SUPPLEMENTARY MATERIAL

Evaluation of groundwater sustainability for agricultural irrigation in the Tolon District, Northern Region of Ghana

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Table S1. Classification of groundwater samples based on irrigation water quality indices (*IWQIs*) during the rainy season

IWQIs	**Range**	**Degree of restriction**	**Samples**	
			number	**%**
EC	<700	excellent	23	42.0
	⟨700; 1,500⟩	good	22	40.0
	(1,500; 3,000⟩	fair	10	18.0
	>3,000	rejection	0	0
TDS	<450	excellent	33	60.0
	⟨450; 900⟩	good	16	29.0
	(900; 2,000⟩	fair	6	11.0
	>2,000	rejection	0	0.0
SAR	<8	excellent	44	80.0
	⟨8; 16⟩	good	10	18.2
	(16, 28⟩	doubtful or fairly poor	1	1.8
	>28	unsuitable	0	0
PI	>75%	good class – I	48	87.7
	(25%; 75%⟩	suitable class – II	7	12.3
	<25%	unsuitable class – III	0	0
PS	<3	excellent to good	46	83.6
	⟨3; 5⟩	good to injurious	3	5.6
	>5	injurious to unsatisfactory	6	10.9
MH	>50%	suitable	45	82.0
	<50%	unsuitable	10	18.0
TH	⟨0; 75⟩	soft	27	49.0
	(75; 150⟩	moderately hard	15	27.0
	(150; 300⟩	hard	9	16.0
	>300	very hard	4	7.0
RSC	<1.25	safe	24	44.0
	⟨1.25; 2.5⟩	marginal	3	5.0
	>2.5	unsafe	28	51.0
Na^{2+}	<50	suitable	14	25.0
	⟨50; 150⟩	good	30	55.0
	(150; 400⟩	marginal	11	20.0
	>400	rejection	0	0
K^{+}	<2	excellent	29	53.0
	(2; 5⟩	good	2	4.0
	(5; 35⟩	fair	18	33.0
	>35	rejection	6	11.0
Cl^{-}	<70	safe	47	85.0
	(70; 140⟩	slight to moderate injury	3	5.0
	(140; 350⟩	slight to substantial injury	3	5.0
	>350	rejection	2	4.0

Explanations: *EC* = electrical conductivity, *TDS* = total dissolved solids, *SAR* = sodium adsorption ratio, *PS* = potential salinity, *PI* = permeability index, *MH* = magnesium hazard, *TH* = total hardness, *RSC* = residual sodium carbonate.

Source: own study.

Table S2. Classification of groundwater samples based on irrigation water quality indices (*IWQIs*) during the dry season

IWQIs	**Range**	**Degree of restriction**	**Samples**	
			number	**%**
EC	<700	excellent	16	38
	⟨700; 1,500⟩	good	16	38
	(1,500; 3,000⟩	fair	7	17
	>3,000	rejection	3	7
TDS	<450	excellent	21	50
	⟨450; 900⟩	good	14	33
	(900; 2,000⟩	fair	7	17
	>2,000	rejection	0	0
SAR	<8	excellent	42	100
	⟨8; 16⟩	good	0	0
	(16, 28⟩	doubtful or fairly poor	0	0
	>28	unsuitable	0	0
PI	>75%	good class – I	21	50
	(25%; 75%⟩	suitable class – II	20	48
	<25%	unsuitable class – III	1	2
PS	<3	excellent to good	25	60
	⟨3; 5⟩	good to injurious	6	14
	>5	injurious to unsatisfactory	11	26
MH	>50%	suitable	14	33
	<50%	unsuitable	28	67
TH	⟨0; 75⟩	soft	3	7
	(75; 150⟩	moderately hard	2	5
	(150; 300⟩	hard	8	19
	>300	very hard	29	69
RSC	<1.25	safe	16	38
	⟨1.25; 2.5⟩	marginal	6	14
	>2.5	unsafe	20	48
Na^{2+}	<50	suitable	12	28
	⟨50; 150⟩	good	8	18
	(150; 400⟩	marginal	20	50
	>400	rejection	2	4
K^{+}	<2	excellent	8	19
	(2; 5⟩	good	26	62
	(5; 35⟩	fair	8	19
	>35	rejection	0	0
Cl^{-}	<70	safe	24	57
	(70; 140⟩	slight to moderate injury	5	12
	(140; 350⟩	slight to substantial injury	8	19
	>350	rejection	5	12

Explanations as in Tab. S1.

Source: own study.

Table S3. Yield potential of various crops

Crop name	Yield potential					Rating
	100%	90%	75%	50%	0 (maximum)	
	irrigation water salinity EC_w (µS·cm^{-1})					
Field crops						
Bean	42% (700)	59% (1,000)	79% (1,500)	93% (2,400)	97% (4,200)	S
Groundnut	92% (2,100)	93% (2,400)	97% (2,700)	97% (3,300)	97% (4,400)	MS
Maize (corn)	60% (1,100)	84% (1,700)	93% (2,500)	97% (3,900)	97% (6,700)	MS
Rice	92% (2,000)	95% (2,600)	97% (3,400)	97% (4,800)	97% (7,600)	MS
Sugarcane	60% (1,100)	92% (2,300)	97% (4,000)	97% (6,800)	98% (12,000)	MS
Cowpea	97% (3,300)	97% (3,800)	97% (4,700)	97% (6,000)	97% (8,800)	MT
Sorghum	97% (4,500)	97% (5,000)	97% (5,600)	97% (6,700)	97% (8,700)	MT
Soybean	97% (3,300)	97% (3,700)	97% (4,700)	97% (5,000)	97% (6,700)	MT
Wheat	97% (4,000)	97% (4,900)	97% (6,300)	97% (8,700)	98% (13,000)	MT
Sugarbeet	97% (4,700)	97% (5,800)	97% (7,500)	97% (10,000)	98% (16,000)	T
Vegetable crops						
Carrot	42% (700)	60% (1,100)	87% (1,900)	97% (3,000)	97% (5,400)	S
Okra						S
Onion	51% (800)	68% (1,200)	86% (1,800)	97% (2,900)	97% (5,000)	S
Broccoli	87% (1,900)	95% (2,600)	97% (3,700)	97% (5,500)	97% (9,100)	MS
Cabbage	68% (1,200)	87% (1,900)	97% (2,900)	97% (4,600)	97% (8,100)	MS
Cucumber	84% (1,700)	92% (2,200)	97% (2,900)	97% (4,200)	97% (6,800)	MS
Lettuce	57% (900)	77% (1,400)	92% (2,100)	97% (3,400)	97% (6,000)	MS
Pepper	59% (1,000)	79% (1,500)	92% (2,200)	97% (3,400)	97% (5,800)	MS
Potato	60% (1,100)	84% (1,700)	93% (2,500)	97% (3,900)	97% (6,700)	MS
Spinach	68% (1,300)	92% (2,200)	97% (3,500)	97% (5,700)	97% (10,000)	MS
Sweet potato	59% (1,000)	80% (1,600)	92% (2,300)	97% (4,000)	97% (7,100)	MS
Tomato	84% (1,700)	92% (2,300)	97% (3,400)	97% (5,000)	97% (8,400)	MS
Fruit crops						
Avocado	57% (900)	68% (1,200)	84% (1,700)	93% (2,400)		S
Grape	59% (1,000)	84% (1,700)	97% (2,700)	97% (4,500)	97% (7,900)	S
Grapefruit	68% (1,200)	80% (1,600)	92% (2,200)	97% (3,300)	97% (5,400)	S
Lemon	60% (1,100)	80% (1,600)	92% (2,200)	97% (3,200)	97% (5,400)	S
Orange	60% (1,100)	80% (1,600)	92% (2,200)	97% (3,200)	97% (5,300)	S
Strawberry	42% (700)	57% (900)	68% (1,200)	84% (1,700)	97% (2,700)	S

Explanations: S = sensitive, MS = moderately sensitive, MT = moderately tolerant, T = tolerant, percentage values = % of samples number, values in the brackets = EC_w values.

Source: Table's design after Ayers and Westcot (1985), own study.

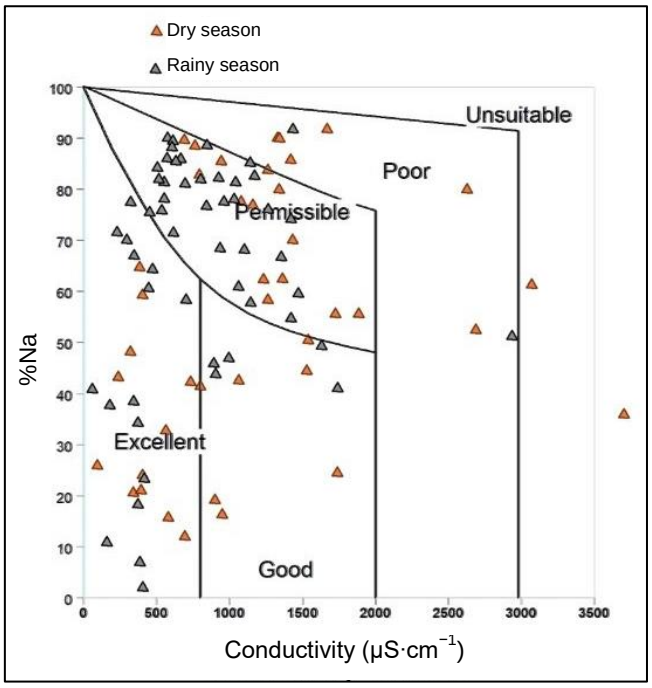

Fig. S1. Wilcox's diagram for irrigation water classification; source: own study

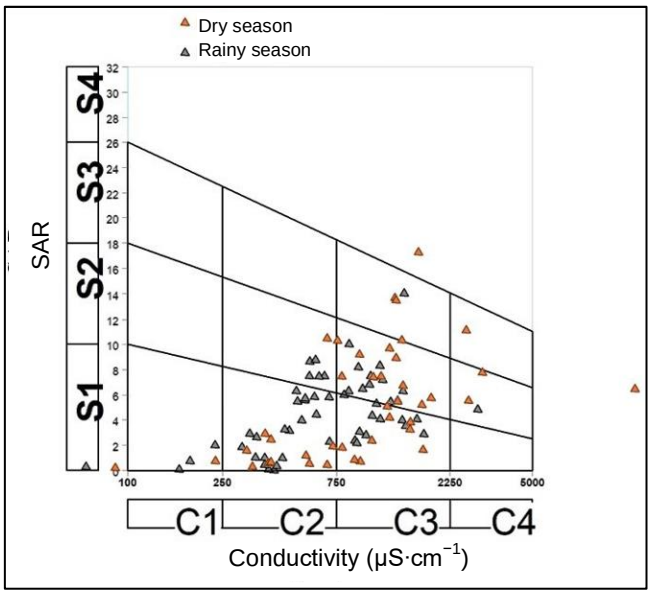

Fig. S2. United States Salinity Laboratory diagram for irrigation water classification; *SAR* = sodium adsorption rate; source: own study