THE SALINITY MEASUREMENT IN THE LOWER SEYHAN IRRIGATION PROJECT

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INTRODUCTION

It is generally known that soil productivity changes based on its physical and chemical properties. The most important factors effecting soil productivity are soil salinity, alkalinity and ground water levels. Soil salinity and alkalinity are mainly caused by natural and misuse of land by humans (secondary salinisation) factors. While climate, natural drainage, topographic properties, geologic structure, parent material, distance to the sea are natural factors; unsuitable irrigation methods and water quality, insufficient drainage, poor land management are cultural factors. Saline, saline-alkaline and alkaline soils are usually seen in the hollow and flat topographies in the arid and semi arid climatic conditions. In these areas, the upward movement of high groundwater, floods and excess evapotranspiration can cause salt accumulation at the soil surface (Mehanni, 1998; Özcan and Çetin, 1998). The salt caused both by natural and anthropogenic effects (land use, irrigation etc) on soil can be of chemical, physical and biological origin. Chemical effects are the cation exchanges and the interaction among salts. Whereas the major physical effects are on permeability where a non-permeable subsoil layer can partly or completely prevent salt leaching from soil (Dinç et al., 1990; Smedema and Rycroft, 1983). Biological effects are the changes in osmotic pressure and alteration of protoplasmatic actions in plants (Özgül, 1974; FAO, 1985; Smedema and Rycroft, 1983).

The Lower Seyhan Irrigation Plain (LSIP), one of the earlier irrigation projects of Turkey, has been highly effected by salinisation. Yüzgeç (1985) investigated salt changes in the surface horizons of the Çukurova Region between 1956 and 1984. Results revealed that the strongly saline areas decreased from 16,8% to 2,1% with irrigation and saline soils from 105.639 ha to 60.898 ha. Özcan and Çetin (1996) examined maximum soil salinity and alkalinity in a soil profile (within 150 cm) from 1956 to 1979 in the fourth project area of LSIP. They pointed out that there had been 2,5 and 1,5 fold increases in saline-alkaline and strongly saline areas respectively, with a 1,5 fold decrease in saline soils. The reasons of these changes were; vicinity leakage owing to upper catchment irrigation, irrigation from drainage canals and the highly saline groundwater. The northern part of the area intended for investigation has been under irrigation since 1960 following the Seyhan dam construction. But, the study area has not had irrigation infrastructure and the drainage canals have been partly constructed since 1990 as is the usual practice in many similar cases.

Thus the aim of the study seeks to determine spatial distribution of the salinity in the area by field measurements and laboratory analyses of soils to be able to shed light on the spatial variability of salinity of the area by monthly measurements between June 2005 and November 2006.

1. Study Area

The salinity measurements are undertaken on the Lower Seyhan Irrigation Project area of 4th stage (which is not irrigated yet but infrastructural constructions are accelerated recently for irrigation), located mainly on the northern margins of Akyatan Lagoon. Moreover, measurement sites in the 3rd Stage June 2005 and November 2006 (Figure 1, 2).

Measurements were undertaken at 50 points between Bebeli villages and Tuzla township (Figure 2). Measurement points were selected according to soil type and its dominance in the study area (Dinç et a. 1990)

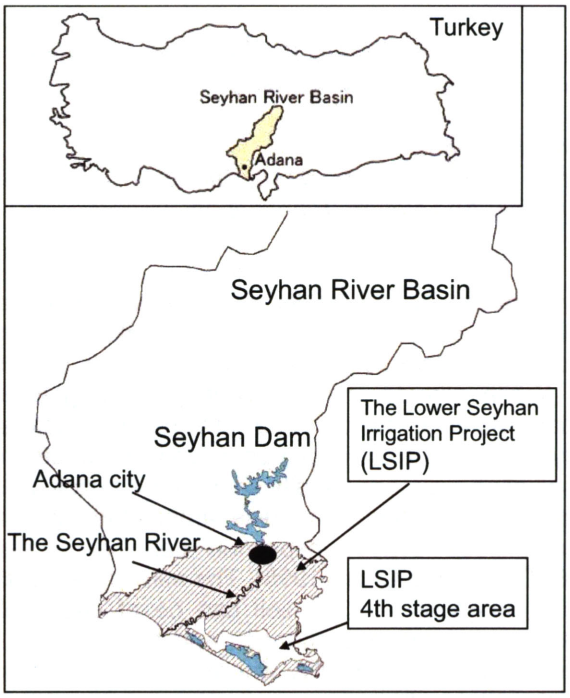

Figure 1. The Lower Seyhan Irrigation Project (LSIP) site

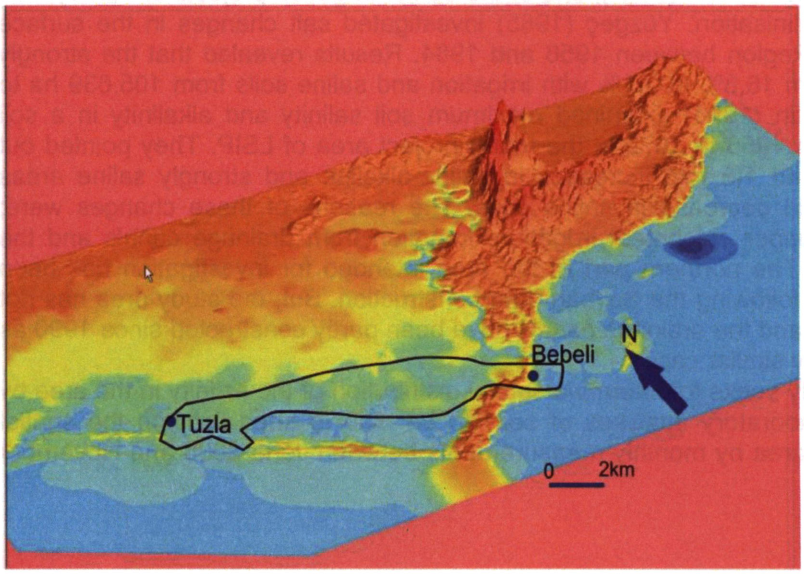

Figure 2. DTM of the study area

2. Methodology

The ECa (Apparent electrical conductivity) values measured by the EMI method (Electromagnetic Induction Method) were expressed as ECv values (generally described as ECa) by using EM38-DD (McNeil, 1980). The measurements were conducted at June 2005 and November 2006 at 50 points. Points are selected according to dominancy of soil series (Dinç et al. 1990) (Table 1) (Figure 4, 5) and within the each measurement point, 5 to 6 parallel measurements are undertaken at 30m intervals. For calibrating EM measurements at Points 1, 14, 20, 26 and 46 soil samples from surface, 0-30, 30-60, 60-90, 90-120cm were collected for laboratory analyses. TDR measurements were also undertaken at points of soil sampling. However, due to irrelevant data of TDR when compared to EM and soil samples, the TDR measurement was abandoned following September 2005.

Table 1. Soil Series of the Lower Seyhan Irrigation Plain

SOIL SERIES	FAO/ISRIC/IUSS, 1998	USDA, 2003
1. Canakci	Calcaric Fluvisol	Typic Xerofluvent – (Entisol)
2. Arikli	Chromic Vertisol	Entic Chromoxerert – (Vertisol)
3. Arpaci	Calcaric Fluvisol	Aquic Xerofluvent – (Entisol)
4. Misis	Vertic Cambisol	Vertic Xerochrept – (Inceptisol)
5.Yenice	Calcaric Fluvisol	Vertic Xerofluvent – (Entisol)
6. Incirlik	Chromic Vertisol	Entic Chromoxerert – (Vertisol)
7. Helvaci	Gleyic Solonchak	Vertic Halaqeupt – (Inceptisol)
8. Oymakli	Calcaric Fluvisol	Typic Xerofluvent – (Entisol)
9. Baharli	Eutric Regosol	Typic Xeropsamment – (Entisol)
10. Ismailiye	Eutric Regosol	Typic Xerorthent – (Entisol)
11. Pekmez	Chromic Vertisol	Typic Chromoxerert – (Vertisol)
12. Arkaca	Chromic Vertisol	Palexerollic Chromoxerert – (Vertisol)
13. Innapli	Vertic Cambisol	Vertic Xerochrept – (Inceptisol)
14. Mürsel	Calcic Cambisol	Fluventic Xerochrept – (Inceptisol)
15. Seyhan	Rendzina	Lithic Haploxeroll – (Mollisol)
16. Karataş	Rendzina	Lithic Haploxeroll – (Mollisol)
17. Gölyaka	Rendzina	Lithic Haploxeroll – (Mollisol)
18. Adana	Calcic Luvisol	Calcic Rhodoxeralf – (Alfisol)
19. Karabucak	Eutric Histosol	Hydric Medihemist – (Histosol)
20. Gemisüre	Chromic Vertisol	Typic Chromoxerert – (Vertisol)

To assess the impact of the groundwater environment affected by irrigation water on soil salinization, LANDSAT data for August 1990 and August 2005 were used to identify salt-affected fields. Salt-affected fields were identified from the classification of unsupervised classes (ISO method) using the field investigation data and the soil map (Dinç et al., 1991) (figure 4a).

EM and laboratory measurements were also compared with groundwater values that are recently opened by DSI (State Hydraulic Works) in the 4th Stage (Figure 4b) (Donma et al. 2004) as well as the values of Dinç et al. (1990) and Ozcan et al (1996).

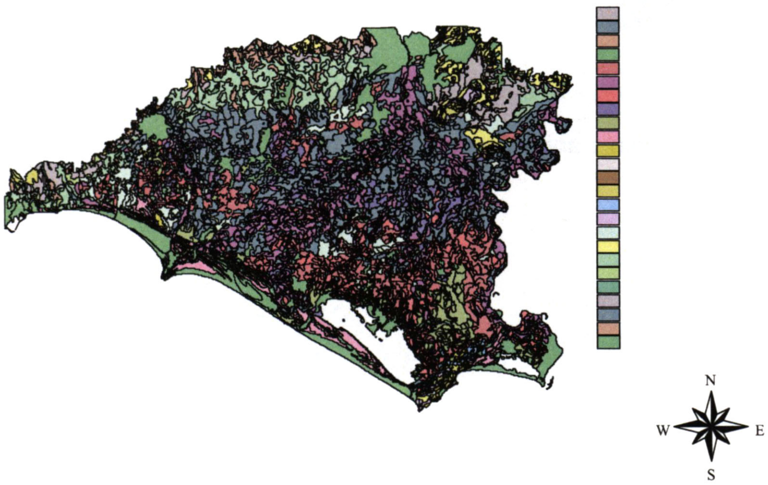

Figure 4a. Soil series of the LSIP (Dinç et al. 1990) for legend see Table 1)

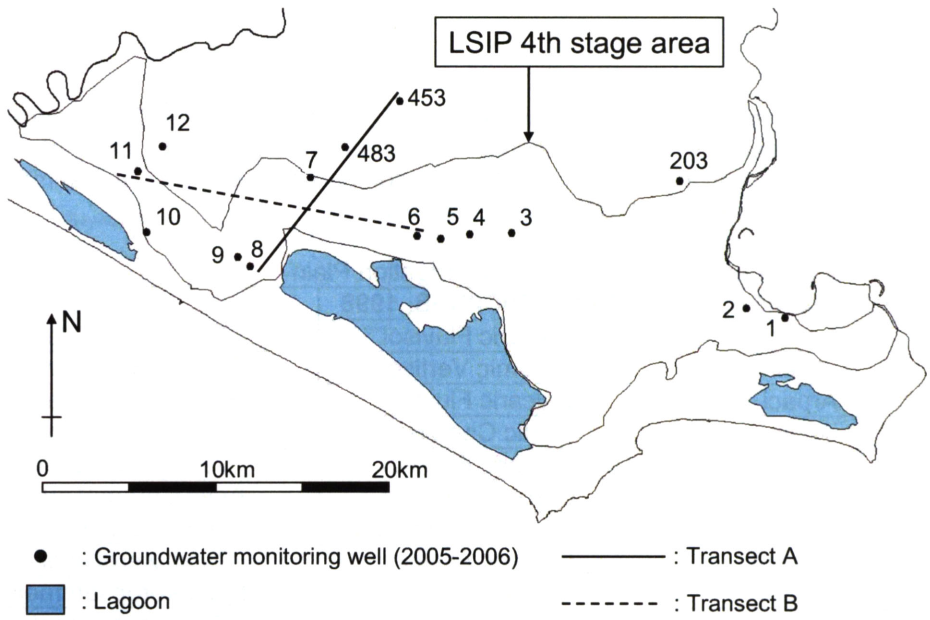

Figure 4b. Ground water wells in the study area

3. RESULTS

The EM measurements undertaken at 50 points on several series and various land managements (Table 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and Figure 5, 6) revealed that ECv values above 200mS/m significantly hinder plant growth (Figure 6). ECv values are decreasing with distance from Akyatan lagoon and saline wetlands (primary saline lands) (Figure 7, 8, 9).

Wheat, maize, and other crops were cultivated on suitable land ie the slightly saline parts of the delta were allocated for these crops, whereas some cotton fields were located on saline soils adjacent to the bare lands near the lagoon and are affected by severe soil salinity despite the attempts to properly manage the land and with new irrigation projects (Figure 10).

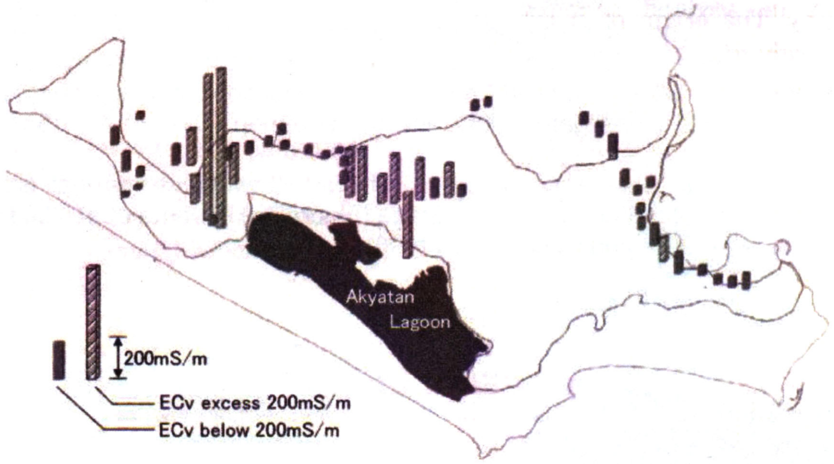

Figure 5. Location of measurements points and ECv values

Figure 6. Soil sampling and EM measurements

Figure 7. Saline land and tomato plantation

Figure 8. The Akyatan Lagoon

Table 2. June, 2005 EM Measurement, Land Use and Elevation of the Points

No	x	y	ECv (mS/m)	ECh (mS/m)	Land use	Elevation (m) (SRTM)	(m) (ICCAPdem)
1	723764	4057923	58	33	wheat (burning)	2	4.52
2	724766	4057343	103	65	bare land	3	0
3	725711	4057137	110	66	Ploughed	4	0
4	726597	4057080	128	102	cotton	4	0
5	722255	4058087	191	135	cotton	5	16.1
6	721257	4058844	171	126	Ploughed	4	27.5
7	720290	4059846	226	166	cotton	3	39.9
8	719814	4060967	89	65	S.C. maize	6	49.1
9	719731	4061924	64	49	Ploughed	6	48.3
10	720062	4063593	82	63	wheat (burning)	5	46.2
11	719247	4063065	55	28	wheat (burning)	6	43.8
12	718732	4063687	193	121	wheat (burning)	4	39.8
13	717971	4065390	91	62	wheat (burning)	3	33
14	717673	4065889	63	40	wheat (burning)	5	30.7
15	717057	4066820	61	37	cotton	5	26.6
16	716065	4067596	120	76	wheat (burning)	4	25.2
17	709756	4068764	41	27	wheat	6	16.5
18	708919	4068488	71	58	water melon	7	15.7
19	708046	4062978	93	64	wheat	3	6.1
20	707224	4062911	275	184	cotton	2	5.7
21	706332	4062852	115	64	bare - wheat	5	4.8
22	705373	4062788	254	172	cotton	4	4.4
23	704113	4062484	546	480	cotton	4	3.2
24	703632	4062574	423	307	cotton	1	2.9
25	702932	4062570	277	192	wheat	3	2.7
26	701463	4062719	455	327	bare land	2	2.2
27	700862	4062940	441	329	cotton	1	2.4
28	700480	4064108	89	49	wheat	3	3.8
29	700515	4065108	111	69	tomato	3	5.6
30	700164	4065757	24	15	wheat	4	6.7
31	699256	4065390	104	86	tomato	4	5.5
32	698174	4065664	87	53	bare-water melon-tomato	5	5.9
33	696034	4066139	79	51	wheat-water melon	2	5.2
34	696680	4065963	53	33	wheat (burning)	3	4.8
35	695623	4066168	88	64	S.C. maize-tomato	2	5.2
36	694364	4065680	97	68	wheat (burning)- maize-maize	2	4.9
37	693016	4065263	136	123	tomato	2	4
38	691936	4063794	225	170	bare-graze-water melon	2	1.7
39	691710	4062911	173	98	wheat	2	0.5
40	691777	4061513	712	648	wetland-wheat	1	0
41	692571	4060968	1544	1542	wetland	0	0
42	692070	4061121	96	62	Maize	1	0
43	690715	4065008	428	388	sweet melon	1	3.3
44	689670	4065013	175	107	tomato	1	3.2
45	687378	4064265	69	72	citrus	3	1.8
46	686411	4062949	68	68	wheat	0	0
47	686626	4064096	50	23	penut	4	1.3
48	686471	4064617	224	177	wheat	2	2
49	685762	4066305	179	119	tomato	3	4.5
50	687377	4067922	72	56	eggplant	5	7.3

Table 3. July, 2005 EM Measurement, Land Use and Soil Series

No	Ave. ECv (mS/m)	Ave. ECh (mS/m)	Soil series (Table 1)	Land use
1	83	14	5	ash-bare
2	59	7	5	melon
3	109	42	5	cotton
4	80	27	5	maize
5	NA	NA	4	NA
6	227	118	4	cotton
7	244	148	4	cotton
8	105	46	5	maize
9	74	22	5	maize
10	112	51	4	maize
11	57	7	5	ploughed
12	249	109	4	maize
13	378	245	8	cotton
14	150	77	4	maize
15	160	105	8	maize
16	105	58	8	bare - natural
17	83	29	5	maize
18	79	24	1	maize
19	60	8	6	bare
20	297	174	4	cotton
21	137	54	6	bareland
22	467	355	4	cotton
23	595	455	4	bareland
24	552	382	4	cotton
25	338	213	4	cotton
26	486	278	4	bare -natural
27	536	368	4	cotton
28	79	16	8	ploughed
29	106	28	6	tomato
30	45	0	4	ploughed
31	65	8	4	Ploughed
32	72	44	4	melon
33	76	14	4	ploughed
34	118	95	4	maize
35	68	11	5	ploughed
36	84	50	6	maize
37	129	45	5	maize
38	520	346	30	bare - natural
39	239	126	4	ash-bare
40	1457	1346	5	bare - natural
41	1564	1661	8	bare - natural
42	95	40	1	maize
43	398	256	4	maize
44	184	73	1	tomato
45	94	49	5	citrus
46	61	0	9	bare
47	64	4	30	peanut
48	203	96	5	tomato
49	194	79	4	tomato
50	65	10	1	egg plant

Table 4. August, 2005 EM Measurement and Land Use

No	Ave. ECv (mS/m)	Ave. ECh (mS/m)	Land Use
1	78	39	bare
2	73	54	cotton
3	86	47	cotton
4	183	118	cotton
5	N/A	N/A	
6	269	219	maize
7	144	87	cotton
8	105	63	maize
9	95	65	cotton/maize
10	86	53	maize
11	103	84	maize
12	54	20	maize
13	254	162	cotton
14	178	131	maize
15	139	97	maize
16	51	25	cotton
17	93	50	soybean
18	102	61	maize
19	121	77	cotton
20	269	173	cotton
21	164	104	bare
22	431	299	cotton
23	682	608	cotton
24	414	293	bare
25	252	217	maize
26	479	290	natural veg
27	443	309	cotton
28	137	91	bare
29	66	28	bare
30	38	14	bare
31	26	4	bare
32	71	39	bare
33	88	44	bare
34	54	20	bare
35	59	27	bare
36	132	96	bare
37	66	27	bare
38	320	362	bare
39	342	267	bare
40	1479	1495	natural veg
41	1565	1579	natural
42	77	49	maize
43	280	187	bare
44	184	94	bare
45	61	53	citrus
46	32	13	bare
47	32	12	bare
48	137	77	bare
49	135	75	bare
50	49	28	egg plant

Table 5. September, 2005 EM Measurement and Land Use

No	Ave. ECv (mS/m)	Ave. ECh (mS/m)	Land Use
1	87	43.2	ploughed
2	111.4	60.8	cotton
3	71.4	31.8	cotton
4	89	49	cotton
5	NA	NA	
6	170.2	112.6	corn/cotton
7	NA	NA	
8	NA	NA	
9	88.4	58.8	corn/cotton
10	58.6	35.4	maize
11	82	43.6	maize
12	57.2	16.2	ploughed
13	185.6	96.8	cotton
14	190.8	135.8	maize
15	139.8	96	maize
16	103	53	bareland
17	59.8	32.8	soybean
18	53.6	22.2	ploughed
19	73	34	cotton
20	369.8	273.8	cotton
21	170	98.8	bareland
22	325.8	198.6	cotton
23	540	369.2	cotton
24	346.2	235.4	maize
25	171.2	84.2	cotton
26	414.8	240.4	natural
27	341.6	203.8	cotton
28	88.4	48.6	bareland
29	67.6	25.6	bareland
30	46	17.8	bareland
31	27.6	2.2	bareland
32	50.4	21	bareland
33	85.2	35.6	bareland
34	55.8	18	bareland
35	97.2	61.4	ploughed
36	80.2	29.8	bareland
37	63.8	26.4	bareland
38	408.6	331.4	bareland
39	253	175.8	bareland
40	1353.6	1136	natural
41	935.6	960.2	natural
42	81.8	42.8	bareland
43	232	118.4	ploughed
44	183.8	94.2	ploughed
45	NA	NA	citrus
46	31.2	2.4	bareland
47	24.2	6	bareland
48	99.4	47.8	ploughed
49	100	42.4	ploughed
50	72.2	36.8	ploughed

Table 6. October, 2005 EM Measurement and Land Use

No	Ave. ECv (mS/m)	Ave. ECh (mS/m)	Land Use
1	113	67	Cultivated
2	80	41	cotton
3	49	19	harvested cotton
4	60	32	cotton
5	160	102	Corn harvested
6	214	155	corn/cotton harvested
7	168	112	cotton ploughed
8	74	43	Corn-2nd crop
9	54	32	corn/cotton
10	75	49	Corn harvested
11	62	31	ploughed
12	138	90	ploughed
13	120	82	burned maize stubble
14	88	52	Corn harvested
15	168	111	maize
16	76	59	Corn-2nd crop
17	51	35	ploughed
18	64	40	ploughed
19	85	45	cotton ploughed
20	287	210	cotton
21	135	83	ploughed wheat
22	157	89	cotton ploughed
23	307	189	cotton ploughed
24	440	289	maize
25	206	127	cotton ploughed
26	379	229	natural
27	290	171	cotton ploughed
28	126	91	bareland
29	58	21	tomato ploughed
30	27	21	ploughed
31	19	14	bareland
32	47	35	bareland
33	94	67	ploughed
34	44	32	ploughed
35	53	39	ploughed
36	86	71	ploughed
37	69	38	ploughed
38	276	244	natural
39	268	224	ploughed
40	1352	1304	natural
41	1565	1533	natural
42	84	60	corn ploughed
43	242	153	ploughed
44	149	91	ploughed
45	97	67	citrus
46	27	19	ploughed
47	26	21	bareland
48	155	124	bareland
49	84	48	ploughed
50	51	49	eggplant

Table 7. November, 2005 EM Measurement and Land Use

No	Ave. ECv (mS/m)	Ave. ECh (mS/m)	Land Use
1	130	100	Ploughed
2	94	64	Winter Wheat
3	75	40	Winter Wheat
4	119	84	Ploughed
5	182	144	Ploughed
6	208	146	Harvested Maize
7	193	140	Soughed
8	81	54	Harvested Maize
9	52	42	Harvested Maize
10	70	58	Harvested Maize
11	59	37	Soughed
12	161	117	Harvested Maize
13	133	111	Harvested Maize
14	107	82	Harvested Maize
15	65	48	Cotton Harvested
16	148	112	Winter Wheat
17	51	39	Bare
18	79	68	Winter Wheat
19	78	65	Winter Wheat
20	302	239	Soughed
21	278	217	Winter Wheat
22	239	184	Winter Wheat
23	448	318	Ploughed
24	444	350	Ploughed
25	174	147	Ploughed
26	495	370	Natural Vegetation
27	425	335	Cotton Harvested
28	129	114	Onion
29	94	87	Ploughed
30	47	52	Ploughed
31	78	69	Winter Wheat
32	90	87	Ploughed
33	99	49	Ploughed
34	80	55	Ploughed
35	97	53	Winter Wheat
36	67	75	Ploughed
37	204	144	Wetland
38	265	286	Winter Wheat
39	146	118	Natural Vegetation
40	1299	1216	Wetland
41	1452	1442	Wetland
42	76	45	Winter Wheat
43	281	176	Ploughed
44	125	61	Ploughed
45	101	101	Citrus
46	21	70	Ground Nut
47	0	0	Harvested Maize
48	184	131	Ploughed
49	138	98	Ploughed
50	32	44	Ploughed

Table 8. February, 2006 EM Measurement and Land Use

No	Ave. ECv (mS/m)	Ave. ECh (mS/m)	Land Use
1	119	50	Wheat
2	120	40	Wheat
3	135	47	Ploughed
4	144	56	Ploughed
5	224	143	Wheat
6	NA	NA	Wheat
7	194	98	Cotton Ploughed
8	114	40	Corn Ploughed
9	155	72	Wheat
10	80	17	Wheat
11	98	35	Wheat
12	25	9	Corn Ploughed
13	145	68	Corn Ploughed
14	115	44	Corn Ploughed
15	81	18	Cotton Ploughed
16	183	109	Wheat
17	67	6	Soy Bean Ploughed
18	93	37	Wheat
19	120	39	Wheat
20	265	162	Wheat
21	275	159	Ploughed
22	283	156	Wheat
23	388	254	Ploughed
24	437	287	Ploughed
25	227	117	Ploughed
26	385	236	Natural
27	496	380	Wheat
28	114	51	Onion
29	139	49	Ploughed
30	72	18	Ploughed
31	110	41	Onion
32	92	36	Ploughed
33	109	44	Wheat
34	86	17	Ploughed
35	81	19	Ploughed
36	104	34	Wheat
37	188	87	Ploughed
38	327	247	Natural
39	134	54	Wheat
40	1141	980	Natural
41	1369	1317	Natural
42	95	30	Wheat
43	305	172	Ploughed
44	136	50	Ploughed
45	96	32	Citrus
46	69	9	Ploughed
47	26	0	Ploughed
48	157	70	Ploughed
49	194	81	Ploughed
50	71	12	Wheat

Table 9. April, 2006 EM Measurement and Land Use

No	Ave. ECv (mS/m)	Ave. ECh (mS/m)	Land Use
1	135	88	wheat
2	113	62	Wheat
3	82	57	Onion
4	137	83	Ploughed
5	141	89	Ploughed
6	169	125	Ploughed
7	174	137	Ploughed
8	205	145	Ploughed
9	122	85	Wheat
10	45	32	Wheat
11	60	54	Wheat
12	71	47	Ploughed
13	133	106	Ploughed
14	104	79	Ploughed
15	71	47	Ploughed
16	108	85	Wheat
17	50	34	Low Tunnel/Vegetable
18	47	36	Wheat
19	50	27	Wheat
20	181	115	Wheat
21	184	125	Ploughed
22	183	131	Ploughed
23	445	332	Ploughed
24	463	362	Ploughed
25	273	192	Ploughed
26	496	390	Natural
27	440	327	Wheat
28	80	52	Onion
29	89	61	Tomatoes
30	58	37	Ploughed
31	96	67	Onion
32	87	84	Water Melon
33	142	108	Water Melon
34	77	52	Melon
35	83	75	Water Melon
36	57	35	Wheat
37	224	188	Ploughed
38	245	175	Natural
39	117	92	Wheat
40	1345	1465	Natural
41	1612	1715	Natural
42	65	42	Wheat
43	231	147	Ploughed
44	204	130	Ploughed
45	66	48	
46	48	30	Ploughed
47	33	25	Water Melon
48	134	88	Water Melon
49	145	84	Water Melon
50	38	27	Tomatoes

Table 10. August, 2006 EM Measurement and Land Use

No	Ave. ECv (mS/m)	Ave. ECh (mS/m)	Land Use
1	142	95	bare
2	138	92	cotton
3	115	55	cotton
4	138	122	cotton
5	NA	NA	
6	138	119	cotton
7	240	154	cotton
8	95	82	soybean
9	68	44	maize
10	58	34	cotton
11	104	57	cotton
12	185	121	maize
13	172	1138	maize
14	81	42	ploughed
15	64	34	maize
16	110	66	Wheat/burned
17	57	45	cotton
18	96	77	maize
19	89	56	cotton
20	299	222	cotton
21	376	287	ploughed
22	286	172	ploughed
23	560	489	cotton
24	486	420	cotton
25	312	257	maize
26	463	309	natural veg
27	488	333	cotton
28	94	51	Water melon
29	120	70	ploughed
30	75	69	ploughed
31	123	120	cotton
32	144	108	ploughed
33	80	42	ploughed
34	64	34	Water melon
35	78	70	Winter Maize
36	85	51	ploughed
37	219	140	Tomatoes
38	285	198	ploughed
39	84	41	Deeply ploughed
40	1354	1137	natural veg
41	1520	1251	natural
42	75	35	Deeply ploughed
43	319	185	ploughed
44	240	154	cotton
45	NA	NA	citrus
46	59	37	bare
47	NA	NA	Water melon
48	232	140	cotton
49	196	144	cotton
50	61	45	ploughed

Table 11. October, 2006 EM Mmeasurement and Land Use

No	Ave. ECv (mS/m)	Ave. ECh (mS/m)	Land Use
1			wheat
2	145	153	cotton
3	75	45	cotton
4	62	29	cotton
5	NA	NA	
6	220	158	cotton
7	148	101	cotton
8	146	133	Ploughed
9	65	43	Ploughed
10	47	55	maize
11	78	66	Ploughed
12	60	36	Ploughed
13	96	66	Ploughed
14	56	33	Ploughed
15	38	16	cotton
16	230	135	Ploughed
17	62	52	Low Tunnel/Vegetable
18	69	50	maize
19	56	31	cotton
20	278	210	cotton
21	215	132	Ploughed
22	235	155	Ploughed
23	512	406	cotton
24	534	432	Ploughed
25	235	139	cotton
26	524	380	Natural
27	490	357	cotton
28	58	38	cotton
29	40	15	Ploughed
30	40	26	Ploughed
31	73	42	cotton
32	62	34	Ploughed
33	52	25	Ploughed
34	60	30	Ploughed
35	60	32	Ploughed
36	74	45	Ploughed
37	130	93	Ploughed
38	310	238	Natural
39	60	31	Ploughed
40	234	144	Ploughed
41	1412	1387	Natural
42	1539	1488	Natural
43	92	43	Ploughed
44	121	64	cotton
45	NA	NA	
46	36	20	Ploughed
47	NA	NA	Ploughed
48	106	155	Ploughed
49	86	52	Ploughed
50	48	45	Ploughed

Table 12. November, 2006 EM Measurement and Land Use

No	Ave. ECv (mS/m)	Ave. ECh (mS/m)	Land use
1	110	98	wheat
2	124	85	wheat
3	75	45	wheat
4	105	77	wheat
5	NA	NA	Ploughed
6	210	147	wheat
7	177	152	wheat
8	112	125	Ploughed
9	58	43	Ploughed
10	77	62	maize
11	69	44	wheat
12	141	100	wheat
13	121	88	wheat
14	56	33	wheat
15	55	37	Ploughed
16	125	87	Ploughed
17	44	28	Low Tunnel/Vegetable
18	65	47	maize
19	56	31	cotton
20	278	210	cotton
21	215	132	Ploughed
22	235	155	Ploughed
23	512	406	cotton
24	534	432	Ploughed
25	235	139	cotton
26	524	380	Natural
27	490	357	cotton
28	58	38	cotton
29	40	15	Ploughed
30	40	26	Ploughed
31	73	42	cotton
32	62	34	Ploughed
33	52	25	Ploughed
34	60	30	Ploughed
35	60	32	Ploughed
36	74	45	Ploughed
37	130	93	Ploughed
38	310	238	Natural
39	60	31	Ploughed
40	234	144	Ploughed
41	1412	1387	Natural
42	1539	1488	Natural
43	92	43	Ploughed
44	121	64	cotton
45	NA	NA	Citrus
46	36	20	Ploughed
47	NA	NA	Ploughed
48	106	155	Ploughed
49	86	52	Ploughed
50	48	45	Ploughed


Figure 9. The wetlands


Figure 10. New irrigation network in Area 4 of the LSIP

Fluctuations of the ECv values at sites below 200mS/m closely related to irrigation and precipitation, thus values in rainy seasons are generally lower than the values of dry periods (Tables 2-11).

Soil salinization occurs in Area 4 due to the high groundwater depth and its high EC. LANDSAT images revealed that salt-affected fields in the LSIP area decreased almost 50% from 1990 (30.3%) to 2005 (17.8%) (Figure 11), most probably due to the development of irrigation and drainage facilities. The groundwater EC showed a linear relationship, that is, a similar pattern, from 1977 to 2005-2006 (Fig.9). Therefore, the distribution pattern of groundwater EC in 2005–2006 was similar to that in 1977. Finally, a comparison of the distributions showed that salt-affected fields corresponded to high groundwater EC areas (Figure 12).

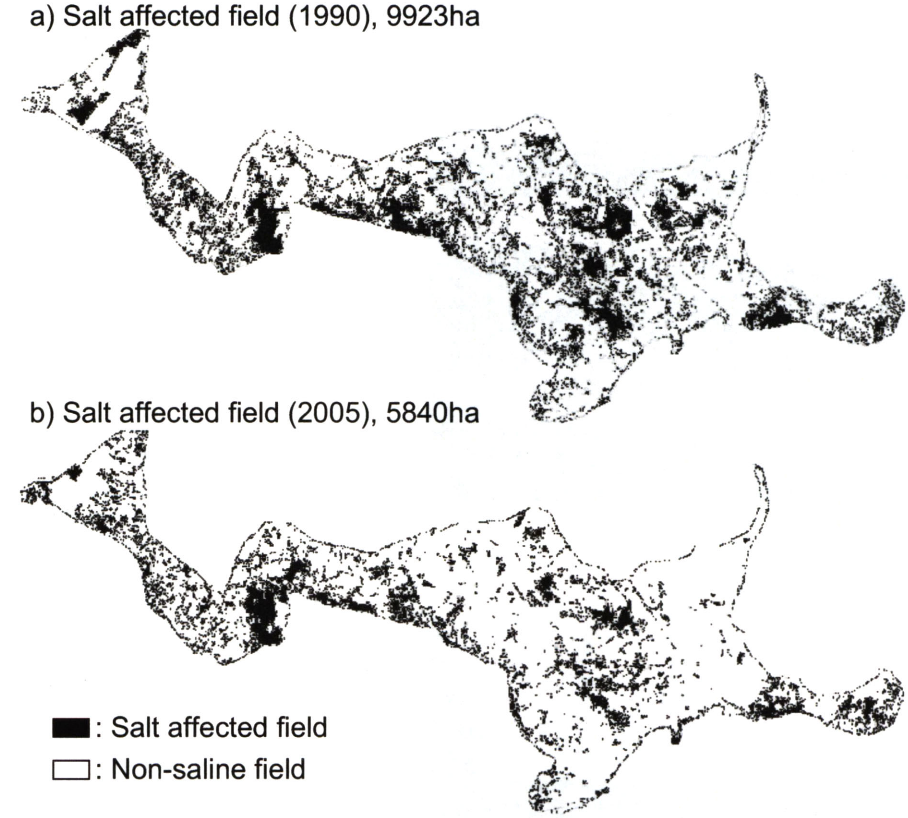

Figure 11. Distribution of salt-affected fields in Area 4 in a)1990, b)2005

Figure 12. Distribution of the groundwater EC in Area 4 in 1977

Salt-affected fields corresponded to the area of high groundwater EC in area 4.

The total area of salt-affected fields was reduced by half from 1990 to 2005, although it was still about 6,000 ha. Based on the EC, Na+, and SAR of the groundwater environment, we postulated that sodium accumulates on soil particles in the salt-affected fields.

This study showed that irrigation water use upstream in the LSIP affects the fluctuation of groundwater depth downstream in the LSIP, which is Area 4. Excess irrigation water use upstream reduces the groundwater depth downstream. Some fields in Area 4 are below sea level and those areas were waterlogged, with insufficient drainage facilities. Therefore, irrigation water use in areas 1-3 in summer causes deterioration in the groundwater environment in Area 4, and most probably induces soil salinization.

4. CONCLUSIONS

1. The annual precipitation (ca 700 mm/year) may leach improve salinity conditions by itself provided sufficient drainage is present.

2. Uncontrolled irrigation practices which may soon begin can increase salinity with C2S1 quality water containing 0.45-0.50 dS/m salinity (DSİ, 1979). Thus applying 1000mm irrigation water in the area leaves 3 ton/ha/year salt on the soil. This may be another way for increased salinisation under poor drainage conditions allowing insufficient percolation and drainage discharge.

3. High saline groundwater, soil and topographic conditions are more effective than the effects of the sea and the Akyatan Lagoon for salinity development.

4. Absence and/or lack of well maintained drainage networks are the main cause of developing salinity as elsewhere.

5. Primary salinization levels of wetlands did not show a significant fluctuation during seasonal changes but somewhat higher in dry seasons.

6. Land use practices (mostly corn-wheat-cotton rotation) slightly affect the fluctuation levels of salinisation.

7. A comprehensive evaluation salinity risk is needed to identify the specific factors of salinisation of the area regarding land use, soil types, irrigation/drainage facilities and microtopography.

5. References

Dinç, U.,_M. Sari, S. Şenol, M. Sayin, M.R. Derici, V.S. Çavuşgil, M. Gök, H. Ekinci, N. Ağca, E. Schlicting, 1990. Soils of the Çukurova Region. University of Çukurova. Pub. Pub. No. 26, Adana, Turkey (in Turkish).

Donma, S., Nagano T., and Watanabe, T., 2004. Irrigation system and improvement in the Lower Seyhan Plain, The interim report of ICCAP, ICCAP pub.3

Kume, T., Akça, E., Nagano, T., Donma, S., Serdem, M., Kapur, S., and Watanabe, T. 2006. An analysis of spatial variability of soil salinity in an irrigated area-southern Turkey, Water and Land Management for Sustainable Irrigated Agriculture, (CD-ROM).

McNeil, J.D. Electromagnetic terrain conductivitymeasurement at low induction numbers, Mississauga, Ontario, Canada, Geonics Ltd. Technical Note TN-6.

Mehanni, A.H. 1988. The Influence of Depth and Salinity of Watertables on the Salt Levels in the Duplex Red-Brown Earths of Goulburn Valley of Victoria. Australian-Journal of Experimental-Agriculture. V. 28(5), p.593-597. Australia.

Özcan, H.; Çetin, M. 1996. Land Degradation Induced By High Groundwater Level and Soil Salinity In The IV. Stage Project Area of Yüreğir Plain: A Case Study. (S. Kapur, E. Akça, A.R. Mermut, A.D. Öcal, H.ç Eswaran) ST International Conference on Land Degradation. Proceedings, p. 93-99, 10-14 June, Adana, Turkey.

Özcan, H. and Çetin, M. 1998. The Relationship Between Groundwater and Soil Salinity in the Eastren Mediterranean Coastal Region, Turkey. Şefik Yeşilsoy International Symposium on Arid Region Soils. 21-23 September, Izmir-Turkey.

Özcan, H., Akça, E., Kapur, S. and Dinç, O. 2000. National Soil Science Society. Proceedings of International Symposium on Desertification.13-17 June Konya.

Smedema, L.K.; Rycroft, D.W. 1983. Land Drainage. Batsford Academic and Educational Ltd. London. 376 pp.

Yüzgeç, A. 1985. Formation and Distribution and Properties of Saline and Alkaline Soils of the Çukurova Region. Univ. of Cukurova, M. Sc. Thesis. Adana.