Supplementary File.

Supplementary S1. Wellfields simulations and optimization.

The objective is to analyze the potentials of the wellfields at a finer spatial scale and maximize their exploitation, taking into account the Safe Yield concept [70–75]. Optimization of the wellfields was undertaken on the following bases:

Avoiding groundwater over-exploitation. Over-exploitation occurs to the extent that groundwater abstraction exceeds (or accounts for a significant portion of) groundwater recharge from precipitation and surface water contribution. An acceptable ratio of abstraction vs. recharge was sought.

Avoiding occurrence of deep piezometric depressions in the wellfields. Deep piezometric depressions (i.e., high drawdowns) may cause environmental problems. At each wellfield, reasonable and acceptable drawdowns are set as optimization constraints according to the hydrogeological context and in agreement with the end-users (MoWR, Ministry of Water Resource). Limiting piezometric lowering is a constant concern of water resources managers [32] and is commonly used as constraints to optimize groundwater resources exploitation [76].

S1—Mermero-Gocha Wellfield

The Mermero-Gocha wellfield is plotted in Figure S1A. It includes 7 wells (NBTW4, NBTW5, BTW9, GOCW1, and HobocBH1, NBTW16, NBTW17).

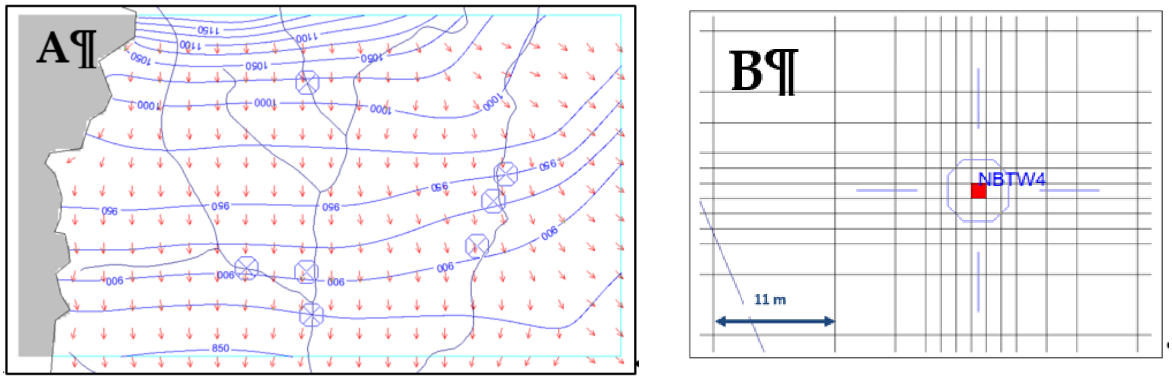

Figure S1. A. Mermero-Gocha wellfield extracted from the general model and the piezometric map of the area when no well is operating. B. Grid refinement around the wells.

The extracted Mermero-Gocha wellfield model is first refined with a cells size of 50m x 50m. Afterwards refinement is enhanced around each well in order to get each well located in a cell with size <1m (Figure S1B). The piezometric map when no well is operating (Figure S1A) points out a general North-South groundwater flow. Hydraulic gradients are high northward close to the elevated Teltele area. The water balance is shown in Table 1. The wellfield is then simulated with the current discharge rates (Q). The water balance is also reported in Table 1

Table S1. Water balance of the Mermero-Gocha wellfield.

	No well is operating		With current discharges	
	In (m^3/year)	Out (m^3/year)	In (m^3/year)	Out (m^3/year)
Wells	0	0	0	4.77×10^6
Recharge.	36.2×10^6	0	36.2×10^6	0
Head Dependant Boundaries	8.50×10^6	44.7×10^6	8.86×10^6	4.02×10^7
Total	44.7×10^6	44.7×10^6	45.1×10^6	45.1×10^6

The calculated drawdowns in each well are shown in Table S2. It should be noted that the simulated drawdown values obviously do not include abnormal head losses and accordingly should not be compared to observed drawdowns. Simulated drawdowns are quite high and vary between 14 m and 50 m. The theoretical specific capacity ranges between 24 m^2/d and 93 m^2/d. These results show that the potential of the wellfield is low and varies slightly in space. The total current abstraction (4.77×10^6 m^3/year) represents 13% of the wellfield recharge (36.2×10^6 m^3/year). Under these conditions, the wellfield is not in overexploitation condition. To optimize the wellfield exploitation, constraints are imposed on drawdowns. Excessive piezometric depression due to high pumping rates can affect the environment in the wellfield, as mentioned above. Considering the drawdowns caused by the current pumpings, two scenarios are simulated with the following constraints: Scenario 1: drawdowns ≤30 m; Scenario 2: drawdowns ≤50 m. The first scenario is reasonable, while the second is beyond the sustainable yield framework. Optimized pumping rates for both scenarios are given in Table S3 and water balances in Table S4.

Table S2. Current discharges rates and drawdowns calculated by the model at Mermero-Gocha wellfield. SC: Specific Capacity.

No.	BH_Code	x	y	Q (m^3/d)	Simulated Drawdown (m)	Theoretical SC (m^2/d)
4	NBTW-4	305,869	526,340	880	37	24
5	NBTW-5	300,532	510,052	4320	50	72
21	BTW9	322,243	515,942	648	22	86
42	GOCW1	323,316	518,310	1210	50	45
70	Hobok BH-1	306,254	505,927	648	14	24
Ad6	NBTW16	320,813	511,987	2400	26	29
Ad7	NBTW17	305,806	509,705	2400	50	93

Table S3. Optimized scenarios under different constraints. DD: drawdown.

BH_code	Current Q (m^3/d)	Simulated Drawdown (m)	Q(m^3/d) Scenario DD≤30m	Q(m^3/d) Scenario DD≤50m
NBTW-4	880	37	700	1138
NBTW17	2400	50	2127	3467
NBTW-5	4320	50	2463	3964
Hobok BH-1	648	14	3257	5326
GOCW1	1210	50	661	1062
BTW9	648	22	1041	1695
NBTW16	2400	26	2840	4589
Total Q	12,506		13,089	21,241

Table S4. Water balance of the wellfield under scenario 1 (DD ≤ 30m) and scenario 2 (DD ≤ 50m).

	Scenario 1 (DD ≤ 30m)		Scenario 2 (DD ≤ 50m)	
	In (m^3/year)	Out (m^3/year)	In (m^3/year)	Out (m^3/year)
Wells	0	4.78×10^6	0	7.75×10^6
Recharge	36.2×10^6	0	36.2×10^6	0
Head Dependant Boundaries	8.81×10^6	40.2×10^6	9.00×10^6	37.4×10^6
Total	45.0×10^6	45.0×10^6	45.2×10^6	45.2×10^6
Ratio Abstraction/Recharge	13%		21%	

The ratio between total abstraction and recharge is reasonable for the 1st scenario (DD ≤ 30m). It is equivalent to the ratio associated with the current abstraction rates (13%). Under the 2nd scenario (DD ≤ 50m) It increases only to 21%. But this scenario implies a high drawdown and large unsaturated zones in the aquifer. These consequences are not compatible with the Sustainable Yield concept.

To conclude, the Mermero-Gocha wellfield can optimally be operated under scenario 1. This scenario limits the piezometric drawdown to 30m in all wells. The optimized total abstraction rate satisfies current needs. No further increase in abastraction rates can be recommended.

S2—Gelchet-Wobock Wellfield

The Gelchet-Wobock wellfield includes 12 wells. The area is extracted from the general Borena model and refined as previously (Figure S2). The piezometric map of the Gelchet-Wobock area, when not any well is operating, is given in Figure S2. Groundwater is flowing into the area from the northern and eastern boundaries and exits the area mostly from the southern boundary. This map also indicates that groundflow is important along the Ririba valley. The water balance of the wellfield is given in Table S5.

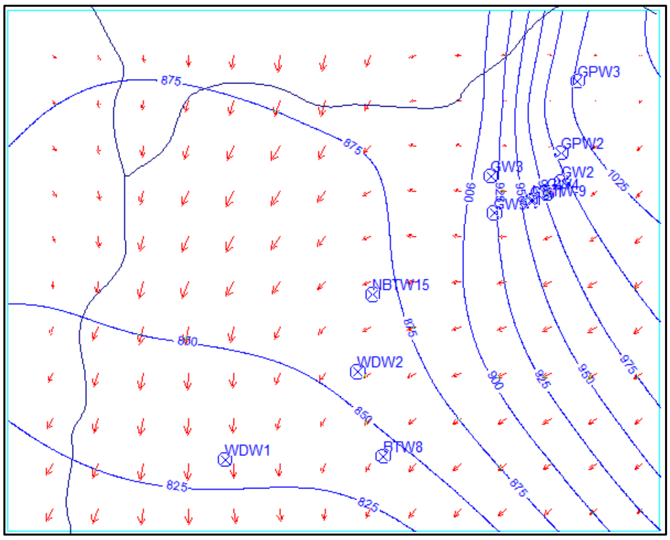

Figure S2. Piezometric map of the Gelchet-Wobock area when no well is operating.

Table S5. Water balance of the Gelchet-Wobock wellfield when no well is operating and with the current discharges.

	No Well Is Operating		Current Discharges	
	In (m^3/year)	Out (m^3/year)	In (m^3/year)	Out (m^3/year)
Wells	0	0		5.46×10^6
Recharge	5.35×10^7	0	5.35×10^7	
Head Dependant Boundaries	1.25×10^8	1.79×10^8	1.29×10^8	1.77×10^8
Total	1.79×10^8	1.79×10^8	1.83×10^8	1.83×10^8

Current discharge rates, simulated drawdowns and theoretical SC (Specific Capacity) are reported in Table S6. The water balance of the wellfield with the current pumping is given in Table S5. With the current pumping rates, simulated drawdowns vary between 1m and 56 m. The theoretical SC is highly variable. The smallest SC value is 36 m^2/d and the largest 2152 m^2/d, which shows that the wellfield potential is very different from place to place. The largest SC is located at the well WDW1 along the Ririba rift valley.

Table S6. Current discharges rates and drawdowns simulated by the model at Gelchet-Wobock wellfield. SC: Specific Capacity.

BH_code	X	Y	Q (m^3/d)	Simulated Drawdown (m)	Theoretical SC (m^2/d)
BTW8	352,697	491,178	259	0.9	284
GPW2	362,521	507,901	1210	30.4	40
GPW3	363,415	511,851	259	7.2	36
GW1	360,826	505,258	1469	39.2	38
GW2	362,519	506,349	1296	24.2	54
GW3	358,637	506,621	1210	24.9	48
GW4	361,707	505,679	1296	30.0	43
GW5	358,825	504,597	518	11.3	46
NBTW15	352,117	500,102	2400	3.6	668
NBTW9	360,943	505,273	3456	56.2	62
WDW1	343,976	490,986	1210	0.6	2152
WDW2	351,284	495,846	363	1.2	301

The total current pumping (5.46×10^6 m^3/year) represents 10% of the wellfield area recharge (53.5×10^6 m^3/year). The wellfield is not under overexploitation condition. A first optimization of the wellfield is conducted under the constraint DD ≤ 30m (scenario 1). Results are given in Tables S6 (Col.4) and S7. Though the constraint DD ≤ 30 m seems reasonable, the total abstractions exceed the wellfield recharge (ratio abstraction/recharge = 121%). The well WDW1 provides 119,059 m^3/d out of a total of 177,385 m^3/d. At three other wells (BTW8, NBTW15, WDW2) abstraction rates exceed 10,000 m^3/d. This scenario is out of the scope of the Sustainable Yield framework.

An alternative scenario (scenario 2) is simulated, to limit abstraction rates on these four wells (WDW1, BTW8, NBTW15, WDW2). Given the theoretical SC estimated at these wells, the following constraints are imposed under this scenario: Well WDW1: DD ≦ 10m; Wells BTW8, NBTW15, WDW2: DD ≦ 20m; All other wells: DD ≦ 30m. Results are given in Tables S7 (Col.5) and S8. Under this scenario, the ratio abstraction/recharge is still important (57%). It can also be noted that total abstraction in this scenario far exceeds the current total abstraction. Most of the pumped water is provided by the wells WDW1, BTW8, NBTW15, and WDW2.

The 3rd scenario is conducted to minimize drawdown in wells GW1 to GW5, GPW2, NBTW9 (sector 1) and maximize abstraction in wells NBTW15, WDW2, WDW1, BTW8 (sector 2) while respecting a reasonable ratio of abstraction vs. recharge. The following constraints are thus imposed: Sector: DD ≦ 20m; Well WDW1: DD ≦ 5m; Wells BTW8, NBTW15, WDW2: DD ≦ 15m. The results show that the ratio of abstraction vs. recharge amounts under this scenario to 35%, which is acceptable. The total abstraction amounts to 18.7×10^6 m^3/year, which can satisfy the current needs (current abstraction 5.5×10^6 m^3/year). Under this scenario, the abstraction is maximized and the piezometric depression is quite moderate, which is rather beneficial for environmental purposes.

To conclude, the Gelchet-Wobock wellfield can optimally be operated under scenario 3. The optimized abstraction rates are given in Table S7 (Col.6). Under this scenario, the current needs are fully satisfied and abstraction is maximized. The environment is preserved as the piezometric depression is moderate. This scenario fully agrees with the Sustainable Yield concept.

Table S7. Optimized scenarios under different constraints. DD: drawdown.

BH_code	Current Q (m^3/d)	Simulated Drawdown (m)	Q(m^3/d) Optimized Scenario 1 DD ≤ 30m	Q(m^3/d) Optimized Scenario 2	Q(m^3/d) Optimized Scenario 3
BTW8	259	0.9	13,583	9359	7121
GPW2	1210	30.4	1139	1145	768
GPW3	259	7.2	1309	1310	881
GW1	1469	39.2	1210	1238	1001
GW2	1296	24.2	1867	1882	1292
GW3	1210	24.9	1393	1429	975
GW4	1296	30.0	1419	1439	1007
GW5	518	11.3	2745	2848	1955
NBTW15	2400	3.6	17,821	12,293	9458
NBTW9	3456	56.2	1155	1180	299
WDW1	1210	0.6	119,059	39,052	18,694
WDW2	363	1.2	14,685	10,258	7855
Total Q	14,945		177,385	83,434	51,308

Table S8. Water balance of the wellfield under scenarios 1, 2 and 3.

	Scenario 1		Scenario 2		Scenario 3	
	In (m^3/year)	Out (m^3/year)	In (m^3/year)	Out (m^3/year)	In (m^3/year)	Out (m^3/year)
Wells	0	64.7×10^6	0	3.05×10^7	0	1.87×10^7
Recharge	53.5×10^6		53.5×10^6		53.5×10^6	
Head Dependant Boundaries	145.4×10^6	134.2×10^6	1.37×10^8	1.60×10^8	1.33×10^8	1.68×10^8
Total	198.9×10^6	198.9×10^6	1.91×10^8	1.91×10^8	1.86×10^8	1.87×10^8
	121%		57%		35%	

S3—Megado Wellfield

The Megado wellfield includes 4 wells: BTW1, Megado1, NBTW13 and NBTW14 (Figure S3). The piezometric map displays general groundwater flow from the N-NE boundary to the Ethio-Kenyan border. The water balance of the wellfield is given in Table 9. The simulated drawdowns due to current pumpings are given in theTable S10.

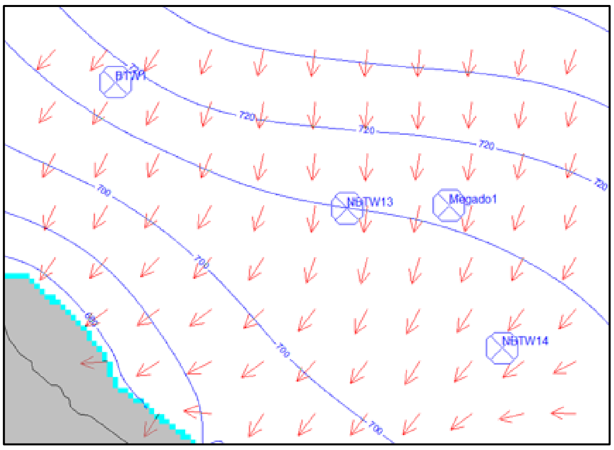

Figure S3. Extracted Megado wellfield from the general model. Piezometric map when no well is operating.

Table S9. Water balance of Megado wellfield when no well is operating and with the current discharges.

	No well Is Operating		Current Discharges	
	In (m^3/year)	Out (m^3/year)	In (m^3/year)	Out (m^3/year)
Wells	0	0	0	2.0 x 10^6
Recharge	6.7 x 10^6	0	6.7 x 10^6	
Head Dependant Boundaries	282.6 x 10^6	289.3 x 10^6	283.4 x 10^6	288.1 x 10^6
Total	289.3 x 10^6	289.3 x 10^6	290.1 x 10^6	290.1 x 10^6
Ratio Abstraction/Recharge			29%	

Table S10. Current discharges rates and simulated drawdowns at Megado wellfield. SC: Specific Capacity.

No	BH_code	x	y	Q (m^3/d)	Simulated Drawdown (m)	Theoretical SC (m^2/d)
11	BTW1	396,127	421,962	328	0.3	1286
Ad3	NBTW13	407,244	415,901	2400	0.6	3777
62	Megado-1	412,154	416,043	383	0.2	1623
Ad4	NBTW14	414,696	409,192	2400	0.7	3402
	Total Q (m^3/d)			5511		

We can note that recharge value is significantly small compared to other wellfields (Mermero-Gocha, Gelchet-Wobock, and Hobock). On the other hand, the hydraulic properties of this wellfield area are high. The theoretical SC is much higher with respect to SC at other wellfields. Drawdowns in all wells are less than 1m, for the current discharge rates. However, under the current exploitation, the ratio abstraction vs. recharge already rises to 29%. This wellfield is probably not far from its maximum operating capacity. Two scenarios are simulated with the following constraints: Scenario 1: drawdowns ≤ 1 m; Scenario 2: drawdowns ≤ 2 m. The optimized abstraction rates are given in Table S11 and the water balance of the wellfield under both scenarios in Table S12. Under both scenarios, the piezometric depression is limited. The ratio Abstraction vs. Recharge in both cases is high. Even under scenario 2, the total abstraction exceeds the wellfield area recharge.

Table S11. Optimized scenarios under different constraints. DD: drawdown; Scn: scenario.

Well code	Current Q (m^3/d)	Simulated Drawdown (m)	Q(m^3/d) Scn 1 DD ≤ 1m	Q(m^3/d) Scn 2 DD ≤ 2m	Q(m^3/d) Scn 3 DD ≤ 0.75m
BTW1	328	0.3	1348	2760	994
Megado1	383	0.2	3534	7255	2602
NBTW13	2400	0.6	2746	5640	2022
NBTW14	2400	0.7	3443	6834	2594
Total Q	5511		11,070	22,488	8212

Table S12. Water balance of the wellfield under scenarios 1, 2 and 3.

	Scenario 1		Scenario 2		Scenario 3	
	In (m^3/year)	Out (m^3/year)	In (m^3/year)	Out (m^3/year)	In (m^3/year)	Out (m^3/year)
Wells	0	4.0×10^6	0	8.2×10^6	0	2.99×10^6
Recharge	6.7×10^6		6.7×10^6		6.7×10^6	
Head Dependant Boundaries	284.3×10^6	287.0×10^6	286.2×10^6	284.7×10^6	283.8×10^6	287.6×10^6
Total	291.0×10^6	291.0×10^6	292.9×10^6	292.9×10^6	290.6×10^6	290.6×10^6
	60%		122%		44%	

A 3rd scenario is sought, with the objective to reduce the ratio Abstraction/Recharge. The constraint on drawdown is drawdowns < 0.75 m. The water balance of scenario 3 is reported in Table S12. Optimized pumping rates are given in Table 33 (Col.6). Under this scenario, total abstraction exceeds current pumping. The ratio Abstraction/Recharge has lowered and amounts to 44%, which is reasonable within sustainable exploitation of the wellfield. To conclude, scenario 3 can be recommended to exploit the Megado wellfield, sustainably.

S4—Liso-Sadeka Wellfield

The Liso-Sadeka wellfield is located along the Ririba rift valley. The shape of the wellfield is fairly elongated in a North-South direction. The wellfield includes 6 wells: NBTW-11, NBTW-12, NBTW-18, BTW10, Goray-1, Goray-2. Coordinates and current discharge rates of the wells are reported in Table S14. The extracted model is shown in Figure S4. The water balance of the wellfield area when no well is operating and with the current discharges is given in Table S13.

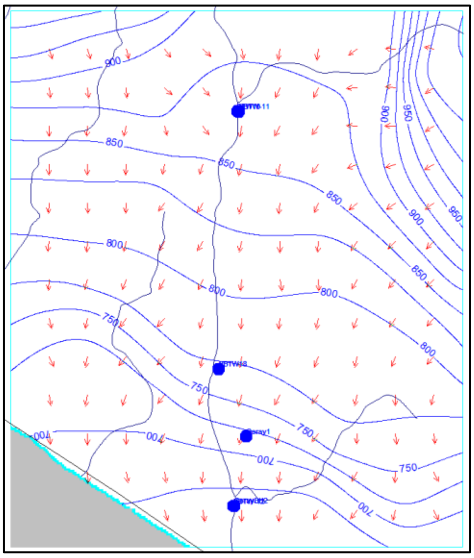

Figure S4. Piezometric map of the Liso-Sadeka area when no well is operating.

Table S13. Water balance of Liso-Sadeka wellfield when no well is operating and with the current discharges.

	No well is operating		Current discharges	
	In (m^3/year)	Out (m^3/year)	In (m^3/year)	Out (m^3/year)
Wells	0	0	0	3.9×10^6
Recharge	150.5×10^6	0	150.5×10^6	0
Head Dependant Boundaries	143.7×10^6	294.2×10^6	145.3×10^6	292.7×10^6
Total	294.2×10^6	294.2×10^6	295.8×10^6	296.6×10^6
Ratio Abstraction/Recharge			3%	

Current discharge rates, simulated drawdowns, and theoretical SC are given in Table S14. These results show that Liso-Sadeka has high exploitation potential: theoretical SC is very high (except at Goray-1 well); with the current abstraction rates, the simulated drawdowns are very low (Table S14, Col.6); the ratio of abstraction vs. recharge is quite reduced (3%).

Table S14. Current and planned discharges rates and simulated drawdowns at Liso-Sadeka wellfield. SC: Specific Capacity.

No	BH_code	x	y	Current Q(m^3/d)	Simulated Drawdown (m)	Theoretical SC (m^2/d)
9	NBTW-11	338,613	505,449	2333	1.1	2130
10	NBTW-12	337,939	454,121	3974	0.5	7717
22	BTW10	338,417	505,453	1642	1.0	1679
63	Goray-1	339,581	463,165	216	0.3	698
67	GorayBH-2	338,000	454,149	346	0.3	1227
Ad8	NBTW18	335,995	471,940	2400	1.6	1514
	Total Q (m^3/d)			10,911		

Given the high theoretical values of SC, the following scenarios are simulated: Scenario 1: drawdowns < 10m; Scenario 2: drawdowns < 20m. Optimized pumping rates under these scenarios are given in Table S15 and the water balances in Table S16.

Table S15. Optimized scenarios under different constraints. DD: drawdown.

BH_code	Current Q (m^3/d)	Simulated Drawdown (m)	Q(m^3/d) Optimized Scenario dd ≤ 10m	Q(m^3/d) Optimized Scenario DD ≤ 20m
NBTW-11	2333	1.1	19,712	38,789.2
NBTW-12	3974	0.5	55,867	110,966
BTW10	1642	1.0	20,011	39,546.2
Goray-1	216	0.3	19,767	38,991.9
GorayBH-2	346	0.3	62,157	122,074
NBTW18	2400	1.6	12,837	25,385
Total Q(m3/d)	10,911	xx	190,350	375,752

Table S16. Water balance of the wellfield under scenario 1 (DD ≤ 10m) and scenario 2 (DD ≤ 20m).

	Scenario 1 (DD ≤ 10 m)		**Scenario 2 (DD ≤ 20 m)**	
	In (m^3/year)	Out (m^3/year)	In (m^3/year)	Out (m^3/year) (m^3/year)
Wells	0	69.5×10^6	0	137.2×10^6
Recharge	150.5×10^6	0	150.5×10^6	0
Head Dependant Boundaries	160.2×10^6	242.2×10^6	176.7×10^6	191.0×10^6
Total	310.7×10^6	311.7×10^6	327.2×10^6	328.2×10^6
Ratio Abstraction/Recharge	46%		91%	

The following remarks can be drawn from the above simulation results:

- The current exploitation and both simulated scenarios preserve the environment, as the piezometric depression is limited;
- As the hydraulic properties of the wellfield area are high, thus when constrained drawdowns are increased, the total exploited groundwater volume augment considerably (see Table S15, Col.4 & 5).
- However, augmenting abstracted groundwater volume affects the ratio abstraction vs. recharge. When imposed drawdowns are ≤20m, this ratio reaches the value of 91%, i.e., almost the whole recharge is exploited. This is, of course, unacceptable within the frame of sustainable management of the wellfield.

To conclude, the Liso-Sedeka wellfield can be optimally operated under scenario 1. This scenario allows to increase significantly the abstracted groundwater volume, and at the same time preserves the environment

S5—Sarite Wellfield

The extracted model is shown in Figure S5. There are three wells in this wellfield: Sarite-1, NBTW-10 and NBTW19.

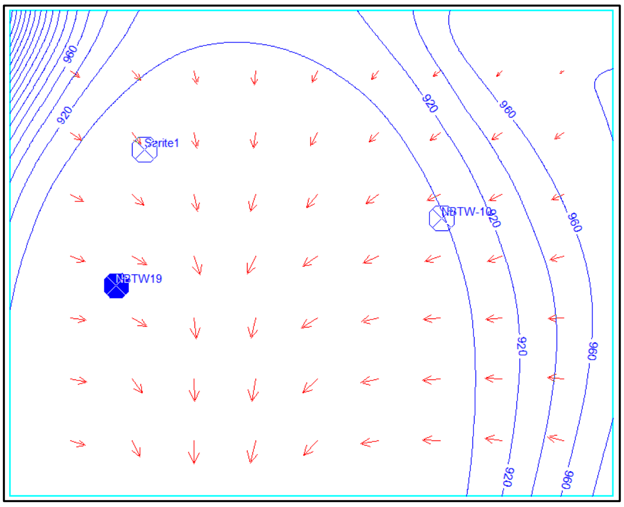

Figure S5. Piezometric map of the Sarite area when no well is operating.

The piezometric map (Figure S5) reveals that this area is a groundwater convergence zone. High gradients are in the NW part towards Teltele sub-basins. The water balance of the wellfield, without any pumping and with the current discharges, is given in Table S17. With the current discharge rates, the ratio Abstraction vs. Recharge is quite small (6%). Current discharge rates, simulated drawdowns and theoretical SC (Specific Capacity) are reported in Table S18.

Table S17. Water balance of the Sarite wellfield when no well is operating and with the current discharges.

	No Well Is Operating		With Current Discharges	
	In (m^3/year)	Out (m^3/year)	In (m^3/year)	Out (m^3/year)
Wells	0	0	0	1.55×10^6
Recharge	25.9×10^6	0	25.9×10^6	
Head Dependant Boundaries	16.5×10^6	42.4×10^6	16.6×10^6	40.9×10^6
Total	42.4×10^6	42.4×10^6	42.5×10^6	42.5×10^6
Ratio Abstraction/Recharge			6%	

Table S18. Current and planned discharges rates and simulated drawdowns at Sarite wellfield. SC: Specific Capacity.

No	BH_code	x	y	Q(m3/d)	Simulated Drawdown (m)	Theoretical SC (m^2/d)
8	NBTW-10	359,028	542,560	1555	10.4	149
64	Sarite-1	346,964	545,325	281	0.7	418
Ad9	NBTW19	345,818	539,835	2400	0.6	3905

The results show that the wellfield potential is quite variable in space. The highest potential is at the well NBTW19. Given the observed results, the following constraints are imposed: Scenario 1: DD at NBTW10 and Sarite1 ≤ 20 m, DD at NBTW19 ≤ 10 m. Optimized abstraction rates are given in Table S19 (Col.4) and water balance of the wellfield under this scenario in Table S20. The ratio abstraction vs. recharge is high (72%) and most of the water is pumped at NBTW19. Accordingly, under scenario 2, the same constraints are kept at Sarite1 and NBTW10. But at NBTW19, drawdown is lowered (DD ≤ 5m).

Scenario 2: DD at NBTW10 and Sarite1 ≤ 20 m, DD at NBTW19 ≤ 5 m. Optimized abstraction rates are given in Table S19 (Col.5) and water balance of the wellfield under scenario 2 in Table S20. Under scenario 2, the ratio abstraction vs. recharge reaches an acceptable value (44%), although slightly exceeding the 40% limit previously set. Drawdowns are limited and total abstraction has increased compared to current exploitation.

To conclude, scenario 2 can be applied to operate the Sarite wellfield.

Table S19. Optimized scenarios under different constraints. DD: drawdown.

BH_code	Current Q (m^3/d)	Simulated Drawdown (m)	Q(m^3/d) Optimized Scenario 1 Constraints: See Text	Q(m^3/d) Optimized Scenario 2 Constraints: See Text
NBTW-10	1555	10.4	3143	3180
Sarite-1	281	0.7	8275	8451
NBTW19	2400	0.6	40,301	20,047
Total Q	4236		51,719	31,678

Table S20. Water balance of the wellfield under scenarios 1 and 2.

	Scenario 1		Scenario 2	
	In (m^3/year)	Out (m^3/year)	In (m^3/year)	Out (m^3/year)
Wells	0	18.9×10^6	0	11.6×10^6
Recharge	25.9×10^6		25.9×10^6	
Head Dependant Boundaries	17.2×10^6	24.2×10^6	16.9×10^6	31.3×10^6
Total	43.1×10^6	43.1×10^6	42.9×10^6	42.9×10^6
Ratio Abstraction/Recharge	72%		44%	

S6—Teltele Wellfield

The volcanic formations found in the Teltele basin consist of Pre-rift/Syn-rift basaltic successions. The tickness of this sequence may exceed 300 m.

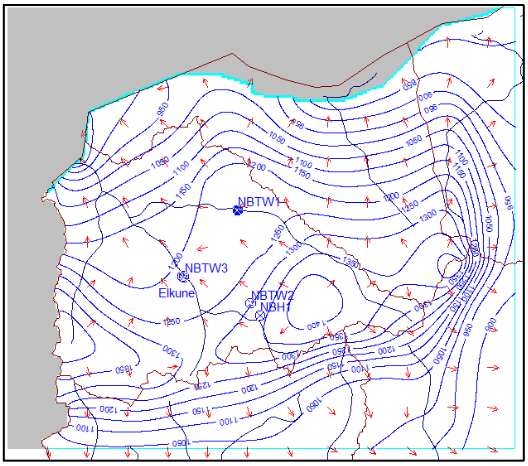

Figure S6. Piezometric map of the Teltele area when no well is operating.

The piezometric map shows a piezometric dome roughly centered in the middle of the perimeter. Groundwater flows from the dome to the limits of the perimeter. There are five wells in this wellfield. Their current abstraction rates are given in Table S22. The water balance of the wellfield area when no well is operating and with the current discharges is given in Table S21.

Table S21. Water balance of Teltele wellfield when no well is operating. and with the current discharges.

	No Well Is Operating		Current Discharges	
	In (m^3/year)	Out (m^3/year)	In (m^3/year)	Out (m^3/year)
Wells	0	0	0	1.3×10^6
Recharge	41.5×10^6	0	41.5×10^6	
Head Dependant Boundaries	18.4×10^6	59.9×10^6	18.6×10^6	58.9×10^6
Total	59.9×10^6	59.9×10^6	60.2×10^6	60.2×10^6
Ratio Abstraction/Recharge			3%%	

Table S22. Current discharges rates and simulated drawdowns at Teltele wellfield. SC: Specific Capacity.

No	BH_code	x	y	Q (m^3/d)	Simulated Drawdown (m)	Theoretical SC (m^2/d)
1	NBTW-1	311,927	557,149	1531	61	25.3
2	NBTW-2	313,602	545,518	406	203	2.0
3	NBTW-3	305,256	548,785	960	74	13.0
44	NBH-1	314,779	543,971	346	260	1.3
59	Elkune	305,054	548,887	311	63	4.9
	Total Q (m^3/d)			3554		

These results show that the potential of the Teltele wellfield is very limited. Specific Capacity values are quite reduced. Drawdown at NBTW2 and NBH1 exceeds 200 m, causing deep piezometric depression which obviously is unfavorable for the environment. The current total abstraction, though being small compared to recharge (3%), is not compatible with the preservation of the environment and sustainable operation of the wellfield. Thus, an optimized scenario is sought, limiting drawdown at 50 m, at all wells. The optimized abstraction rates are given in Table S23 and the water balance of the wellfield under this scenario in Table S24.

Table S23. Optimized scenario. DD: drawdown.

BH_code	Current Q (m^3/d)	Simulated Drawdown (m)	Q(m^3/d) Optimized Scenario DD ≤ 50 m
NBTW-1	1531	61	1676
NBTW-2	406	203	60
NBTW-3	960	74	439
NBH-1	346	260	50
Elkune	311	63	474
Total Q	3554		2699

Table S24. Water balance of the wellfield under optimized scenario (DD ≤ 50 m).

	In (m^3/year)	Out (m^3/year)	Ratio Abstraction/Recharge
Wells	0	0.98×10^6	2%
Recharge	41.5×10^6		
Head Dependant Boundaries	18.6×10^6	59.1×10^6	
Total	60.1×10^6	60.1×10^6	

The simulation results demonstrate that the current exploitation of the Teltele wellfield causes a significant lowering of the water table around the 5 wells in operation. The maximum drawdown exceeds 200 m. An optimized exploitation scenario is proposed, limiting drawdown at 50 m at each well. Following remarks can be formulated:

- The total abstraction, under this scenario, is lower than the current one;
- However, discharge rates at NBTW1 and Elkune wells are slightly higher than the current discharge rates;
- Discharge rates at NBTW2, NBTW3, and NBH1 are drastically reduced.

The optimized scenario, simulated by the model, can be an efficient option to exploit the Teltele groundwater resources, without much harm to the environment. It should be recalled that this scenario implies 50 m piezometric depression, which is a limit not to exceed.