National Authority for Remote Sensing and Space Sciences

DEFINING SPATIAL DISTRIBUTION OF MOSQUITO BREEDING SITES AND AREAS UNDER RISK USING REMOTE SENSING – GIS INTEGRATION

Prepared By

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INTRODUCTION

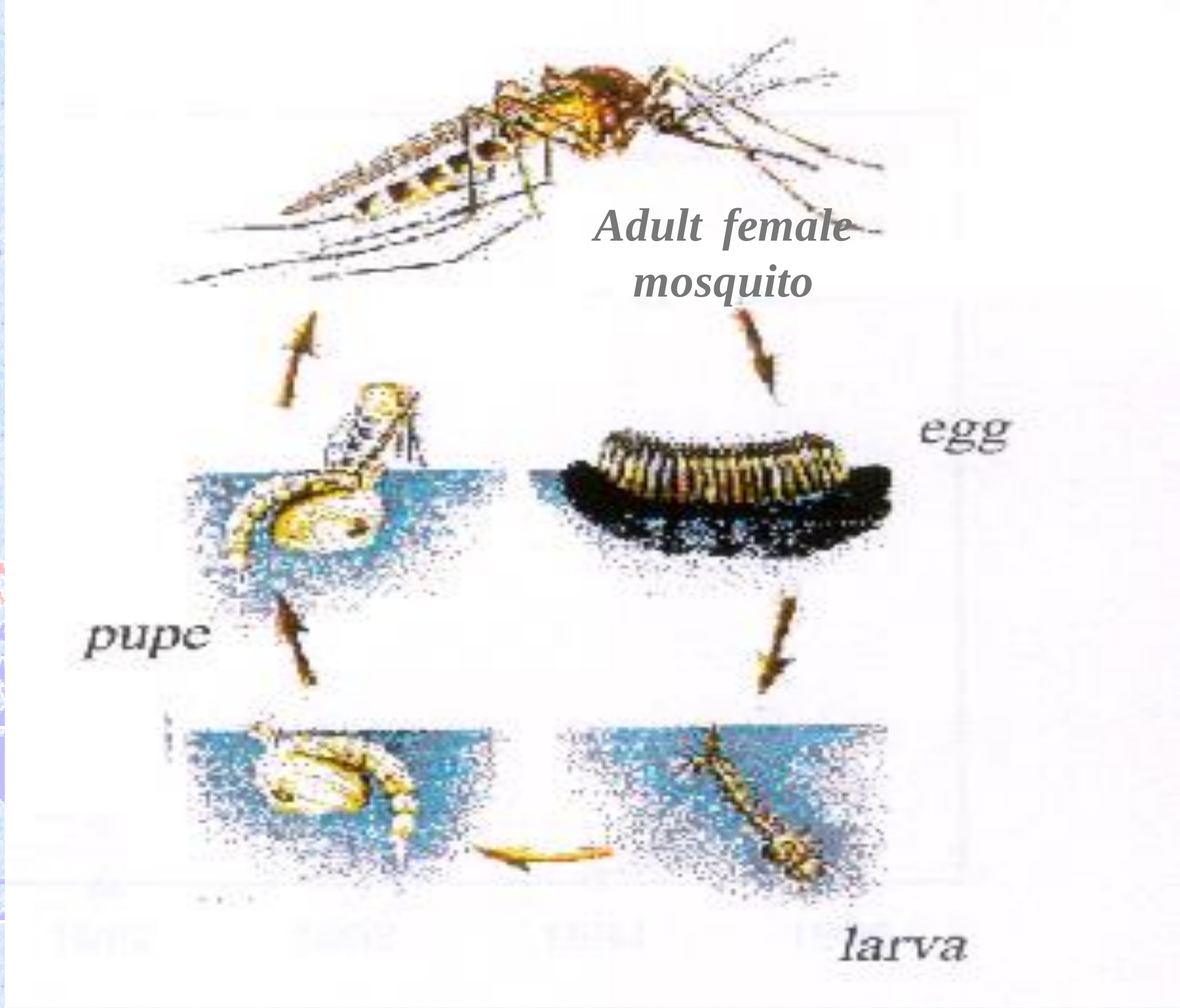
- **About 20 years ago, several ambitious developmental programs were planned and started in the northwest area .**
- **Such projects aimed to establish new settlements which could held inhabitants most of them are young graduates coming from Nile Delta where many diseases are endemic or epidemic.**
- ***Several mosquito species have been reported in this area, and some of them have public health importance (Harback et al., 1988).***
- **The present study resorted to remote sensing and GIS in combination with limited field surveys**
  - **To delineate the extent of mosquito breeding habitats,**
  - **To define areas at risk from mosquito nuisance and disease transmission.**
  - **To provide practical information to assist mosquito control efforts and to guide development planning in the project area.**

Objective

- The overall goal of this study is to develop and use geographic information system (GIS) technology and remote sensing resources to research and define the spatial relationships of environmental factors and vector (mosquito) distributions within the study village, El-Sowinat of Matrouh governorate, Egypt.
- This first objective to create a GIS of different indices, by using multispectral satellite image.
- Create landuse/landcover map
- The second objective is to map the distribution of the wells, using ArcGIS software to create distribution mosquitogenic maps.
- The third objective is to assess environmental and land cover influences of mosquito transmission of diseases using satellite imagery.

(Landsat ETM image provide an overview of the area and the location of major land cover classes within the area).

Mosquito life cycle



MATERIALS AND METHODS

MATERIALS AND METHODS

- ***Study Area***
- **The locality selected as indicator for this study shown figure (1)**

N.B.

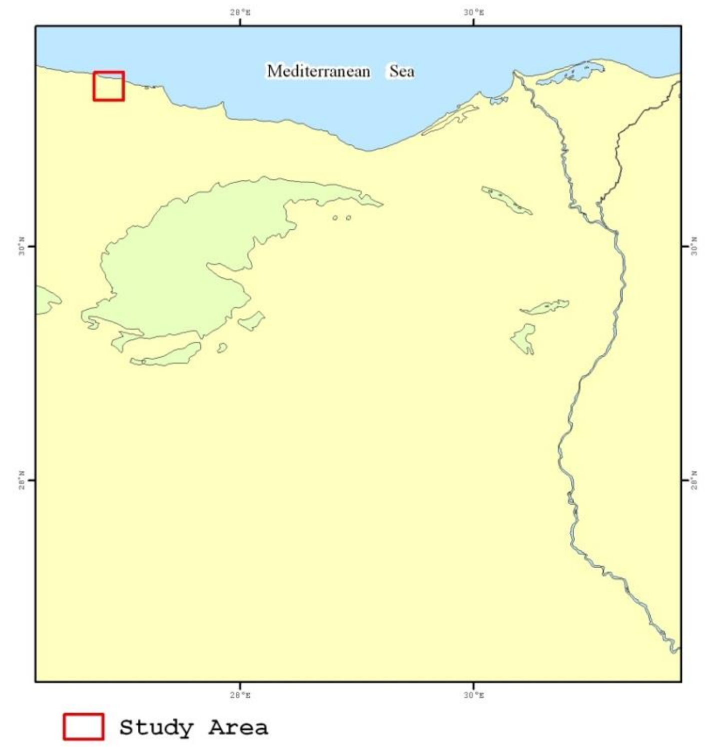
- **Geographic locations of study areas were determined using GPS equipment (GPS 12 X 1 Personal Navigator, Garmin, Europe LTD).**

The Global Positioning System (GPS) is a space-based system that provides location and time information in all weather conditions, anywhere on or near the Earth.

MATERIALS AND METHODS

Base map of study area

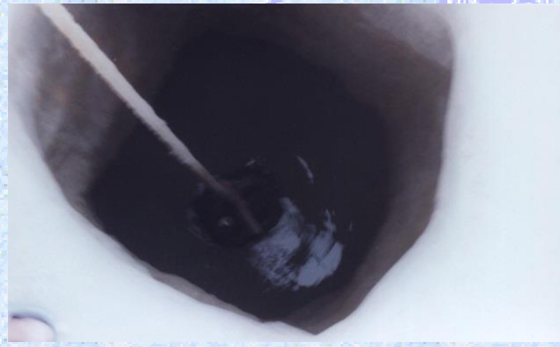
El-Sowinat village (Marsa Matruh governorate)



MATERIALS AND METHODS

- **In all breeding places, larval collections were carried out by dipping in wells (using a bucket hanged by rope).**



MATERIALS AND METHODS

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- **Collected larvae were transported to the laboratory in a fixative solution (containing 70% Ethyl Alcohol).**
- **Each surveyed site was geo-referenced using a hand-held Global Positioning System (GPS) devise (Magellan 320, USA.**
- **In the laboratory all specimens (4th larval instars) were identified using the Keys of Gad (1963), Harbach (1985).**
- **The study area was visited and surveys were carried out in a small number of representative wells to locate and identify mosquito-breeding habitats and associated vegetation.**
- **A topographic map sheet (Marsa Matruh) at scale 1: 50,000 were used. The map is produced by the Military survey authority (MSA) during 1982.**
- **ETM images, dated 2001, covering the study area were used. Path178,179, Row 39, Date 2001, Bands 1 to 8.**

MATERIALS AND METHODS

Laboratory works
Identification of mosquito 4th instar larvae

MATERIALS AND METHODS

Digitizing specifications:

- **The digitizing specification was defined according to the available themes.**
- **Each theme was subdivided into sub-themes, which were coded for the purpose of GIS modeling.**
- **A thematic layer of the sheet includes roads, railways, urban, shoreline, wells, natural and cultivated lands.**

Editing bas maps:

- **The digital map was corrected from different errors after the georefrence process; it became GIS really thematic layers.**

Remote sensing data

- **Satellite data was digitally processed to develop a land cover map of the study area using georeferenced information collected during field surveys.**
- **Satellite data were digitally processed using Erdas Imagine software (version 8.5) running on a Microsoft windows operating system.**
- **The classification was done by selecting the breeding habitats for mosquito and other important land covers delineated during filed surveys in a supervised classification.**
- **NDVI, Moisture Index and Land surface temperature were calculated from satellite image**

GIS processes

ArcGIS software (version 9) under Microsoft windows media was used to analyze and create 2-km buffer zones around the defined natural and cultivated sites and habitats positive for mosquito breeding.

To create a GIS-Generated Map delineating the predicted mosquitoginc sites and the areas at risk of mosquito and disease transmission.

Satellite based estimations

(The following equations can be used only for Landsat ETM data)

Normalized difference Vegetation Index (NDVI):

NDVI= band 4 – band 3/ band 4 + band 3

NDVI = (Near-IR Reflectance- Red Reflectance) / (Near-IR Reflectance+ Red Reflectance)

Moisture Index (MI)

MI = (band 5– band 4)/ (band 5+ band 4)

MI=(Mid IR Reflectance-Near-IR Reflectance) / (Mid IR Reflectance+Near-IR Reflectance+)

Land Surface Temperature (LST):

Changing from DN values to reflectance:

Reflectance= 0.05518 * (DN of B6.1) + 1.2378

Changing from reflectance to temperature in Kelvin

Temperature (Kelvin) =1282.71 / log (666.09 / Reflectance) +1

Changing from temperature in Kelvin to temperature in Celsius

Temperature (Celsius) = Temperature in Kelvin -273

RESULTS

Mosquito species collected from wells in El-Sowinat village, Matrouh governorate, their breeding sites discrebtions and geographic coordinates

Site number	Geographic coordinates	Breeding site	PH	Identified mosquito species
1	N 31° 15′ 00″ E 27° 23′ 05″	Fresh water clear beside water pipe some vegetation and sunny	6.5	*Oc.detritus,Cx.pipiens Cs.longiareolata*
2	N 31° 28′ 10″ E 26° 55′ 09″	Open well and turbid stagnant water with green algae	8	*Cx.pipiens ,Cs.longiareolata*
3	N 31° 25′ 44″ E 26° 55′ 42″	Covered well beside houses. Turbid and stagnant water without green algae	6	*Cx.pipiens*
4	N 31° 26′ 01″ E 26° 55′ 50″	Open well beside olive farm. Turbid and stagnant water with green algae	7.25	*Cs.longiareolata*
5	N 31° 25′ 57″ E 26° 54′ 14″	Open well beside olive and fig farm. Turbid and stagnant water with green algae.	9	*Oc.detritus, Cx.pipiens Cx.laticinctus*
6	N 31° 25′ 57″ E 26° 53′ 30″	Open well for agriculture irrigation. Turbid and stagnant water with green algae.	6.5	*Cs.longiareolata*
7	N 31° 25′ 02″ E 26° 51′ 41″	Covered well. Turbid and stagnant water without green algae. For cheep drinking.	6.5	*Cs.longiareolata*
8	N 31° 26′ 19″ E 26° 51′ 01″	Open well with herbs and grass beside olive, palm and fig farm. Turbid and stagnant water with green algae.	6.5	*Oc.detritus, Cx.pipiens Cx.laticinctus**
9	N 31° 02′ 12″ E 28° 27′ 30″	Covered well. Turbid and stagnant water without green algae. For cheep drinking	7.25	*Cx.pipiens Cs.longiareolata*
10	N 31° 04′ 19″ E 27° 57′ 54″	Open well, fresh and clear water.	6	*Cx.pipiens Cs.longiareolata*

Mosquito species & Breeding Sites Characteristics

No	Breeding_site discrebtion	PH	Identified mosquito species	POINT_X	POINT_Y	LST	MI	NDVI
1	Fresh water clear beside water pipe some vegetation and sunny	6.500	*Oc.detritus - Cx.pipiens - Cs.longiareolata*	27.3847	31.2500	33.6082	0.0046	0.1160
3	Covered well beside houses. Turbid and stagnant water without green algae	6.000	*Cx.pipiens*	26.9283	31.4289	32.8317	0.0414	0.0886
4	Open well beside olive farm. Turbid and stagnant water with green algae	7.250	*Cs.longiareolata*	26.9306	31.4336	32.1268	0.0168	0.1053
5	Open well beside olive and fig farm. Turbid and stagnant water with green algae.	9.000	*Oc.detritus - Cx.pipiens - Cx.laticinctus*	26.9039	31.4325	31.2801	0.0237	0.1077
6	Open well for agriculture irrigation. Turbid and stagnant water with green algae.	6.500	*Cs.longiareolata*	26.8917	31.4325	31.7154	0.0224	0.1412
7	Covered well. Turbid and stagnant water without green algae. For cheep drinking.	6.500	*Cs.longiareolata*	26.8614	31.4172	31.7469	0.0494	0.1020
8	Open well with herbs and grass beside olive, palm and fig farm. Turbid and stagnant water with green algae.	6.500	*Oc.detritus - Cx.pipiens - Cx.laticinctus*	26.8503	31.4386	28.4272	0.0083	0.1034
9	Covered well. Turbid and stagnant water without green algae. For cheep drinking	7.250	*Cx.pipiens - Cs.longiareolata*	26.4710	31.0337	31.9718	0.0755	0.1109
10	Open well, fresh and clear water.	6.000	*Cx.pipiens - Cs.longiareolata*	26.9650	31.0719	32.2524	0.0640	0.1163
		PH	LST	MI	NDVI			
	Average	6.833	31.7734	0.0340	0.1102			
	Max	9.000	33.6082	0.0755	0.1412			
	Min	6.000	28.4272	0.0046	0.0886			
	±SD	0.927	1.4285	0.0249	0.0143			

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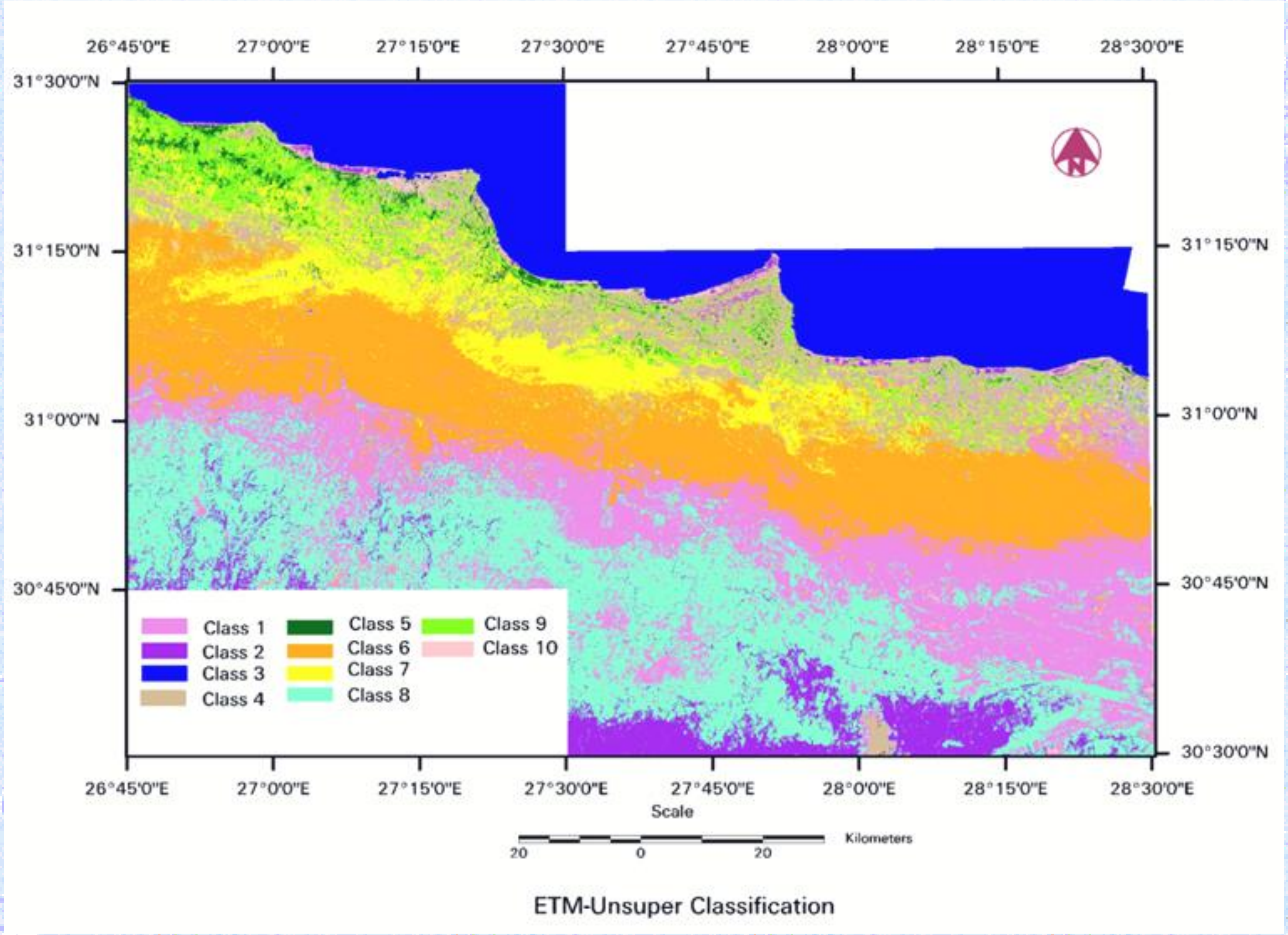

Unsupervised Classification (10 classes) of ETM+, 2001

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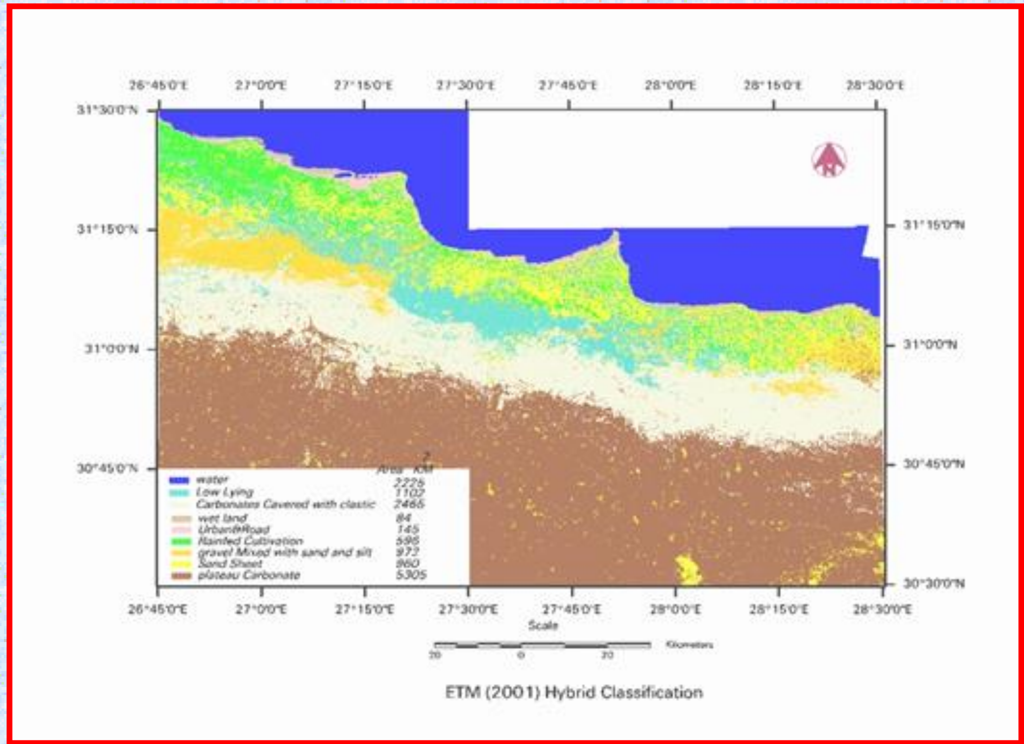

Land use / Land cover classes	Area (km^2)
Water	2225
Low lying carbonate	1102
Carbonates covered with clastic sediments	2465
Wet land	84
Urban & Road	145
Rain fed cultivation	596
Gravel mixed with sand and silt	972
Sand sheet	960
Plateau carbonate	5305
total	13854

Land use/ land cover classes, of ETM Landsat satellite image

Land use/ land cover classes classified ETM satellite image

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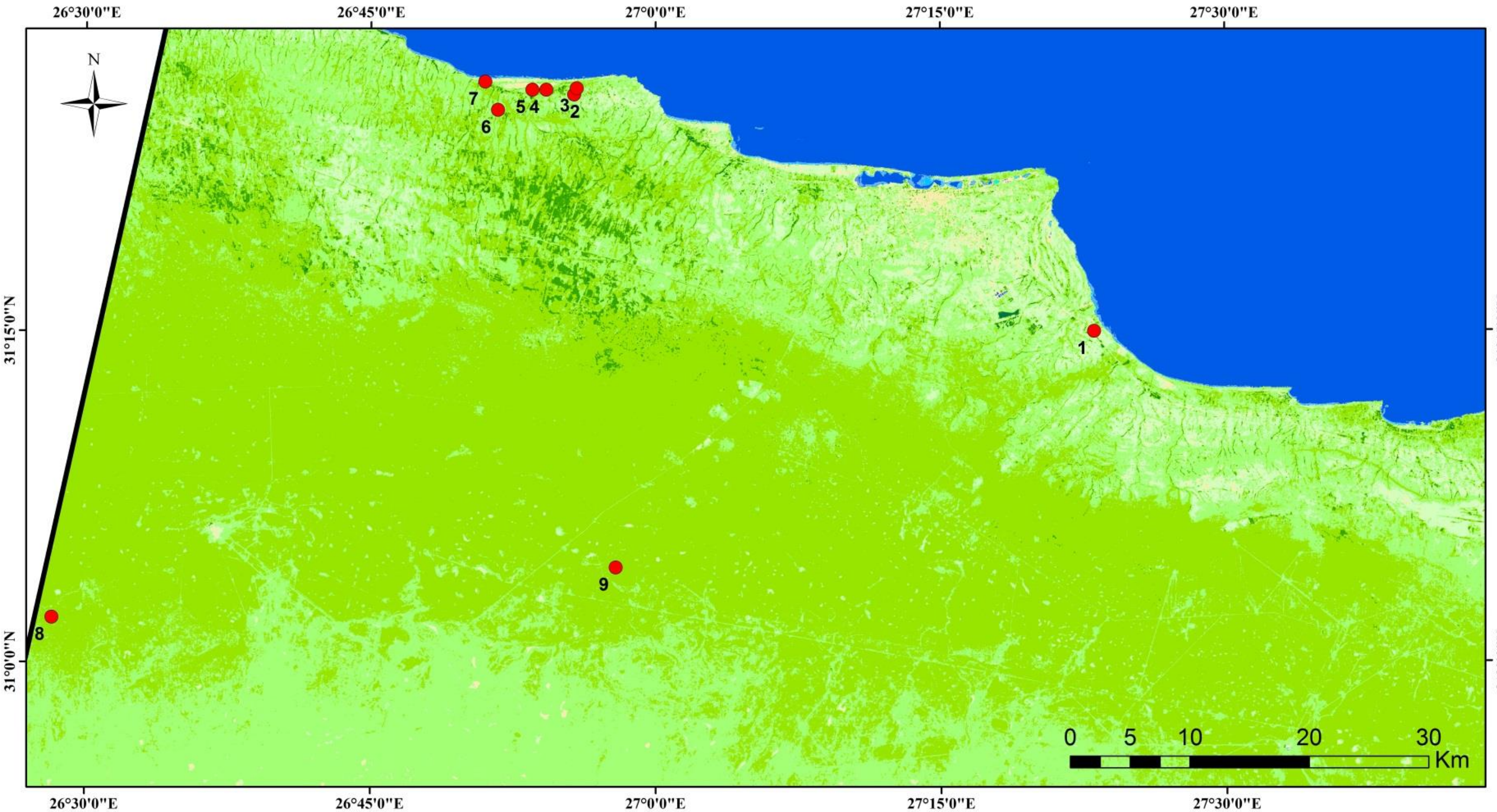
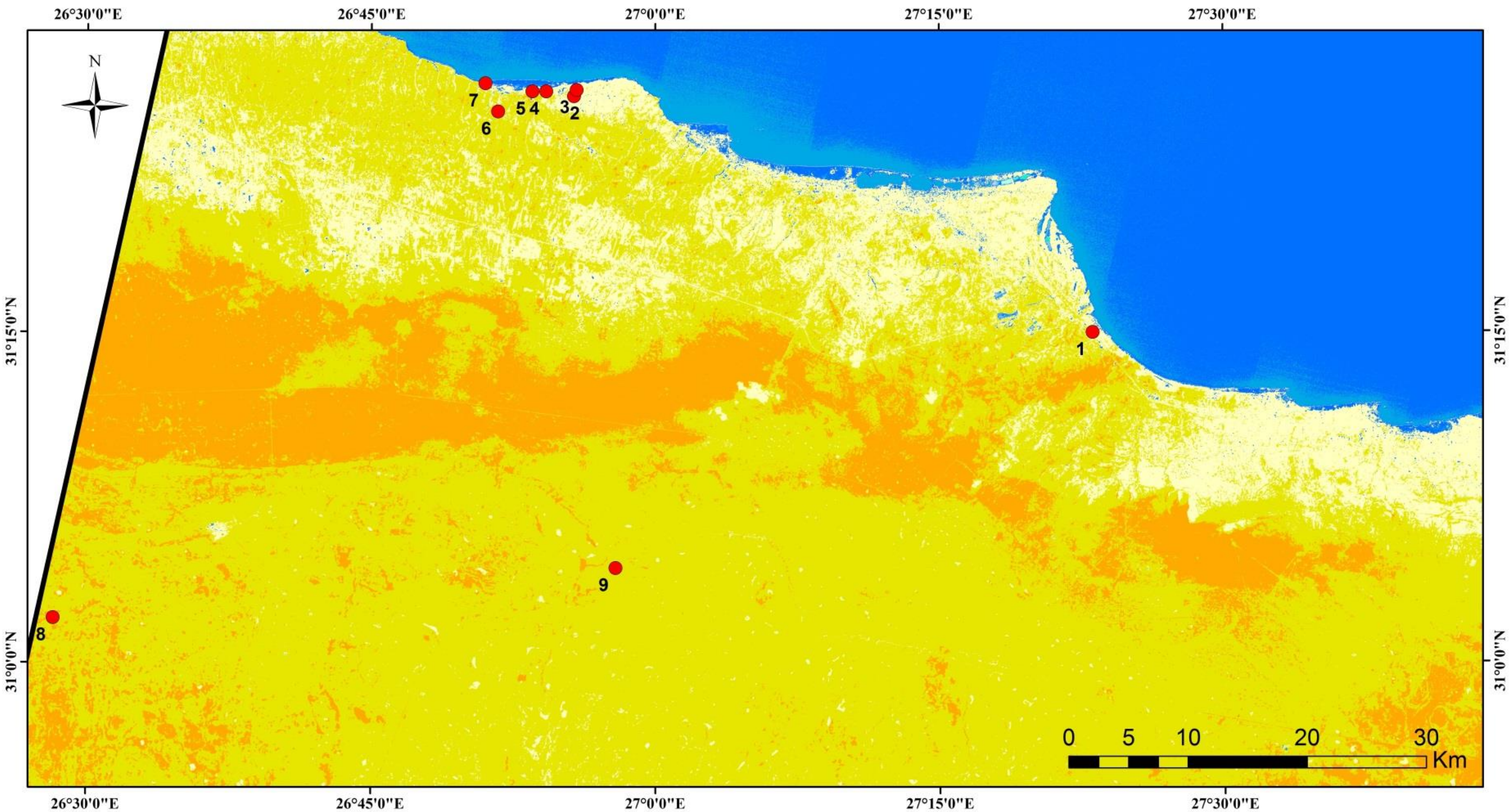


No	Breeding site	PH	Identified	Ndvi
1	Fresh water clear beside water pipe some vegetation and sunny	6.5	Oc.detritus - Cx.pipiens - Cs.longiareolata	0.116
2	Covered well beside houses. Turbid and stagnant water without green algae	6.0	Cx.pipiens	0.089
3	Open well beside olive farm. Turbid and stagnant water with green algae	7.3	Cs.longiareolata	0.105
4	Open well beside olive and fig farm. Turbid and stagnant water with green algae	9.0	Oc.detritus - Cx.pipiens - Cx.laticinctus	0.108
5	Open well for agriculture irrigation. Turbid and stagnant water with green algae	6.5	Cs.longiareolata	0.141
6	Covered well. Turbid and stagnant water without green algae. For cheep drinking	6.5	Cs.longiareolata	0.102
7	Open well with herbs and grass beside olive, palm and fig farm. Turbid and stagnant water with green algae	6.5	Oc.detritus - Cx.pipiens - Cx.laticinctus	0.103
8	Covered well. Turbid and stagnant water without green algae. For cheep drinking	7.3	Cx.pipiens - Cs.longiareolata	0.111
9	Open well, fresh and clear water	6.0	Cx.pipiens - Cs.longiareolata	0.116

Normalized difference Vegetation Index values corresponding to each mosquito breeding site



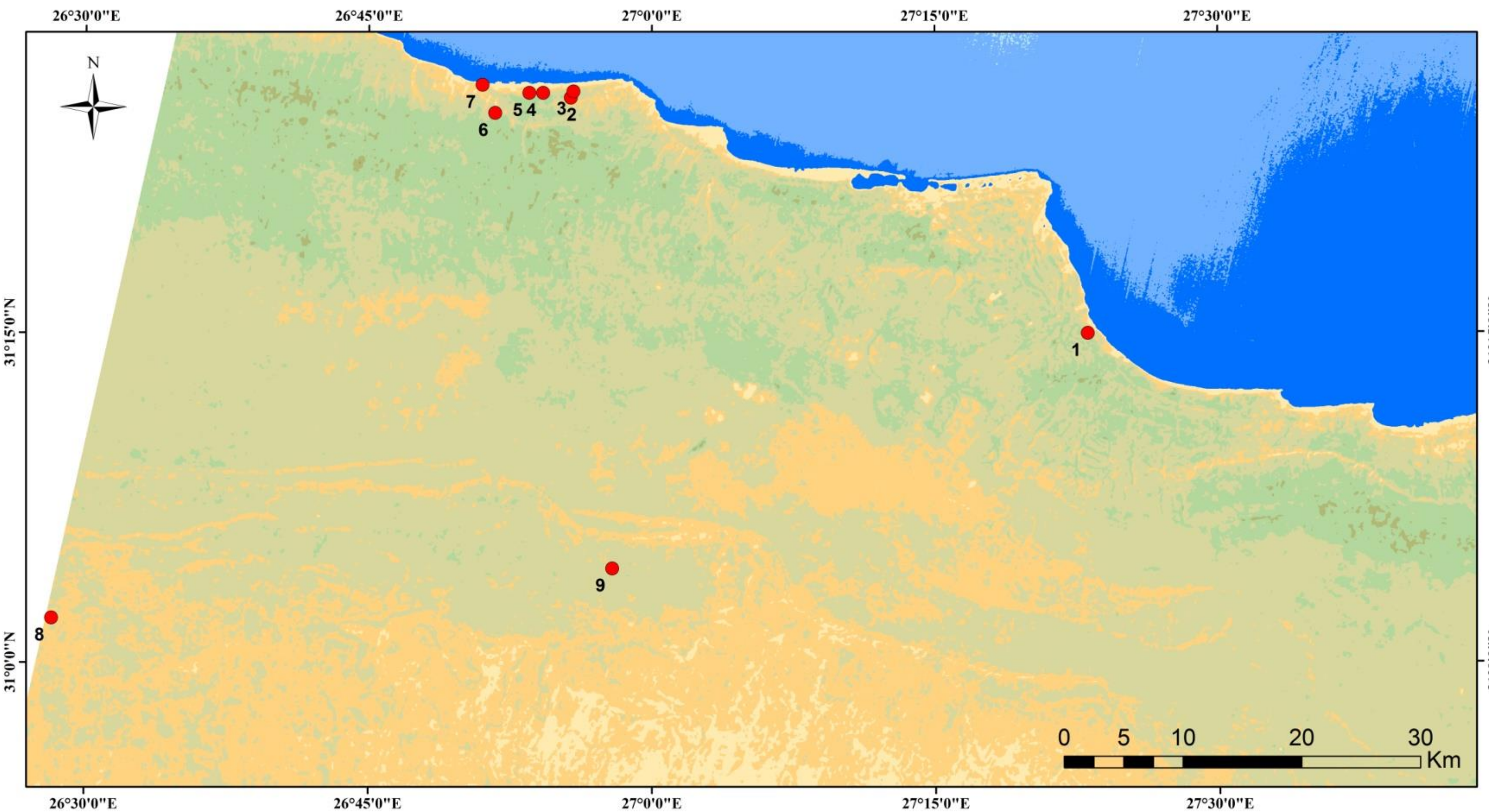
No	Breeding site	PH	Identified	Musher Index
1	Fresh water clear beside water pipe some vegetation and sunny	6.5	Oc.detritus - Cx.pipiens - Cs.longiareolata	0.005
2	Covered well beside houses. Turbid and stagnant water without green algae	6.0	Cx.pipiens	0.041
3	Open well beside olive farm. Turbid and stagnant water with green algae	7.3	Cs.longiareolata	0.017
4	Open well beside olive and fig farm. Turbid and stagnant water with green algae	9.0	Oc.detritus - Cx.pipiens - Cx.laticinctus	0.024
5	Open well for agriculture irrigation. Turbid and stagnant water with green algae	6.5	Cs.longiareolata	0.022
6	Covered well. Turbid and stagnant water without green algae. For cheep drinking	6.5	Cs.longiareolata	0.049
7	Open well with herbs and grass beside olive, palm and fig farm. Turbid and stagnant water with green algae	6.5	Oc.detritus - Cx.pipiens - Cx.laticinctus	0.008
8	Covered well. Turbid and stagnant water without green algae. For cheep drinking	7.3	Cx.pipiens - Cs.longiareolata	0.076
9	Open well, fresh and clear water	6.0	Cx.pipiens - Cs.longiareolata	0.064

Mosquito Breeding Site

Moisture Index

- 0.61- - 0.42-
- 0.41- - 0.30-
- 0.29- - 0.22-
- 0.21- - 0.14-
- 0.13- - 0.078-
- 0.077- - 0.046-
- 0.045- - 0.0021-
- 0.002- - 0.048
- 0.049 - 0.074
- 0.075 - 0.16
- 0.17 - 0.46
- 0.47 - 1

Moisture Index values corresponding to each mosquito breeding site



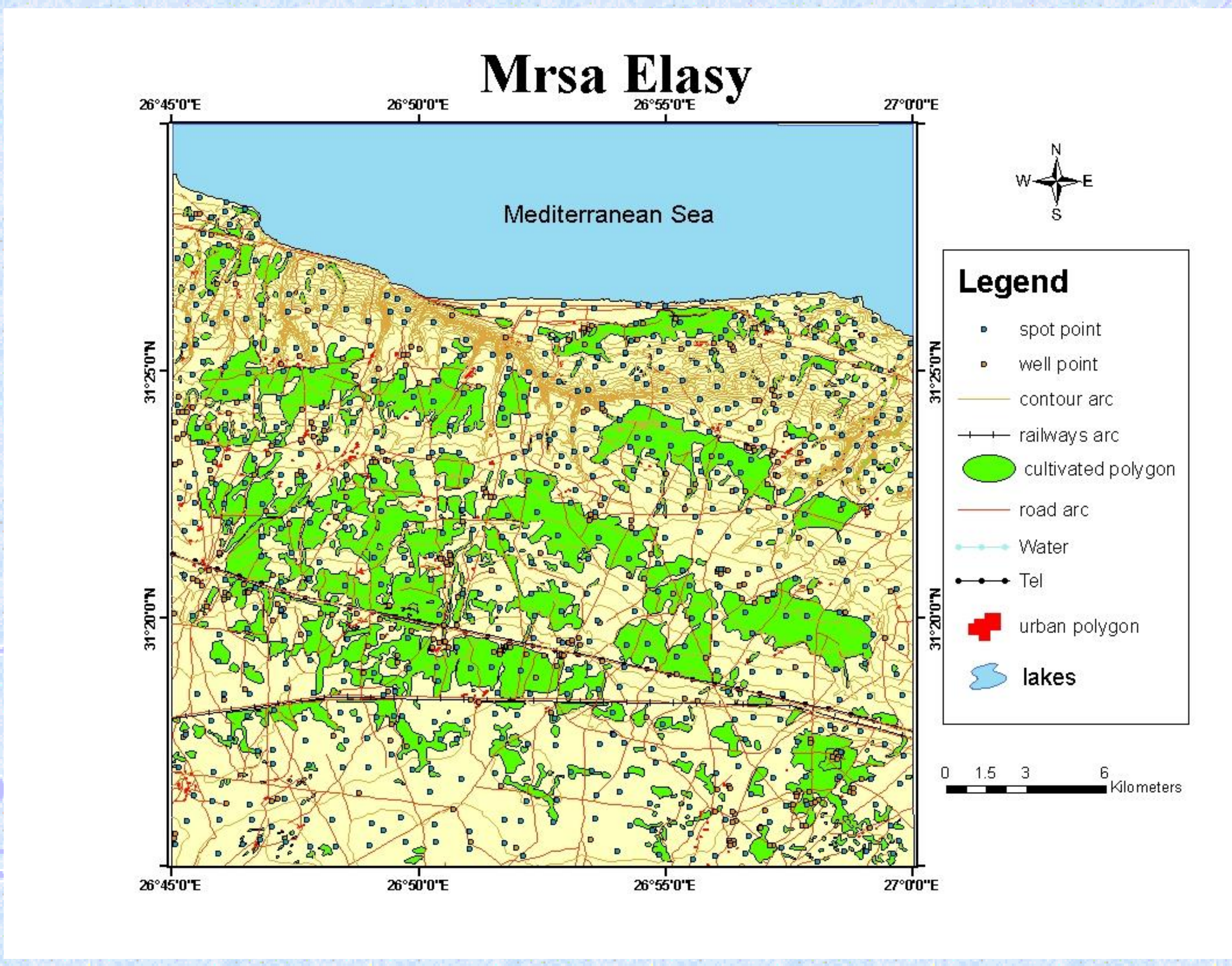
No	Breeding site	PH	Identified	Surface Temperature
1	Fresh water clear beside water pipe some vegetation and sunny	6.5	Oc.detritus - Cx.pipiens - Cs.longiareolata	33.608
3	Covered well beside houses. Turbid and stagnant water without green algae	6.0	Cx.pipiens	32.832
4	Open well beside olive farm. Turbid and stagnant water with green algae	7.3	Cs.longiareolata	32.127
5	Open well beside olive and fig farm. Turbid and stagnant water with green algae	9.0	Oc.detritus - Cx.pipiens - Cx.laticinctus	31.280
6	Open well for agriculture irrigation. Turbid and stagnant water with green algae	6.5	Cs.longiareolata	31.715
7	Covered well. Turbid and stagnant water without green algae. For cheep drinking	6.5	Cs.longiareolata	31.747
8	Open well with herbs and grass beside olive, palm and fig farm. Turbid and stagnant water with green algae	6.5	Oc.detritus - Cx.pipiens - Cx.laticinctus	28.427
9	Covered well. Turbid and stagnant water without green algae. For cheep drinking	7.3	Cx.pipiens - Cs.longiareolata	31.972
10	Open well, fresh and clear water	6.0	Cx.pipiens - Cs.longiareolata	32.252

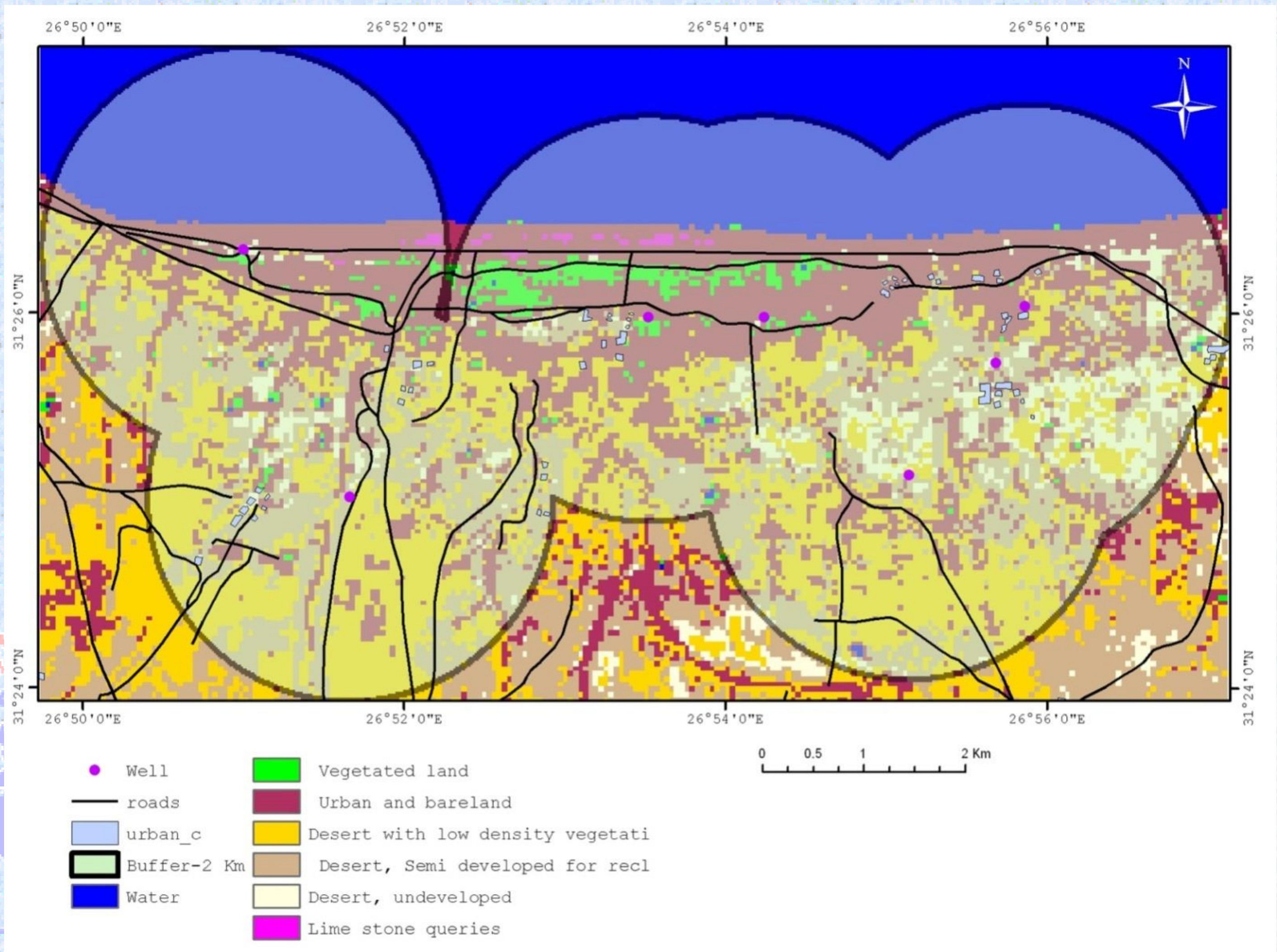
Mosquito Breeding Site

Surface Temperature

- 7.98 - 14.5
- 14.6 - 16.1
- 16.2 - 17.2
- 17.3 - 23.6
- 23.7 - 30.1
- 30.2 - 31.7
- 31.8 - 33.6
- 33.7 - 35.7
- 35.8 - 37.8
- 37.9 - 39.8
- 39.9 - 42.1
- 42.2 - 57.1

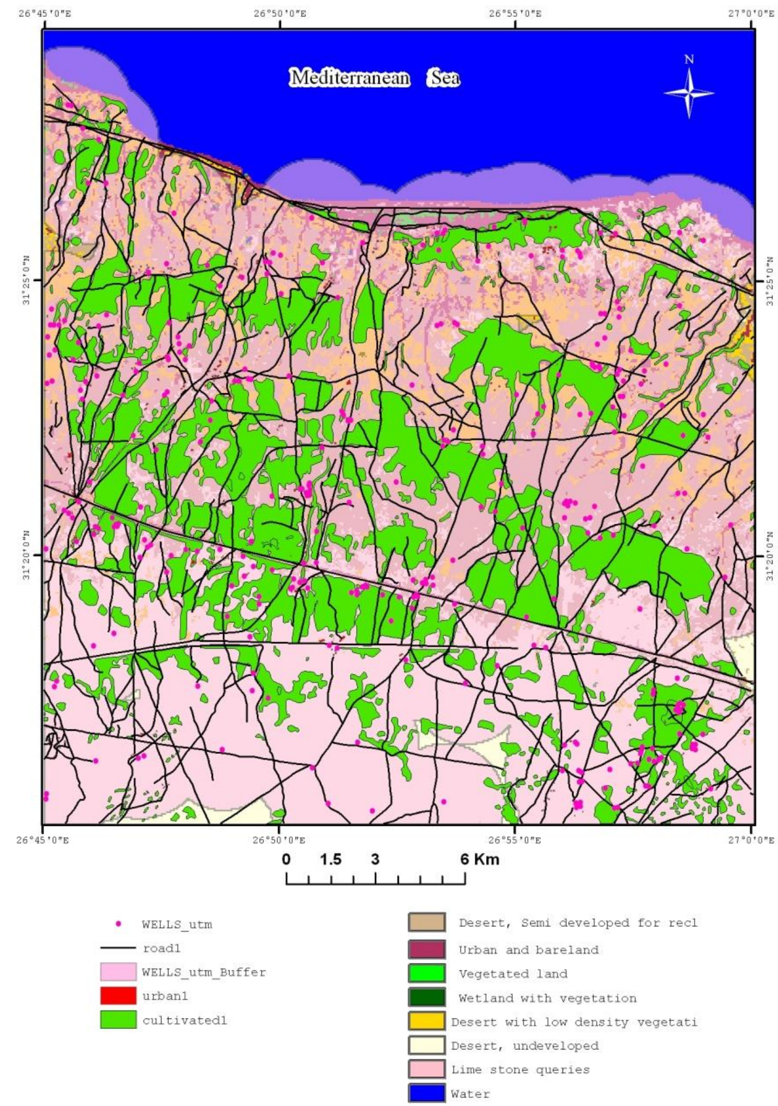
Land Surface Temperature (LST) values corresponding to each mosquito breeding site


Mrsa Elasy
26°45'0"E
26°50'0"E
26°55'0"E
27°0'0"E
31°25'0"N
31°20'0"N
Mediterranean Sea
N
W
E
S
Legend
spot point
well point
contour arc
railways arc
cultivated polygon
road arc
Water
Tel
urban polygon
lakes
0 1.5 3 6
Kilometers



Buffer zone around selected breeding sites

A GIS-Generated Map delineating the predicted mosquitoginc sites and the areas at risk of mosquito and disease transmission.

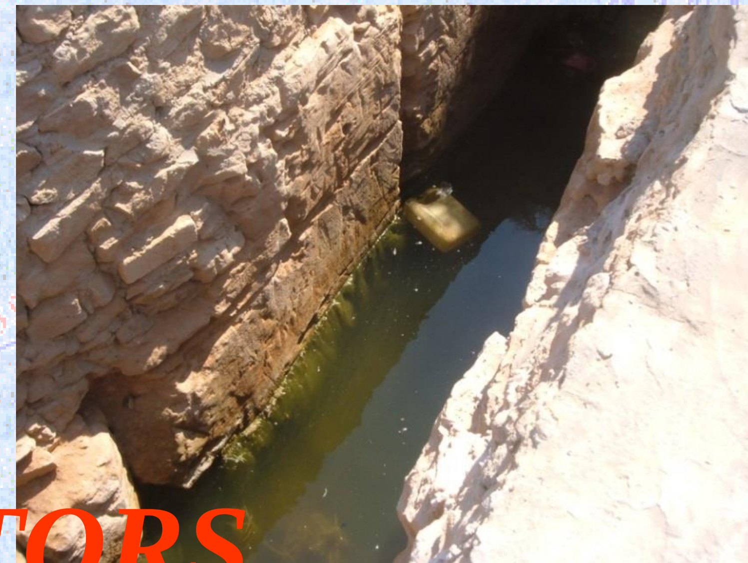


Vector map developed by NARSS

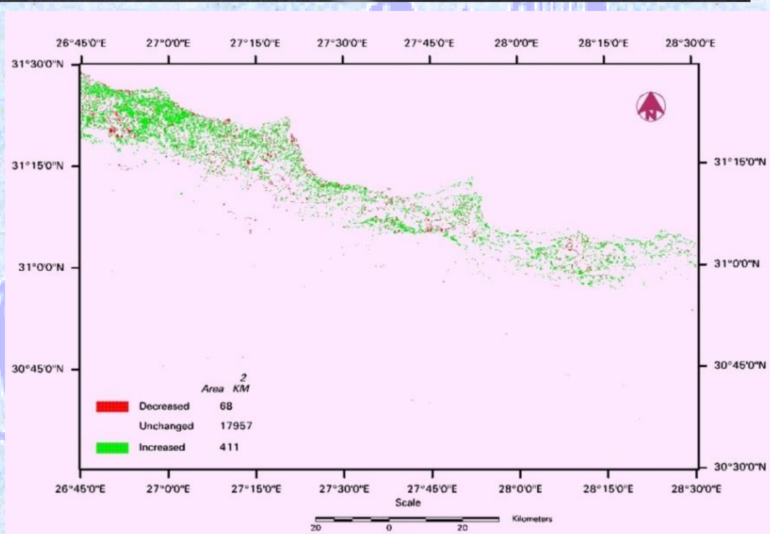
DISCUSSION

- **The present study represents one of the initial attempts to identify the mosquito fauna of well water resources and transplant development projects in Egypt**
- **The ecosystem of these new areas will certainly be affected and changed during the coming years. Therefore, much efforts and research work are needed to avoid the epidemicity of the disease in this area .**
- **The presence of *Cx.pipiens*, *Oc.detritus* and *Cx.laticinctus* in the study area is epidemiologically important since *Cx.pipiens* was reported as the main vector of RVF virus; bencroftian filariasis and West Nile virus (Gad *et al*., 1989 and Turell *et al*., 1996; Southgate, 1976; Harb *et al*., 1993 and Turell *et al*., 2002, sowilem, 2004).**
- **the study area lies in the buffer zone between Marsa Matruh and libia where some investigators have shown that animal importation may take place illegally.**
- **The main vector of filariasis in Egypt, *Cx.pipiens*, has an uneven distribution in natural and artificial breeding sites.**
- **Recent findings have identified the relative importance of well breeding of the vector as a significant risk factor in the transmission of *W.bancrofti*, West Nile Virus, RVF.**
- **The present study demonstrated that several mosquito vectors are already present in major water (wells) resources/agricultural development and new touristy villages on the costal zone.**
- **the expected human and animal population movement into the area creates a potential risk of vector-borne disease transmission.**
- **This study introduced integration of limited ground surveys and remote sensing-based stratification of mosquitoginc habitats over a large area that otherwise would have taken more time, effort and money if traditional ground surveys were used .**
- **the risk map showed that a large part of urban and proposed development project at the study area would be at risk since it would be located within the risk area .**
- **The results demonstrated that remote sensing and GIS technologies could provide important data and information to assist in taking better informed decision by the health authorities to secure a healthy environment and sustainable development.**

RISK FACTORS



RISK FACTORS



Change Detection of Cultivation (1987-2001)

RISK FACTORS

CONCLUSIONS

- **This study helped decision-makers to understand that remote sensing technology is a highly-effective tool for assessing current and future distribution of mosquito_borne diseases and can provide so much more than just nice photos.**
- **GIS can be used effectively to help track, monitor and combat the spread of a disease (RVF, Filaria, Malaria and West Nile Virus).**
- **The use of a GIS package can help the local, state, and national level organizations develop a comprehensive plan to keep the mosquito_borne diseases in check.**
- **The continual monitoring of the mosquito_borne diseases will also keep the public informed of the disease and how to protect the population from having a serious epidemic.**

Thank you