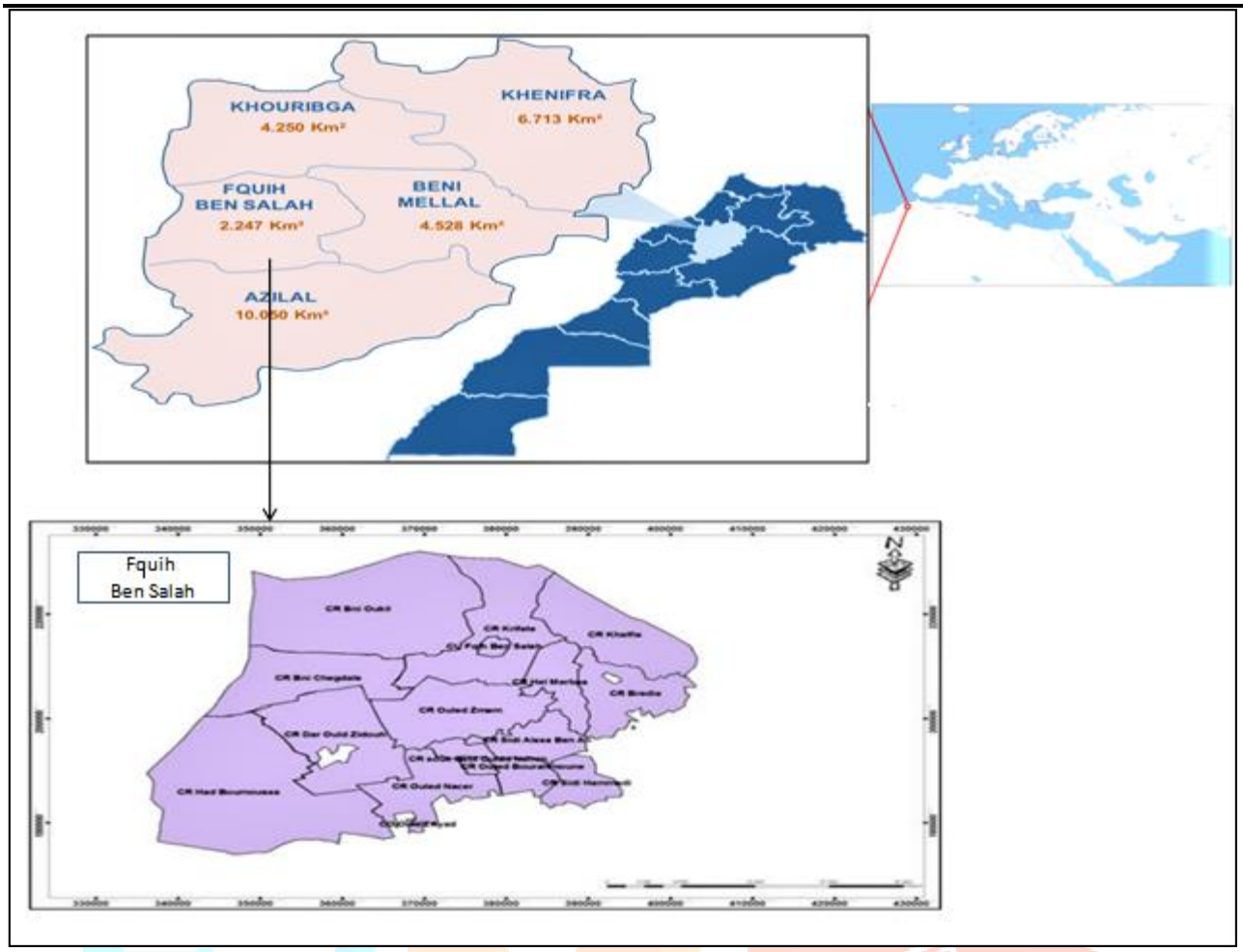

Figure 1: Location maps of the study area

The climate of the area is of the Mediterranean type, specifically semi-arid, with a dry period between April-October and a wet period from November-March. Annual rainfall is irregular, fluctuating around a cumulative 300 mm. The air temperature is an annual average of 19°C. The area attributes itself to very active economic activities with a predominantly agricultural vocation, due to various favorable conditions combined, including soil fertility, relatively sufficient irrigation water resources and also by the existence of hydro-electric facilities. The agricultural system is modern about large areas of crops grown in irrigated mode (ORMVAT, 2021).

2.2 Evaluation of the evolution of the population of inhabitants

The method of carrying out the projection of the evolution of the human population was apprehended according to the following stages.

2.2.1 Reference to last two official general censuses of population in Morocco. Dates: the years of 2004 and 2014, including for populations in local communes of study area about Province of Beni Mellal zone (HCP, 2005; 2015).
2.2.2 Calculation of the average rate of population change by local municipality in study area,at over the period 2004-2014.

2.2.3 Application of the basic rate of population evolution, at projections for years: 2018; 2023; 2028 and 2033.

2.2.4 Determinate annual population projection figures for the local communes for the study period 2018-2033.

2.3 Assessment methods of solid waste production

The production of solid waste in the study area, which is specific to local municipalities, responds in accordance with the Moroccan regulations in force (MTEDD, 2022c) and whose main equation of the distribution and/or treatment balance sheet. It is schematizing in Figure 2.

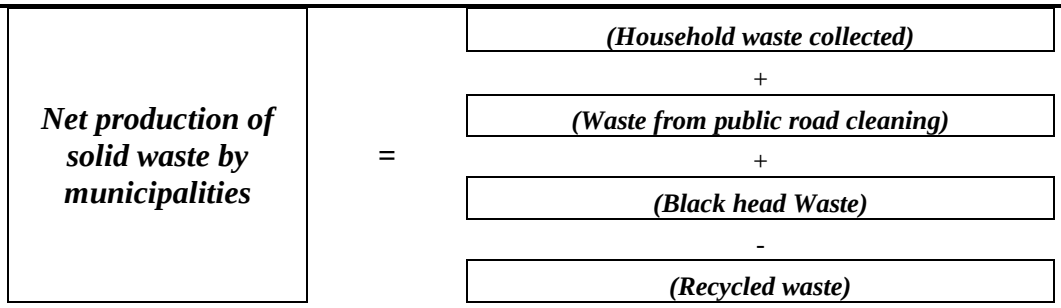

Figure 2: Composition diagram of the net production of solid household waste in the study area.

It should be noted that the components of the solid household waste production balance in the study area were determined for each municipality taking into account the following (see Figure 2).

2.3.1 The estimated daily volumes for waste from the cleaning of public roads and for waste collected at black spot levels following regular interventions by the municipalities involved.

2.3.2 The solid household waste recycling operation according to the municipalities concerned.

2.3.3 The daily receipt of solid household waste from public landfills is estimated according to the municipal origin in the study area.

2.3.4 The daily volumes of direct collection of solid household waste from the own homes of the inhabitants of the corresponding municipalities are approximated by the calculation of the three previous elements of the balance sheet in question (see paragraphs above: 2.3.1; 2.3.2 and 2.3.3).

2.4 Projection methods production of solid and similar household waste

On the basis of predictions of trends in the evolution of the populations of the municipalities in the study area in the next decade 2023-2033, analyzes of the projection of solid household and similar waste have been carried out on the horizons of the benchmark years of 2023, 2028 and 2033. This is consistent with the conditions of the regulations in this sense in application in the study area, according to the provincial master plan for the management of household and similar waste (MTEDD, 2022d).

III. RESULTS AND DISCUSSION

3.1 RESULTS

3.1.1 Projections of evolution of the populations of the inhabitants

The results analyzers of projection at evolution of inhabitants on territories of local communes in study area at year 2033 reported in Table 1.

Table 1: Population change projections for local municipalities in the study area for the period 2018-2033.

Local commune	*Reference 1:* Population of 2004 (HCP, 2005)	*Reference 2:* Population of 2014 (HCP, 2015)	Basic annual variation rate of population in municipality (Period: 2004-2014)	Population growth projections by municipality (Reference year: 2014)			
				2018	2023	2028	2033
Fquih Ben Salah (Municipality)	82,446	102,019	2.37%	111,707	123,817	133,505	145,614
Ouled Ayad (Municipality)	21,466	23,818	1.10%	24,862	26,167	27,211	28,515
Souk Sebt Ouled Nemma (Municipality)	51,049	60,076	1.77%	64,325	69,637	73,886	79 198
Sidi Hammadi	14,535	14,227	-0.21%	14 106	13,956	13,835	13,684
Ouled Bourahmoune	13,635	15,113	1.08%	15,768	16,587	17,243	18,062
Sidi Aissa Ben Ali	22,697	25,563	1.26%	26,854	28,468	29,759	31,373
Ouled Zmam	31,905	33,652	0.55%	34,389	35,310	36,047	36,969
krifate	34 103	29,214	-1.43%	27,539	25,445	23,769	21,675
Hel Merbaa	12,614	12,025	-0.47%	11,800	11,520	11,295	11,014
Khalfia	14,341	15,451	0.77%	15,929	16,527	17,006	17,604
Brady	36,307	40,685	1.21%	42,647	45 100	47,063	49,516
Beni Chegdale	11,582	11,444	-0.12%	11,389	11,321	11,267	11,199
Beni Oukil	14,960	15,260	0.20%	15,382	15,535	15,658	15,811
Dar Ould Zidouh	27,615	31,170	1.29%	32,775	34,781	36,386	38,393
HadBoumoussa	41,731	44,672	0.70%	45,931	47,505	48,765	50,339
Ouled Nacer	26,527	28,438	0.72%	29,257	30,282	31 101	32,126
Total populationin all province	**457 513**	**502 827**	-	**526,682**	**553,982**	**575,824**	**603 125**
Average annual population change rate per municipality (Period: 2004-2014)	-	-	**0.99%**	-	-	-	-
Projected annual rate of change of population of the province compared to the reference year 2014	-	-	-	**4.74%**	**10.17%**	**14.52%**	**19.95%**

The current population of the study area is estimated at approximately 527,000 inhabitants in the year 2018, which is expected to grow to more than 603,000 inhabitants by the year 2033, an increase over this period time interval of 14.4%. The number of inhabitants per municipality is projected in the year 2033 between a minimum of 11,000 individuals in the rural municipality of Hel Merbaa and a maximum of around 146,000 individuals in the municipality of Fquih Ben Salah (see Table 1).

The variation of the population of inhabitants of the study area follows an evolution at the rate of the average annual rate of 0.99%. From the point of view of the unit of the local commune, the fluctuation of population is heterogeneous, in particular its rate of variation which passes from the negative value, the lowest of -1.43% in the rural commune Hel Merbaa to achieve the highest positive rate of 2.3% in the municipality Fquih Ben Salah, the major urban agglomeration and provincial capital (study area) (see Table 1).

3.1.2 Assessment of the current importance of communal household waste

The results of the inventories of household and similar solid waste at the municipal levels of the study area for the reference year of 2018 are reported in Table 2.

Table 2: Assessments of solid household waste production in local municipalities in the study area
(Reference year: 2018)

Local commune	Population in year 2018 (estimated)	Solid waste (Tons/day)					
		Household waste collected (1)	Waste from public road cleaning (2)	Black head waste (3)	Total household waste (4)=(1)+(2)+(3)	Recycled waste (5)	Total net waste generation (6)=(4)-(5)
Fquih Ben Saleh (Municipality)	111,707	81.76	-	-	81.76	4.00	77.76
Ouled Ayad (Municipality)	24,862	18.25	-	5.00	23.25	-	23.25
Souk Sebt Ouled Nemma (Municipality)	64,325	47.03	-	-	47.03	-	47.03
Sidi Hammadi	14 106	10.30	-	-	10.30	-	10.30
Ouled Bourahmoun	15,768	11.53	-	-	11.53	-	11.53
Sidi Aissa Ben Ali	26,854	19.69	-	-	19.69	-	19.69
Ouled Zmam	34,389	25.26	-	-	25.26	-	25.26
Krifatee	27,539	20.15	-	-	20.15	-	20.15
Hel Merbaa	11,800	8.68	-	-	8.68	-	8.68
Khalfia	15,929	11.66	-	-	11.66	-	11.66
Brady	42,647	31.27	0.60	-	31.87	-	31.87
BniChegdal	11,389	8.36	-	-	8.36	-	8.36
BniOukil	15,382	11.20	-	-	11.20	-	11.20
Dar Ould Zidouh	32,775	24.03	-	-	24.03	-	24.03
HadBoumoussa	45,931	33.66	-	-	33.66	-	33.66
Ouled Nacer	29,257	21,507	-	-	21,507	-	21.51
Total waste by origin and/not recycled (T / day)	**524 664**	**384.33**	**0.60**	**5.00**	**389.93**	**4.00**	**385.93**
Recyclable quantity of household waste (Tons /day) (Base rate = 24%)	-	**92.24**	**0.14**	**1.2**	**93.58**	-	-

For a population of around 524,700 inhabitants at year 2018 in study area, a tonnage of solid household and similar waste was produced of 389.93 Tons/day, i.e. the equivalent of a production of an average daily per capita of 0.73 kg per day. The majority of this tonnage produced originates from households in a daily volume of 384.33 Tons (98.56%), which is constantly supplemented by collections from the cleaning of public roads and by the daily operation of the decongestion of garbage disposal black spots (see detail on Table 2).

The net generation of solid household waste in the year 2018 is a total of 385.93 tons. The communal quotation fluctuates between the minimum of 8.36 Tons/day in commune Beni Chegdal and the maximum of 77.76 Tons/day in municipality Fquih Ben Salah (see Table 2).

The total potentially recyclable quantity for household waste in the study area is estimated at 94 Tons per day, according to the conventional base rate of 24%, compared to what is currently achievable in a tonnage of 4T/day, relating to the only urban municipality of Fquih Ben Salah and which barely represents the rate of 1.04% of the total produced in this waste.

3.1.3 Projections of evolution of the importance of municipal household waste

The results of projections in net production of solid household waste at the level of municipalities in the study area by the year 2023; 2028 and 2033 are reporting in Table 3.

Table 3: Projections of solid household waste production by local municipalities in the study area for the years: 2023, 2028 and 2033

		Net generation of solid household waste(T/day)				**Share of the municipality in relation to the total** (Project year: 2033)
		Starting Year	Projections			
local municipality		2018	2023	2028	2033	
Fquih Ben Saleh(Municipality)		77.76	86.76	93.86	102.74	23%
Ouled Ayad (Municipality)		23.25	24.18	24.95	25.90	6%
Souk Sebt Ouled Nemma (Municipality)		47.03	51.04	54.16	58.05	13%
Sidi Hammadi		10.30	10.23	10.14	10.03	2%
Ouled Bourahmoun		11.53	12.16	12.64	13.24	3%
Sidi Aissa Ben Ali		19.69	20.87	21.81	23.00	5%
Ouled Zmam		25.26	25.88	26.42	27.10	6%
Krifatee		20.15	18.65	17.42	15.89	4%
Hel Merbaa		8.68	8.44	8.28	8.07	2%
Khalfia		11.66	12.11	12.47	12.90	3%
Brady		31.87	33.66	35.10	36.89	8%
BniChegdal		8.36	8.30	8.26	8.21	2%
BniOukil		11.20	11.39	11.48	11.59	3%
Dar Ould Zidouh		24.03	25.49	26.67	28.14	6%
HadBoumoussa		33.66	34.82	35.74	36.90	8%
Ouled Nacer		21.51	22.20	22.80	23.55	5%
Net total solid waste	(T/day)	**385.93**	**406.19**	**422.19**	**442.20**	**100%**
	(T/year)	**140,864**	**148 258**	**154 100**	**161,403**	-
Total solid waste generated	(T/day)	**389.93**	**410.19**	**426.19**	**446.20**	-
	(T/year)	**142,324**	**149,718**	**155,560**	**162,863**	-
Evolution of net tonnage produced at solid waste		Year of reference : 2018	**5%**	**9%**	**15%**	-
Recyclable quantity of household waste (Tons/day) (Base rate = 24%)		**93.58**	**98.44**	**102.29**	**107.09**	-

It is projecting between 2018 and 2033 that the total volume and the net volume of solid household waste to be produced would respectively increase from 142,324 to 162,863 Tons/day and from 104,864 to 161,403 Tons/year, i.e. an average annual rate of increase in common to both cases of +1%. We note that the range of variation between the local communes would be in year 2033 between 8 and 103 tons per day, respectively for the two extremes between commune Hel Merbaa (lower limit) and municipality Fquih Ben Saleh (upper limit) (see Table 3).

It is noting that the 52% share of the total projected volume of solid household waste production would be restricted to four municipalities, namely: two municipalities of Fquih Ben Saleh (23%) and Souk Sebt Ouled Nemma (13%) in association with two other rural communes of Bradia (8%) and Had Boumoussa (8%) (details on Table 3).

Furthermore, in year 2033, the total quantity in zone of recyclable household solid waste potential in the study area is projected at more than 107 Tones per day (see Table 3).

3.2 DISCUSSION

The daily production of solid and similar household waste per inhabitant in the study area of an average of 0.73 kg/day is noted to be higher compared to the respective data for the Beni Mellal-Khenifera region (integrating the study area) and for the Moroccan national territory for values of 0.36 Kg/inhabitant/day and 0.49 Kg/inhabitant/day (MTEDD, 2022e). This discrepancy is explained by the relatively improved standard of living of the population of the study area with a more intensive agricultural vocation, comparable to the most prosperous areas of the country of Morocco. Indeed, the poverty level of the study area is 6.8% against the higher poverty rate of 9.3% for the total of the Beni Mellal-Khenifera region (HCP, 2018).

The recycling rate of solid and similar managerial waste, which is currently 1.04 % in the study area, remains very low compared to the rate reported across the Moroccan territory of 6% (MTEDD, 2022e). The average annual increase in solid household waste in the study area, determined at 1% per year by 2033, is at a slower pace compared to projections over the period 2015-2030 for the Beni Mellal-Khenifera region. (Rate: 8.1% per year) and for the Moroccan national (Rate: 3.9 % per year) (MTEDD, 2022e). This is explained by the fact that the initial production of solid household waste in the study area is already in principle at a higher level (0.73 kg/inhabitant/day) and which would therefore probably remain in the medium term. in almost stationary levels.

In the event of effective implementation in the study area of the "national strategy for the reduction and recovery of waste "SNRVD", launched in execution by the Moroccan public authorities since the year of 2017 (MTEDD, 2022b), the rest in free tonnage of this waste without any treatment, is likely to stay on the surfaces of public landfills in the study area dedicated to household and similar waste would go from the current rate to 99% to the minimum rate of 50% by the year 2030. This last projected alternative, which is promising, would be entrusted to various specific professionals: recycling (national target rate: 20%), energy recovery (target rate: 10%) and transformation of organic matter in the form of compost (target rate: 20 %) (MTEDD, 2022e).

IV. CONCLUSION

The growth at population in study area on the horizon 2033 is correlating with the trend increase in solid and similar household waste. Indeed, basic level observed of household waste is found to be excessive in comparison to the regional and national Moroccan level's. The active integration of the study area in the dynamics of ambitious national strategy for reduction such waste on Moroccan territory would be a better opportunity in the medium term. So, it is possible to ensure regular treatment for at least half of the gross mass produced with interventions by: recycling, energy production and transformation of rejected green material of compost. The rest on this waste will not likely be subject to artificial transformation treatment.

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