

Supplementary Material

Environmental and Stress Analysis of Wild Plant Habitat in River Nile Region of Dakahlia Governorate on Basis of Geospatial Techniques

Yasser A. El-Amier^{1,*}, Ahmed El-Zeiny^{*,2}, El-Sayed F. El-Halawany¹, Ashraf Elsayed¹, Mohamed A. El-Esawi^{3,*}, Ahmed NourEldeen⁴, Hadeer Darwish⁵, Amal Al-Barty⁴, and Shrouk A. Elagami¹

¹ Botany Department, Faculty of Science, Mansoura University, Mansoura 35516, Egypt; yasran@mans.edu.eg (Y.A.E.); drelhalawany@mans.edu.eg (E.F.E); ashraf-badawy@mans.edu.eg (A.E.); Shrouk_Elagami@outlook.com (S.A.E.)

² Environmental Studies Department, National Authority for Remote Sensing and Space Sciences (NARSS), Cairo 11769, Egypt, aelzeny@narss.sci.eg (A.E.-Z.)

³ Botany Department, Faculty of Science, Tanta University, Tanta 31527, Egypt; mohamed.elesawi@science.tanta.edu.eg (M.A.E.-E.)

⁴ Department of Biology, College of Sciences, Taif University, P.O. Box 11099, Taif 21944, Saudi Arabia; a.nourEldeen@tu.edu.sa (A.N.); aalbarty@tu.edu.sa (A.A.)

⁵ Department of Biotechnology, College of Sciences, Taif University, P.O. Box 11099, Taif 21944, Saudi Arabia; hadeer@tu.edu.sa (H.D.)

* Correspondence: yasran@mans.edu.eg (Y.A.E.); aelzeny@narss.sci.eg (A.E.Z.); mohamed.elesawi@science.tanta.edu.eg (M.A.E.-E.); Tel.: +20-1017229120 (Y.A.E.)

Supplementary Materials

Table S1. Coordinates and description of sampling sites along River Nile Damietta branch, Dakahlia Governorate

Location name	Sites	Coordinate system		Different activities nearby sampling locations from LU/LC analysis
		E	N	
Mansoura City (n=9)	1	31.0688	31.4058	Fertilization factory, Urbina activities and agriculture land
	2	31.0881	31.4203	Agricultural lands and grazing animals
	3	31.1147	31.4306	Agricultural land, and residential area (El-tawella village)
	4	31.1197	31.4320	Agricultural lands
	5	31.1526	31.4497	Agricultural lands
	6	31.1673	31.4714	Orchids
	12	31.0453	31.3483	Residential area (Met-khames village)
	13	31.0458	31.3439	Agricultural lands and residential area (Met-khames village)
	14	31.0147	31.3143	Residential area (Awish Elhagar village) and abandoned area as well as the brick factory
Sherbin City (n=5)	7	31.1649	31.4975	Orchids
	8	31.1891	31.5113	Residential areas (Zarka City) and wastewater from Kafr Eldabosy drain
	9	31.1792	31.5450	Agricultural lands, and island in the Nile which is mostly not inhabited
	10	31.1844	31.5311	Near the border of Sherbin City
	11	31.1985	31.6147	The residential area of the island and sewage treatment station (Meet Elkholy village)
Aga City (n=6)	15	30.9803	31.2859	Residential areas (Sanbakht village) and agricultural lands
	16	30.9589	31.2444	Residential areas (Sammanoud City) and Urbina activities
	17	30.9254	31.2618	Residential areas (Met Abu-Elharis village) and wastewater from Deris drain
	18	30.8949	31.2343	Agricultural lands
	19	30.8420	31.2462	Residential areas (Kafr Elmandra village)
	20	30.7997	31.2305	Residential areas (Met Ashna village) and fish farms
Met-Ghamr City (n=4)	21	30.7405	31.2465	Residential areas (Met-Ghamr City) and Urbina activities
	22	30.6960	31.2673	Residential areas (Met-Ghamr City)
	23	30.6656	31.2770	Residential areas (Kafr Elnaeem village)
	24	30.6203	31.2646	Agricultural lands

Table S2. Various spectral indices and classes formulas used in the present study.

Index	Formula	Classes (ranges)	References
Normalized Difference Vegetation Index (NDVI)	$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$	-1-0.25 No vegetation	[39]
		0.25-0.5 Sparse vegetation	
		0.5-0.75 Moderate vegetation	
		0.75-1 Dense vegetation	
Normalized difference salinity index (NDSI)	$NDSI = \frac{(Red - NIR)}{(Red + NIR)}$	-1-0 Non saline	
		0-0.25 Slightly saline	
		0.25-0.5 Moderately saline	
		0.5-1 Highly saline	
Normalized difference moisture index (NDMI)	$NDMI = \frac{(NIR - SWIR)}{(NIR + SWIR)}$	NDMI > 0.1 high humidity	
		NDMI < -1) low humidity	

Table S3. Enumerated list of plant species along River Nile, Damietta branch (Dakahlia Governorate), together with their families, growth forms, chorotypes, and presence value (P %). Life forms: Th: Therophytes, G: Geophytes, Hy: Hydrophyte, H: Hemicryptophytes, Ch: Chamaephytes, He: Helophytes, Nph: Nanophanerophytes; Chorotypes: COSM: Cosmopolitan, PAL: Palaeotropical, PAN: Pantropical, NEO: Neotropical, ME: Mediterranean, SA: Saharo-Arabian, SZ: Sudano-Zambezian, ES: Euro-Siberian, IT: Irano-Turanian, Cult. & Nat.: Naturalized & Cultivated.

Species	Family	Duration	Life form	Floristic category	P%
a) Hydrophytes					
1. Submerged hydrophytes					
<i>Ceratophyllum demersum</i> L.	Ceratophyllaceae	Perennial	Hy	COSM	95.83
<i>Myriophyllum spicatum</i> L.	Haloragaceae	Perennial	Hy	ME+ES+IT	87.50
2. Floating hydrophytes					
<i>Eichhornia crassipes</i> (C.Mart.) Solms.	Pontederiaceae	Perennial	Hy	NEO	70.83
<i>Ludwigia stolonifera</i> (Guill. et Perr.) Raven	Onagraceae	Perennial	He	SZ	16.67
<i>Lemna gibba</i> L.	Araceae	Perennial	Hy	COSM	12.50
<i>Lemna minor</i> L.	Araceae	Perennial	Hy	COSM	12.50
<i>Pistia stratiotes</i> L.	Araceae	Perennial	Hy	PAN	20.83
<i>Potamogeton nodosus</i> Poir.	Potamogetonaceae	Perennial	Hy	ME+IT	20.83
3. Emergent species					
<i>Alternanthera sessilis</i> (L.) DC.	Amaranthaceae	Perennial	He	PAN	37.50
<i>Cyperus alopecuroides</i> Rottb.	Cyperaceae	Perennial	He	PAN	50.0
<i>Cyperus articulatus</i> L.	Cyperaceae	Perennial	G, He	PAN	20.83
<i>Cyperus difformis</i> L.	Cyperaceae	Annual	Th	PAL	4.17
<i>Cyperus papyrus</i> L.	Cyperaceae	Perennial	G, He	PAL	4.17
<i>Echinochloa crus-galli</i> (L.) Beauv	Poaceae	Annual	Th	PAN	4.17
<i>Echinochloa stagnina</i> (Retz.) P. Beauv.	Poaceae	Perennial	G, He	PAL	75.0
<i>Leersia hexandra</i> Sw.	Poaceae	Perennial	He	PAN	8.33
<i>Persicaria lapathifolia</i> Willd.	Polygonaceae	Perennial	G	PAL	45.83
<i>Persicaria salicifolia</i> Brouss. ex Willd.	Polygonaceae	Perennial	G	PAL	70.83
<i>Ranunculus sceleratus</i> L.	Ranunculaceae	Annual	Th	ME+IT+ES	12.50
<i>Saccharum spontaneum</i> L. Mant. Alt	Poaceae	Perennial	G, He	ME+PAL	66.67
<i>Typha domingensis</i> (Pers.) Poir. ex Steud	Typhaceae	Perennial	He	PAN	16.67
b) Terrestrial species					
<i>Alhagi graecorum</i> Boiss.	Fabaceae	Perennial	H	PAL	12.50
<i>Amaranthus graecizans</i> L.	Amaranthaceae	Annual	Th	ME+IT	4.17
<i>Amaranthus lividus</i> L.	Amaranthaceae	Annual	Th	ME+IT	12.50
<i>Amaranthus viridis</i> L.	Amaranthaceae	Annual	Th	ME	20.83
<i>Arundo donax</i> L.	Poaceae	Perennial	G, He	Cult. & Nat.	29.17
<i>Symphotrichum squamatum</i> (Asch.) Dandy	Asteraceae	Perennial	Ch	NEO	4.17
<i>Beta vulgaris</i> L. var. <i>cicla</i>	Chenopodiaceae	Annual	Th	ME+IT+ES	4.17
<i>Bidens pilosa</i> L.	Asteraceae	Annual	Th	PAN	12.50
<i>Capsella bursa-pastoris</i> (L.) Medic	Brassicaceae	Annual	Th.	COSM	4.17
<i>Chenopodium album</i> L.	Chenopodiaceae	Annual	Th	COSM	12.50
<i>Chenopodium ficifolium</i> Sm.	Amaranthaceae	Annual	Th	ME+ES	4.17
<i>Chenopodium murale</i> L.	Amaranthaceae	Annual	Th	COSM	45.83
<i>Convolvulus arvensis</i> L.	Convolvulaceae	Perennial	H	COSM	20.83
<i>Conyza bonariensis</i> (L.) Cronquist	Asteraceae	Annual	Th	NEO	4.17
<i>Cynanchum acutum</i> L.	Asclepiadaceae	Perennial	H	ME+IT	8.33
<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	Perennial	G.	PAN	25
<i>Cyperus rotundus</i> L.	Cyperaceae	Perennial	G	PAN	12.50
<i>Eclipta prostrata</i> L.	Asteraceae	Annual	Th	NEO	20.83
<i>Ethulia conyzoides</i> L.	Asteraceae	Annual	Th	PAL	8.33
<i>Euphorbia peplus</i> L.	Euphorbiaceae	Annual	Th	ME+IT+ES	4.17
<i>Euphorbia terracina</i> L.	Euphorbiaceae	Perennial	H	ME	4.17
<i>Imperata cylindrical</i> (L.) Raeusch.	Poaceae	Perennial	H	PAL	4.17
<i>Ipomoea carnea</i> Jacq.	Convolvulaceae	Perennial	G	PAN	25
<i>Lamium amplexicaule</i> L.	Lamiaceae	Annual	Th	ME+IT+ES	4.17
<i>Malva parviflora</i> L.	Malvaceae	Annual	Th	ME+IT	4.17
<i>Panicum repens</i> L.	Poaceae	Perennial	G	PAN	8.33
<i>Pennisetum setaceum</i> (L.) R.Br.	Poaceae	Perennial	H	ME+PAL	4.17

<i>Phragmites australis</i> (Cav.) Trin. ex Steud	Poaceae	Perennial	G, He	COSM	75
<i>Phyla nodiflora</i> (L.) Greene	Verbenaceae	Perennial	Ch	PAN	12.50
<i>Pluchea dioscoridis</i> (L.) DC.	Asteraceae	Perennial	Nph	SZ+SA	37.50
<i>Poa annua</i> L.	Poaceae	Annual	Th	COSM	4.17
<i>Portulaca oleracea</i> L.	Portulacaceae	Annual	Th	COSM	25.0
<i>Pseudognaphalium luteoalbum</i> (L.) Hilliard & B.L.Burt,	Asteraceae	Annual	Th	COSM	8.33
<i>Ricinus communis</i> L.	Euphorbiaceae	Perennial	Nph	Cult. & Nat.	4.17
<i>Rorippa palustris</i> (L.) Besser	Brassicaceae	Biennial	Th	ME+ES+IT	8.33
<i>Rumex dentatus</i> L.	Polygonaceae	Annual	Th	ME+IT+SA	16.67
<i>Senecio aegyptius</i> L.	Asteraceae	Annual	Th	ME+IT+ES	4.17
<i>Sisymbrium irio</i> L.	Brassicaceae	Annual	Th	ME+IT+ES	4.17
<i>Solanum nigrum</i> L.	Solanaceae	Annual	Th	COSM	33.33
<i>Sonchus oleraceus</i> L.	Asteraceae	Annual	Th	COSM	25.0
<i>Stellaria pallida</i> (Dumort.) Murb.	Caryophyllaceae	Annual	Th	ME+ES	4.17
<i>Tamarix nilotica</i> (Ehrenb.) Bunge	Tamaricaceae	Perennial	Nph	SA +SZ	8.33
<i>Urtica urens</i> L.	Urticaceae	Annual	Th	ME+IT+ES	16.67

Table S4. Mean and coefficient variation of the importance value (out of 100) of the obtained 3 vegetation groups in 24 sites along River Nile, Damietta branch (Dakahilia). Species in bold are the dominant plants.

Species	Vegetation groups					
	I		II		III	
	Mean	CV	Mean	CV	Mean	CV
Size of groups	3		14		7	
Total number of species	32		52		33	
Species present in 3 groups						
<i>Alternanthera sessilis</i> (L.) DC.	1.08	1.73	2.31	1.13	0.38	2.65
<i>Arundo donax</i> L.	2.56	1.73	1.98	1.53	0.99	2.65
<i>Chenopodium album</i> L.	4.23	0.92	6.10	0.50	14.20	0.63
<i>Convolvulus arvensis</i> L.	2.56	1.73	2.58	1.44	4.27	1.05
<i>Eichhornia crassipes</i> (C. Mart.) Solms.	1.08	1.73	1.67	1.50	0.57	2.65
<i>Eichnocloa staginia</i> (Retz)P.Beauv.	5.73	0.89	5.22	0.79	16.07	0.54
<i>Ethulia conyzoides</i> L.	2.56	1.73	7.65	0.64	2.50	1.75
<i>Panicum repens</i> L.	2.56	1.73	6.23	0.58	13.77	0.81
<i>Phragmites australis</i> (Cav.) Trin .ex Steud	3.29	0.92	8.65	0.15	4.39	1.10
<i>Phyla nodiflora</i> (L.) Greene	1.08	1.73	6.74	0.65	7.07	1.01
<i>Pluchea dioscoridis</i> (L.) DC.	1.08	1.73	2.43	1.85	1.59	2.65
<i>Pseudognaphalium luteoalbum</i> (L.) Hilliard & B.L.Burt,	4.06	0.87	1.22	2.58	2.84	1.76
<i>Saccharum spontaneum</i> L.	3.82	0.89	0.60	3.74	1.74	1.73
<i>Urtica urens</i> L.	2.15	1.73	0.18	3.74	4.39	1.28
Species present in 2 groups						
<i>Alhagi graecorum</i> Boiss.	-	-	1.25	2.97	0.57	2.65
<i>Amaranthus lividus</i> L.	-	-	2.70	1.47	0.38	2.65
<i>Amaranthus viridis</i> L.	3.33	1.73	0.35	3.74	-	-
<i>Ceratophyllum demersum</i> L.	8.29	0.15	0.31	3.74	-	-
<i>Chenopodium murale</i> L.	1.67	1.73	0.18	3.74	-	-
<i>Conyza bonariensis</i> (L.) Cronquist	-	-	0.91	1.77	0.38	2.65
<i>Cynodon dactylon</i> (L.) Pers.	2.50	1.73	0.62	2.56	-	-
<i>Cyperus alopecuroides</i> Rottb.	5.89	0.99	2.06	1.53	-	-
<i>Cyperus articulatus</i> L.	-	-	4.51	0.96	1.14	2.65
<i>Cyperus papyrus</i> L.	-	-	1.07	1.68	1.71	2.65
<i>Ipomoea carnea</i> Jacq.	1.08	1.73	0.27	3.74	-	-
<i>Ludwigia stolonifera</i> (Guill. et Perr.) Raven	-	-	1.86	1.50	1.32	1.73
<i>Lamium amplexicaule</i> L.	-	-	2.13	2.50	1.02	2.65
<i>Lerssia hexandia</i> Sw.	-	-	0.51	3.74	2.28	1.84
<i>Persicaria salicifolia</i> Brouss. ex Willd.	5.31	0.42	3.97	0.94	-	-
<i>Poa annua</i> L.	-	-	3.44	1.41	1.14	2.65
<i>Portulaca oleracea</i> L.	1.67	1.73	0.36	3.74	-	-
<i>Potamogeton nodosus</i> Poir.	-	-	1.35	1.99	0.57	2.65
<i>Ricinus communis</i> L.	-	-	0.18	3.74	0.95	1.76
<i>Rorippa palustris</i> (L.) Besser	0.83	1.73	0.27	3.74	-	-
<i>Rumex dentatus</i> L.	1.67	1.73	0.89	3.74	-	-
<i>Senecio aegyptius</i> L.	-	-	10.34	0.62	2.04	2.65
<i>Sonchus oleraceus</i> L.	3.23	1.73	2.54	1.11	-	-
<i>Stellaria pallida</i> (Dumort.) Murb.	-	-	2.04	1.49	0.38	2.65
<i>Typha domingensis</i> (Pers.) Poir ex Steud.	-	-	0.59	3.61	0.57	2.65
Species present in one group						
<i>Amaranthus graecizans</i> L.	-	-	-	-	0.57	2.65
<i>Beta vulgaris</i> L.	2.15	1.73	-	-	-	-
<i>Bidens pilosa</i> L.	-	-	0.87	2.09	-	-
<i>Capsella bursa pastoris</i> (L.) Medik.	-	-	0.31	3.47	-	-
<i>Chenopodium ficifolium</i> Sm.	-	-	0.60	2.57	-	-

<i>Cyperus difformis</i> L.	1.67	1.73	-	-	-	-
<i>Cyperus rotundus</i> L.	-	-	0.41	3.74	-	-
<i>Echinochloa crusgalli</i> (L.) P. Beauv.	-	-	1.13	2.07	-	-
<i>Cynanchum acutum</i> L.	-	-	0.62	2.56	-	-
<i>Eclipta prostrata</i> (L.)L.	-	-	0.60	3.74	-	-
<i>Euphorbia peplus</i> L.	-	-	0.77	2.96	-	-
<i>Euphorbia terracina</i> L.	2.56	1.73	-	-	-	-
<i>Imperata cylindrical</i> (L.) Raeusch.	-	-	0.36	3.74	-	-
<i>Lemna gibba</i> L.	-	-	0.31	3.74	-	-
<i>Lemna minor</i> L.	-	-	-	-	4.94	1.34
<i>Malva parviflora</i> L.	2.56	1.73	-	-	-	-
<i>Myriophyllum spicatum</i> L.	11.20	0.26	-	-	-	-
<i>Pennisetum setaceum</i> (L.) R.Br.	-	-	-	-	1.71	1.84
<i>Persicaria lapathifolia</i> Willd.	-	-	0.92	2.96	-	-
<i>Pistia stratiotes</i> L.	-	-	0.65	2.58	-	-
<i>Ranunculus sceleratus</i> L.	-	-	-	-	3.17	2.65
<i>Sisymbrium irio</i> L.	-	-	0.17	3.74	-	-
<i>Solanum nigrum</i> L.	2.56	1.73	-	-	-	-
<i>Symphyotrichum squamatum</i> (Asch.) Dandy	-	-	-	-	0.38	2.65
<i>Tamarix nilotica</i> (Ehrenb). Bunge	2.56	1.73	-	-	-	-