American Journal of Life Sciences
2014; 2(6): 369-381
Published online December 23, 2014 (http://www.sciencepublishinggroup.com/j/ajls)
doi: 10.11648/j.ajls.20140206.17
ISSN: 2328-5702 (Print); ISSN: 2328-5737 (Online)

Ecological and climatic attribute analysis for Egyptian *Hypericum sinaicum*

Karim Abdelhai Omar

Nature Conservation Sector (NCS), Egyptian Environmental Affairs Agency (EEAA), St. Katherine Protectorate, South Sinai, Egypt

Email address:
kariemomar@gmail.com

To cite this article:
Karim Abdelhai Omar. Ecological and Climatic Attribute Analysis for Egyptian *Hypericum sinaicum*. *American Journal of Life Sciences.* Vol. 2, No. 6, 2014, pp. 369-381. doi: 10.11648/j.ajls.20140206.17

Abstract: Conservation of globally endangered plant resources is a critical ecological, cultural and economic issue. The undertaking of ecological study focusing on the distribution, abundance and population structures of target species is fundamental to the assessment of the conservation status of wild populations. A study was carried out on the wild herb *Hypericum sinaicum* (Family: Hypericaceae) in Saint Katherine Protectorate (SKP), South Sinai, Egypt, where 22 sites presenting different habitats in SKP were surveyed for: (1) investigate the floristic composition, vegetation types and *H. sinaicum* distribution in the area, (2) define the ecological status of *H. sinaicum* and characterize this range by its size, shape, boundaries and internal structure, (3) clearly identify conservation priorities and suggest appropriate strategies for *H. sinaicum* conservation, (4) detect the effect of environmental factors on the distribution of *H. sinaicum* in order to use it as first step for conservation by rehabilitation or restoration, (5) determine the effect of spatial variation on plant community and *H. sinaicum* productivity, and (6) to determine the ecological and climatic requirements for this species and detect their effect on the species distribution. A total of 113 species were recorded in total within the 237 sites. 37 families were recorded within the study area; Asteraceae (15%) and Lamiaceae (11.5%) presented the dominant families in this area, while the Hypercaceae family which represented the target species (*H. sinaicum*) was recorded only once. *H. sinaicum* was recorded as dominant species in only 12 sites from 237 with 5%. Morphological attributes for *Hypericum* showed great variation due to the variation in the edaphic features of different locations. Finally it’s was observed that vegetation constitutes an organized whole, it operates at a higher level of integration than the separate species and may possess emergent properties not necessarily found in individual themselves. Most of the *H. sinaicum* populations were small and the plants occurred sporadically in space, as little groups conjugated with wet soil. At the micro-site level, *H. sinaicum* plants occupied most of high altitude habitats in SKP such as cliffs, Wadi bed, terrace, gorge, slope and cave habitats. *H. sinaicum* prefers the wet and shady places like gorges, slopes and cliffs with continuous water supply. There is an urgent need to integrate the knowledge derived from ecological, demographic and climatic approaches to species conservation in order to be able to formulate management strategies that take into account all different considerations.

Keywords: Conservation, Medicinal Plants, Near Endemics, Saint Katherine Protectorate, Phytosociological Analysis

1. Introduction

In order to establish an effective conservation program for plant species we should have enough information's about species demography, geography, population structure, habitat preference, etc. It is widely accepted today that the primary strategy for nature conservation is the establishment and maintenance of a system or network of protected areas. But as [1] points out, in a changing world this is a necessary but not sufficient condition of the successful conservation of biodiversity. Some conservationists believe that efforts to expand and strengthen the global system of protected areas should be redoubled and at the same time dismiss the whole concept of sustainable development of resources as a misguided effort [2, 3, and 4]. It is not possible to save every species from extinction; consequently care must be taken to ensure that limited resources are used efficiently. When choosing species for *ex situ* conservation, priority should be given to endangered species of global rarity, morphologically and genetically isolated species, monospecific genera and relict populations [5].

The first step in any conservation programme for target species is to establish a baseline of available information before other activities are initiated. The process of gathering this information is sometimes referred to as an ecogeographical survey or study [6] and is considered central to all issues of conservation and a key requirement in the development of any conservation strategy [7]. Choosing species to include in a conservation programme requires that adequate information is available to make proper decisions and set the right priorities [8]. A word of caution, however, is needed [8]. It is important to gather as much information as possible from as many sources as possible, but the validity of this information should then be double-checked [9]. Once the knowledge baseline has been established, this will allow gaps in the knowledge to be identified and will inform the implementation of the subsequent steps [8].

The high mountains of southern Sinai support mainly Irano-Turanian steppe vegetation. Smooth faced rock outcrops supply sufficient runoff water to permit the survival of the unique flora. SKP is one of the most floristically diverse spots in the Middle East and with 44% of Egypt's endemic plant species. To date, around 1261 species have been recorded in Sinai [10]. 472 plant species have been recorded as surviving and still occurring in SKP [11] of these 19 species of the surviving flora are endemic and more than115 are have known medicinal properties used in traditional therapy and remedies.

The vegetation cover in mountain areas is very important, it affects local and regional climate and reduces erosion. Economy of local communities and millions people in mountain areas depend on forests and plants. They also effectively protect people against natural hazards such as rockfall, landslides, debris flows, and floods [12]. Therefore, understanding of distribution and patterns of vegetation growth along with the affecting factors in those areas are important and have been studied by many researchers [13 – 19].

Climate is one of the major factors governing the distribution of wild plant species, acting directly through physiological constraints on growth and reproduction [20 – 22] or indirectly through ecological factors such as competition for resources [23]. When a species distribution is predicted using climate variables only, it is commonly referred to as a climate envelope model. In the arid and semi-arid region, although there is a correlation between mean rainfall and vegetation productivity over the growing season and the soil moisture is regarded as the determining factor in vegetation conditions, considerable uncertainty of the vegetation response to climate change still remains [24].

Hypericum sinaicum is one of the near endemic plant species in SKP only found in Sinai and North West Saudi Arabia [25]. It have been recorded as rare species [26], this species has a highly medicinal importance value, extraction from aerial parts gives substances like hypericin, protohypericin, pseudohypericin, protopseudohypericin, and hyperforin which showed effect to inhibiting the growth of retroviruses including HIV, the AIDS virus) in animals beside the treatment of depression [27]. However, the ecological and climatic requirements for this species are unknown and there is an urgent need from SKP management for these data to set a good action plan for the conservation of this species.

This study was carried out inside and with total support from SKP management and aims to: (1) determine the plant community composition inside the target study area, (2) define the ecological status of *H. sinaicum* and characterize this range by its size, shape, boundaries and internal structure, (3) clearly identify conservation priorities and suggest appropriate strategies for *H. sinaicum* conservation, (4) detect the effect of environmental factors on the distribution of *H. sinaicum* in order to use it as first step for conservation by rehabilitation or restoration, (5) determine the effect of spatial variation on plant community and *H. sinaicum* productivity, and (6) to determine the ecological and climatic requirements for this species and detect their effect on the species distribution.

2. Materials and Methods

2.1. Phytosociological Analysis

A total of 22 locations where *Hypericum sinaicum* are present were surveyed (Shak Itlah, Wadi Tenia, Farsh Messila, Elmaein, Shak Sakr, Abo Tweita, Kahf Elghola, Elmsirdi, Wadi Eltalaa, Sherage, Ain Shekaia, Tobok, Elzawitin, Elgalt Elazrak, Abu Hebeik, Eltibk, Farsh Elromana, Abu Kasaba, Abu Walei, Elgabal Elahmar, Shak Mosa, Wadi Elrotk) within SKP. Transect/quadrant method was used to study vegetation within 22 locations inside SKP as a base way for analyzing community structure and to deal with the most distribution data about *H. sinaicum*. A stratified sampling technique was reference. A 25-m transect rope was established along each microhabitat depending on the presence of *Hypericum* individuals. Five quadrats, each 5 x 5 m (25 m^2), were placed along its length the alternating sides of the rope. A total of 237 stands within 22 locations were studied. Within each stand assessments were carried out: soil physical and chemical characteristics [28, and 29].

Morphological characteristics of *H. sinaicum* were recorded within the field work by counting the No. of branches, No. of leaves, leaf length, leaf width, leaf area, shape index and internode length. Species richness were measured based on [30]. Vegetation analysis including; floral diversity (Simpson, Shannon-Weiner and Birllouin), abundance, cover, frequency were measured according to [31 – 33]. All these work were undertaken during the period from March 2011 to September 2011 inside SKP.

2.2. Ecological and Climatic Attribute Analysis

Population Demography: Number of individuals, population size, range of spatial distribution and presence were measured for *H. sinaicum* in order to reflect its demography. Spatial size of *H. sinaicum* was estimated based on calculating the area of occupancy (AOO) and extent of occurrence (EOO). "Guidelines for Using the IUCN Red List Categories and Criteria" [34] note that Extent of Occurrence can be measured by drawing a polygon around occupied sites and calculating its area. The simplest approach to this is to draw a figure known as a "convex hull" (the smallest polygon in which no internal angle exceeds 180^o). Extent of Occurrence (EOO) or Area of Occupancy (AOO) will be estimated with Google Earth.

Habitats preference: In this part, microhabitats of *H. sinaicum* were illustrated and presented by comparing the frequency of *H. sinaicum* among different microhabitats. Plant stages: *H. sinaicum* were observed throughout the growth season of year 2011 and all growth stages were recorded and characterized it by scale time. Species correlations: The overlap between *H. sinaicum* and other associated species was calculated based on the number of a species occurrence with *H. sinaicum,* cluster analysis was used in this item.

Climatic variables of the study area were extracted using DIVA GIS software. Nineteen bioclimatic parameters derived from mean monthly climate estimates, to approximate energy and water balances at a given location [35].

3. Results and Discussions

Table 1. *Diversity estimates for the sampled sites computed in different ways.*

Location	Simpson's index	Shannon-Wiener index	Brillouin's index	Sp. Richness
Shak Itlah	0.944	4.040	3.335	26
Wadi Tenia	0.907	3.407	2.940	24
Farsh Messila	0.896	3.370	2.890	26
Elmaein	0.946	3.860	3.210	16
Shak Sakr	0.928	3.905	3.370	27
Abu Tweita	0.835	3.173	2.780	22
Kahf Elghola	0.645	1.890	1.730	8
Elmesirdy	0.862	3.337	3.007	34
Eltalaa	0.893	3.540	3.210	18
Sherage	0.933	3.637	2.893	25
Ain Shekaia	0.852	3.210	2.830	14
Tobok	0.924	3.710	3.240	16
Elzawitein	0.873	3.600	3.045	26
Elgalt Elazrak	0.894	3.420	2.850	15
Abu Hebeik	0.912	3.585	2.980	23
Eltebk	0.874	3.050	2.605	17
Farsh Elromana	0.909	3.455	2.823	28
Abu Kasaba	0.833	3.010	2.670	14
Abu Walei	0.767	2.910	2.390	15
Elahmar	0.916	3.668	3.018	34
Shak Musa	0.885	3.483	2.923	27
Elrotk	0.919	3.620	2.850	16

Phytosociological analysis: A total of 113 species were recorded in total within the 237 sites. However, species number gives indication about the diversity of any community. Great variation in species diversity among different locations was detected in this study confirming the results recorded by [36 and 37]. The overall diversity of all sites is reported here in Table 1 using the conventional, Jackknifed and Chao computations as mentioned earlier. In this study; Elmesirdi, Elahmar and Farsh Elromana presented the highest species richness, while Kahf Elghola presented the lowest (Table 1).

There are considerable differences between the 22 Shannon estimates (parametric and non-parametric) but the trend is conserved. In other words, estimates showed that Elmaein, Shak Itlah, Sherige, and Elahmar are more divers compared to the others. From the vegetation survey, 37 families were recorded within the study area; Asteraceae (15%), Lamiaceae (11.5%), Scrophulariaceae (6.1%) and Caryophyllaceae (5.3%) presented the dominant families in this area and this agrees with results recorded by [37 and 38], while the Hypercaceae family which presented the target species (*H. sinaicum*) was recorded only once

Results showed that *Achillea fragrantissima* (68 sites from 237 with 28.7%), *Phlomis aurea* Decne. (19 sites from 237 with 8%) and *Fagonia mollis* (17 sites from 237 with 7.2%) presented the most frequently dominant species within this study and this agrees with results recorded by [37, 39, and 40]. *Hypericum sinaicum* recorded as dominant species in only 12 sites from 237 with 5% (Figure 1). Species cover is an important factor that reflects the status of a species within its micro-habitat; *H. sinaicum* covers about 84.8 m^2 (8.7%) from the total study area. Abu Tweita (94 m^2), Elahmar (88 m^2), Wadi Tenia (86 m^2), Abu Hebeik (85 m^2) and Shak Itlah (82 m^2) presented the highest vegetation cover within study area resulting from the high amount of shade and water supply. Tobok showed the lowest vegetation cover (5 m^2) (Figure 1).

Many workers [41 and 42] report major differences in desert vegetation between hills and plains based primarily on the dichotomy between rocky and sandy substrates.

We can explain now the repeat of some wadies that own the most diversity and the most vegetation cover by only one figure, results showed that most vegetation cover concentrated in areas with high amount of water and shade, also *Hypericum* presented as dominant species in sheltered and misted surface land as recorded within field work, see Figure (1)

The biomass production index (or growth index) of *Hypericum sinaicum*, as judged by integrating the values of the assessed morphological traits, abundance, frequency, density, and cover showed wide variations for the plants grown on the different sites. As expected, the highest biomass production index was associated with sites having available water/ moisture, more shade and moderate temperature range (Figure 1).

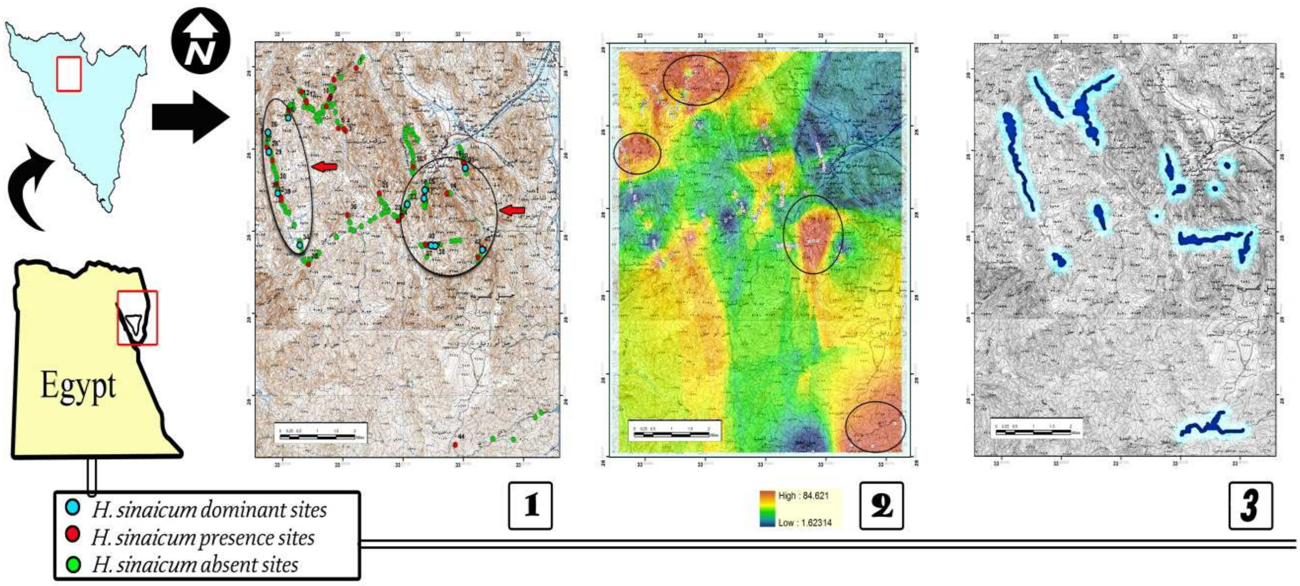

Figure 1. *1. presents the sites where H. sinaicum dominant, 2 presents the vegetation cover within the study area where's red color is the highest and blue is the lowest and 3. presents the areas (locations) of water resources.*

Vegetation constitutes an organized unit which it operates at a higher level of integration than the separate individual species and may possess emergent properties not necessarily found in the individual species themselves, such as competition and other biotic interactions. As such, vegetation provides not only the physical structure but also the functional framework of ecosystems. The same conclusion was obtained by [43]. In this respect, plant species richness is assumed to be high in habitats that have been abundantly available for plants for long periods and is recorded also by [44 – 46].

Morphological characteristics: Table 2 presents the variation in plant locations which showed the great variation in plant traits resulting from the change in environmental factors. The results of the study can be summarized as presented in the next table. It was observed that the highest *Hypericum* Growth and biomass is recorded in Ain Shekaia, Shak Itlah, Elgalt Elazrak, Wadi Eltalaa and Abo Hebik; this may come from the continuous water supply found in these sites.

Table 2. *Descriptive statistics of various quantitative characters in H. sinaicum accessions collected from various locations.*

Plant traits	Minimum Value	Maximum Value	Range	Mean	Std. Error of Mean	Std. Deviation
No of branch/plant	15	665	650	134	18.896	125
No of Leaf/branch	8	34	26	20	0.861	5.7
Leaf/Individuals	144	17955	17811	3104	537.303	3564.
Internode Length (cm)	0.25	1.5	1.25	0.628	0.044	0.3
Leaf length (cm)	0.25	1.3	1.05	0.484	0.027	0.2
Leaf Width (cm)	0.150	0.533	0.383	0.266	0.011	0.1
Leaf Area (cm2)	0.029	0.545	0.515	0.111	0.013	0.1
Plant Width (cm)	7	80	73	30.341	1.990	13
Plant Height (cm)	5	45	40	15.736	1.266	8
Plant Size Index (cm)	6	62.5	56.5	23.039	1.574	10
Shape index of leaf (cm)	1.389	2.438	1.049	1.803	0.037	0.24

Soil Analysis (Physical properties): Soil samples collected from the different locations showed great variation in texture, the most frequent soil types were sandy, loamy sand, and sandy loam, Loam soil was detected only on 3 stands and this agrees with the results come from [37]. Results clearly showed that soil moisture content of the studied stands ranged between 0.23% and 32% with an average of about 2.26%. Data recorded within the fieldwork; indicates that variation in soil texture, drainage, exposure and countless other environmental factors can influence the intensities and abundances of species found in a particular microhabitat and this totally agree with [37, 47, and 48].

Chemical properties: Results showed great variation resulted from spatial variation and altitudinal gradient. Table 3 present the range of differences and reflects the variation between locations.

Table 3. *Descriptive Statistics of chemical prosperities.*

Soil variables	Minimum	Maximum	Mean	Std. Deviation
pH	7.4	8.9	8.24	0.40
EC µs/ cm	18.27	673.08	126.01	114.33
T.D.S PPm	38	1400	251.55	239.01
Water content%	0.23	32	1.63	4.74
Org.matter%	1.72	17.25	4.96	2.54
CaCO3%	12.5	47	28.09	7.16
Ca++meq/L	4	50	20.60	10.88
Mg++ meq/L	0.5	187.5	12.33	29.60
Na+ PPM	10.4	57.14	26.16	12.02
K+PPM	10.4	163.82	30.17	25.06
HCO3- meq/L	4	19	8.88	3.10
Cl-meq/L	2.75	41	10.07	6.25
SO4-- meq/l	16.5	430	81.90	61.01

Results comes from [49 – 53] found also that soils of the south Sinai are gravelly in wadis and plains, rocky at mountains surface, sand to loamy sand in texture, alkaline, non-saline to slightly saline. As South Sinai lid in arid to extremely arid region, it is characterized by an ecological uniqueness due to its diversity in landforms, geologic structures, and climate that resulted in a diversity in vegetation types, which is characterized mainly by the sparseness and dominance of shrubs and sub-shrubs and the paucity of trees and this was record by us and also by [54 and 55].

Ecological attributes analysis: Population Demography: Most of the *H. sinaicum* populations were small and the individuals occurred sporadically in space, as little groups were conjugated with wet soil. 1401 individuals of the target species were recorded within this study, 235 individuals were recorded at Elahmar (16.7%), 213 were recorded at Elmisirdy (15.2%) and 114 were recorded at Abu Tweita (8.14%) (Table 4). At the micro-site level, *H. sinaicum* plants occupied most of the high altitude habitats in SKP such as wadi bed, terrace, gorge, slope, and cave habitats. This indicates that this species has a wide range of spatial distribution and presence.

The estimated spatial size of *H. sinaicum* is based on calculating the Extent Of Occurrence (EOO). The measure reflects the fact that length about 14.7 km and width of 7.4 km, while EOO is estimated about 111.5 sq km, it presents about 2.5% from total SKP (Figure 2).

Table 4. *Total No. of H. sinaicum individuals and its percentage among different locations within study area.*

No.	Location	Total No.	%
1	Elahmar	235	16.77
2	Elmisirdy	213	15.20
3	Abu Tweita	114	8.14
4	Farsh Elromana	97	6.92
5	Wadi Eltebk	94	6.71
6	Shak Musa	88	6.28
7	Abu Hebik	85	6.07
8	Farsh Messila	70	5.00
9	Wadi Eltalaa	59	4.21
10	Wadi Tenia	52	3.71
11	Kahf Elghola	42	3.00
12	Ain Shekaia	41	2.93
13	Shak Sakr	32	2.28
14	Shak Itlah	31	2.21
15	Elzawitein	27	1.93
16	Abu Walee	25	1.78
17	Sheriage	24	1.71
18	Elgalt Elazrak	21	1.50
19	Elmaein	21	1.50
20	Abu Kasaba	14	1.00
21	Tebook	10	0.71
22	Wadi Elrotk	6	0.43

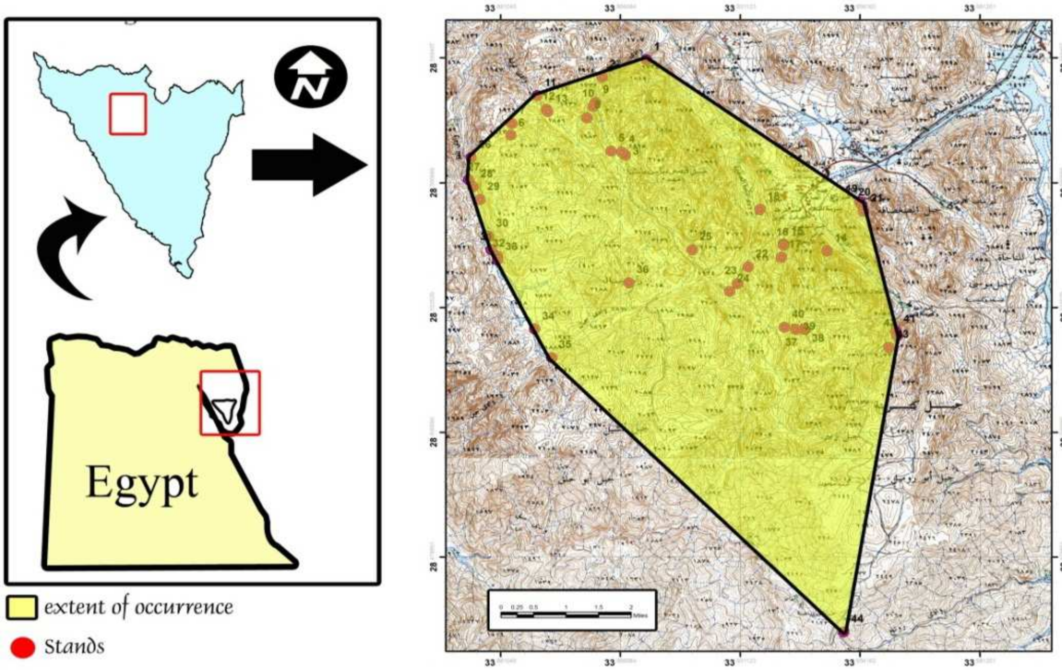

Figure 2. *Extent Of Occurrence (EOO) of H. sinaicum within SKP.*

Habitats preference: During the survey we found that *Hypericum* populations are located in most of the micro-habitats, except at Farsh and this agrees with [56]. Most of *Hypericum* sampled sites were recorded at cliffs and gorges with percentages 27.3% for each, cave is recorded only in one site. Due to the rugged topography of the study area, several microhabitats were recognized namely wet habitats, terraces, wadi bed and proper slopes and cliffs. Each of these microhabitats supports special type of vegetation with characteristic floristic composition and plant cover (Table 5).

Results found that there is spatial variation in soil and morphological characters among the different microhabitats. Soil $CaCO_3$, Ca, Mg, Na, Cl and SO_4 showed the highest values at cave while Water content, EC and TDS showed the highest at cliffs. Soil K recorded as highest value at slope. However cliffs and gorges were recorded as the highest microhabitat presenting *Hypericum sinaicum* which populations within study area. Soil properties of these microhabitats showed comparable ratios, only water content showed great variation between the different microhabitat (Table 5). This may explain why *Hypericum* prefer special microhabitat.

Morphological characteristics showed great variation among different microhabitats, the average of No. leaf per plant, internode length, leaf length, leaf width, shape index and leaf area showed the highest values at cave while *Hypericum* width, height and size indexes showed the highest values at slope. The highest value of No. of branches was recorded at cliff, while total No. of *Hypericum* showed the highest at gorge.

Variations in soil and plant morphological characters among different microhabitats were also recorded by [56 – 60]. Landform type and other elements such as elevation, soil physical characteristics (including soil texture and nature of the surface), slope, aspect and topography, all play an important role in determining the distribution of plant communities as observed also by [61 – 64]

Table 5. *Variation in soil and morphological characters among different microhabitat.*

Micro-habitat	Cave	Cliff	Gorge	Slope	Terraces	W. bed
Elevation	1865	1811	1831	1802	1790	1863
Soil characters						
pH	7.80	8.11	8.28	8.36	8.48	8.16
EC µs/ cm	150.96	180.97	109.83	89.30	134.62	92.98
T.D.S PPm	314.00	376.42	204.50	185.75	280.00	168.14
water content	0.95	3.40	1.14	0.87	0.76	0.92
Org. matter	4.83	4.16	4.90	6.17	4.31	5.46
$\%CaCO_3$	45.50	29.63	26.42	28.13	27.00	26.43
$Ca^{++meq/L}$	45.00	23.75	15.83	20.38	23.75	18.36
$Mg^{++\ meq/L}$	187.50	12.92	4.54	6.50	3.50	11.36
$Na^{+\ ppm}$	31.20	27.28	27.36	28.71	24.95	19.23
K^{+ppm}	32.10	30.96	29.49	42.42	23.70	19.39
$HCO_3^{-\ meq/L}$	9.00	9.38	8.50	8.81	7.75	9.36
$Cl^{-meq/L}$	41.00	9.88	9.73	8.00	9.75	9.11
$SO_4^{--\ meq/l}$	430.00	83.75	68.71	72.13	63.50	73.29

Micro-habitat	Cave	Cliff	Gorge	Slope	Terraces	W. bed
Morphological Characteristics						
No. Leaf	25	21	18	23	23	18
No. Branch	78	174	82	173	130	120
Internode length (cm)	0.95	0.58	0.61	0.66	0.53	0.71
Leaf Length (cm)	0.70	0.49	0.52	0.47	0.40	0.45
Leaf Width (cm)	0.37	0.26	0.28	0.26	0.24	0.25
Shape Index	1.91	1.85	1.81	1.77	1.65	1.83
Leaf Area	0.20	0.11	0.13	0.11	0.08	0.09
Hypericum Total No.	34	221	368	141	81	169
Hypericum Width	27.00	30.55	25.33	35.88	32.00	31.77
Hypericum Height	11.00	16.08	13.58	18.38	17.75	15.36
Hypericum size index	19.00	23.32	19.45	27.13	24.88	23.56
Hypericum % C	1.56	1.43	1.30	1.55	2.74	1.46
Hypericum I.V.I.	87.68	67.10	51.27	57.35	34.50	37.07

Observation revealed that *H. sinaicum* prefers the wet and shady places like gorges, slopes and cliffs with continuous water supply. Garden walls play an important role in the distribution of *Hypericum* because it provides a suitable shelter from high solar radiation. The variation among the different microhabitats is associated with variation in plant community structure; results of the current study, showed that there are variations in dominant species among the different landform types as follow:

Adiantum capillus-veneris (Cave), *Hypericum sinaicum* and *Diplotaxis harra* (Cliff), *Hypericum sinaicum, Diplotaxis harra* and *Phlomis aurea* (Gorge), *Juncus rigidus* (Slope), *Achillea fragrantissima* (Terraces), and *Diplotaxis harra* and *Achillea fragrantissima* (Wadi bed).

Due to variation in physiographic features that control moisture availability [65 and 66], slopes, gorges and terraces have abundant water supply, which may interpret the relatively rich vegetation cover, species richness, and species diversity [67]. Altitude and slope have a direct relation with roughness of soil surface, which plays an important role in effectiveness of rainfall.

The microhabitat of plant populations is made up of many biotic and abiotic components and their importance varies in both space and time. Quantifying the effect of the environment on a plant requires measurement of both the plant and environmental factors of interest. Abiotic components commonly measured in soil include moisture, texture, pH, nutrients, salinity, redox potential and cation exchange capacity. Good general descriptions of methodologies for describing and analysing the soil pertinent for plant studies are provided by [68 – 71].

Plant stages: Through the current study, all growth stages for *H. sinaicum* have been recorded within the fieldwork. The plant in the seedling stage was observed from 10th of March to 20th of April or in early vegetative stage, the late vegetative stage at the beginning of spring and flowering stage were observed in late spring. The plant completed fruiting stage maturation stage at in summer, and finally the plant reached to dryness state to finish their life cycle and the seeds in soil may be grow at the next spring to give a new individual. Observations recorded a great overlapping between *H. sinaicum* stages, the same individual carrying flowers and seeds in the same time were frequently observed. Observation showed the following:

- Vegetative stage (1st March-1st May)
- Flowering stage (10th May-1st Sep.)
- Fruiting stage (10th August- 20th Oct.)
- Dormancy stage (20th Oct- 1st March)

Species correlations: Most of endemic plants in SKP are restricted mostly to higher elevations of SKP mountains [56], This pattern of endemic species was associated with increase in the number of non-endemic plants. This is in part may be due to tremendous geological complexity of the mountains and habitat heterogeneity.

Depending on the presence and absence of each species associated with *H. sinaicum* cluster analysis were performed and results presented in Table 6. The similarity between different species was estimated according to Dice coefficient [72]. The similarity matrix was used in the cluster analysis. The cluster analysis was employed to organize the observed data into meaningful structures to develop taxonomies. At the first step, when each accession presents its own cluster, the distances between these accessions are defined by the chosen distance measure (Dice coefficient). However, once several accessions have been linked together, the distance between two clusters is calculated as the average distance between all pairs of accessions in the two different clusters. This method is called Unweighted Pair Group Method using Arithmetic Average (UPGMA) [72].

The associated index ratio between *H. sinaicum* and other associated species was extracted and separated alone in Table 6. Results found that *H. sinaicum* showed high rate of overlap with *Juncus rigidus* then with *Diplotaxis harra* and *Stachys aegyptiaca* and this agrees with field work observation.

Climatic variables analysis:_Results extracted from DIVA GIS software show us the optimum range of bioclimatic factors for *H. sinaicum* among different sites (Table 7). Annual precipitation and species distribution indicate that *H. sinaicum* naturally occurs in the low-rainfall zones (less than 150 mm), A well distributed rainfall within the range of 50–84 mm is best suited for *H. sinaicum* growth. The annual rainfall in all the collection sites ranged from 49 to 111 mm. The superimposed figure (Figure 3) of BIOCLIM annual Min-temperature, Max-Temperature and species distribution indicate that *H. sinaicum* naturally occurs in the low-temperature zones range from 8.09 – 11.08 C° at winter and from 19.4 - 22.28 C° at summer season.

Table 6. *Spatial similarity ratio between H. sinaicum and other associated species.*

No.	Species	Associated Index
1	*Juncus rigidus* Desf.	0.77
2	*Diplotaxis harra*. (Forssk.) Boiss	0.73
3	*Stachys aegyptiaca* Pers.	0.73
4	*Teucrium polium* L.	0.68
5	*Echinops spinosus* L.	0.66
6	*Mentha longifolia* (L.) Huds.	0.64
7	*Chiliadenus montanus* (Vahl) Brullo.	0.61
8	*Phlomis aurea* Decne.	0.61
9	*Origanum syriacum* (Boiss.) Greater & Burdet.	0.59
10	*Plantago sinaica* (Barneoud) Decne.	0.55
11	*Verbascum sinaiticum* Benth.	0.55
12	*Centaurea eryngioides* Lam.	0.52
13	*Achillea fragrantissima* (Forssk.) Sch. Bip.	0.50
14	*Tanacetum sinaicum* (fresen.) Delile ex Bremer & humphries.	0.48
15	*Alkanna orientalis* (L.) Boiss.	0.43
16	*Galium sinaicum* (Delile ex Decne.) Boiss.	0.43
17	*Zilla spinosa* (L.) Prrantl in Engl. & Prantl.	0.43
18	*Scrophularia libanotica* Boiss.	0.39
19	*Crataegus x sinaica* Boiss.	0.32
20	*Pterocephalus sanctus* Decne.	0.32
21	*Anarrhinum pubescens* Fresen.	0.30
22	*Seriphidium herba-album* (Asso) Sojak.	0.30
23	*Astragalus sieberi* DC.	0.27
24	*Ficus palmata* Forssk.	0.27
25	*Globularia arabica* Jaub. & Spach.	0.27
26	*Adiantum capillus-veneris* L.	0.18
27	*Arenaria deflexa* Decne.	0.16
28	*Nepeta septemcrenata* Benth.	0.16
29	*Ballota undulata* (Fresen.) Benth.	0.14
30	*Matthiola arabica* Boiss.	0.11
31	*Silene schimperiana* Boiss.	0.11
32	*Fagonia mollis* Delile.	0.09
33	*Ficus carica* L.	0.09
34	*Papaver rhoeas* L.	0.09
35	*Salvia multicaulis* Vahl.	0.09
36	*Thymus decussatus* Benth.	0.09
37	*Conyza stricta* Willd.	0.07
38	*Gymnocarpos decandrus* Forssk	0.07
39	*Peganum harmala* L.	0.07
40	*Rosa arabica* Crep.	0.07
41	*Salix mucronata* Thunb	0.07
42	*Asclepias sinaica* (Boiss.) Muschl.	0.05
43	*Bufonia multiceps* Decne	0.05
44	*Cynodon dactylon* (L.)Pers.	0.05
45	*Foeniculum vulgare* (Ucria) Cout.	0.05
46	*Launaea spinosa* (Forssk.) Sch. Bip. ex Kuntze	0.05
47	*Primula boveana* Decn. & Duby.	0.05
48	*Pulicaria undulata* (L.) C. A. Mey.	0.05
49	*Rubus sanctus* Schreb.	0.05
50	*Stipa parviflora* Desf.	0.05
51	*Trigonella stellata* Forssk	0.05
52	*Atraphaxis spinosa* L.	0.02
53	*Ballota kaiseri* Täckh., Svensk Bot. Tidskr.	0.02
54	*Bromus pectinatus* Thunb.	0.02
55	*Caylusea hexagyna* (Forssk.) M. L. Green.	0.02
56	*Colutea istria* Mill.	0.02
57	*Cotoneaster orbicularis* Schltdl.	0.02
58	*Crucianella ciliate*	0.02
59	*Deverra triradiata* Poir.	0.02
60	*Euphorbia obovata*	0.02
61	*Fagonia arabica* L.	0.02
62	*Farsetia aegyptia* Turra	0.02
63	*Launaea nudicaulis* (L.) Hook. F.	0.02
64	*Lotononis platycarpa* (Viv.) Pic. Serm.	0.02
65	*Malva parviflora* L.	0.02
66	*Morus alba*	0.02
67	*Ochradenus baccatus* Delile.	0.02
68	*Onopordum ambiguum* Fresen.	0.02
69	*Pergularia tomentosa* L.	0.02
70	*Phagnalon sinaicum* Bornm. & Kneuck.	0.02
71	*Phoenix dactylifera* L.	0.02
72	*Phragmites australis* (Cav.) Trin. ex Steud.	0.02
73	*Reichardia tingitana* (L.) Roth.	0.02
74	*Rhamnus dispermus* Boiss.	0.02
75	*Veronica anagalis –aquatica* L.,	0.02

The high elevation gradient and the dissected terrain in this area results in restricted gene flow over short distances, thus led to isolation of small populations of the species. In addition, the terrain and elevation gradient together lead to variable climatic patterns resulting in different selective regimes and this confirms results from [73 – 75]. Climate is one of the major factors governing the distribution of wild plant species, acting directly through physiological constraints on growth and reproduction [20 – 22] or indirectly through ecological factors such as competition for resources [23].

In the arid and semi-arid region, although there is a correlation between mean rainfall and vegetation productivity over the growing season and the soil moisture is regarded as the determining factor in vegetation conditions, considerable uncertainty of the vegetation response to climate change still remains [24]. This uncertainty is mainly due to our current limited understanding of the forcing/feedback surface–atmosphere interactions, which usually have complex temporal lag effects [77 – 79].

For example, warming temperature, combined with changes in precipitation, can affect vegetation growth through influencing soil moisture and nutrient availability [80 and 81]. [82] found that, in the arid and semi-arid mid-latitude areas of the northern hemisphere, vegetation net primary production can be affected by temperatures preceding the current period by up to 1 year.

There is an urgent need to integrate the knowledge derived from ecological, demographic and climatic approaches to species conservation in order to be able to formulate management strategies that take into account all different considerations. There is need for arranging and establishing number of enclosures for the species that should cover most of the different habitats that include the species based on the results of identification the species' Hotspots areas and ecological and botanical surveys. Priority should be given for the following areas: Abu Hebeik, Farsh Elromana, Elahmar and Wadi Elrotc. It is very urgent to use information illustrated in this study as a guideline when rehabilitation or restoration process takes place. It is recommended to use this study as a model for assessing rare and endangered plant species. There are urgent needs for *Ex-situ* conservation by seed bank and gene bank beside botanical garden which can be used also in commercial way to meet the continuous requirements for medicine manufacture.

Table 7. *Bioclimatic Conspectus for H. sinaicum habitats.*

	Climatic Variables	Min.	Max.	Average	Range
1	TMIN1	-0.6	2.5	0.52	3.1
2	TMIN2	0.3	3.4	1.43	3.1
3	TMIN3	3.6	6.8	4.77	3.2
4	TMIN4	7.3	10.3	8.35	3
5	TMIN5	10.8	13.6	11.84	2.8
6	TMIN6	13.4	16.3	14.45	2.9
7	TMIN7	16.2	19	17.16	2.8
8	TMIN8	15	17.9	16.01	2.9
9	TMIN9	13	16.1	14.09	3.1
10	TMIN10	9.9	13	11.02	3.1
11	TMIN11	5.4	8.4	6.45	3
12	TMIN12	2.8	5.7	3.88	2.9
13	Annual Min. Temperature	8.091667	11.08333	9.164167	2.991667
14	TMAX1	8.6	12	9.86	3.4
15	TMAX2	11.3	14.2	12.35	2.9
16	TMAX3	14.6	17.6	15.72	3
17	TMAX4	19.6	22.3	20.59	2.7
18	TMAX5	23.7	26.4	24.67	2.7
19	TMAX6	26.1	28.6	27.02	2.5
20	TMAX7	27.7	30.3	28.63	2.6
21	TMAX8	25.7	28.4	26.66	2.7
22	TMAX9	25.3	27.7	26.17	2.4
23	TMAX10	22.6	25.2	23.55	2.6
24	TMAX11	15.7	18.8	16.78	3.1
25	TMAX12	12.6	15.9	13.81	3.3
26	Annual Max. Temperature	19.45833	22.28333	20.48417	2.825
27	PREC1	10	25	19	15
28	PREC2	7	16	12	9
29	PREC3	7	15	12	8
30	PREC4	5	9	7	4
31	PREC5	0	1	0	1
32	PREC6	0	0	0	0
33	PREC7	0	1	1	1
34	PREC8	0	2	2	2
35	PREC9	0	1	0	1
36	PREC10	1	2	1	1
37	PREC11	4	7	6	3
38	PREC12	15	32	25	17
39	Annual Prec. Temperature	49	111	85	62
40	Annual Mean Temperature	13.78	16.68	14.82	2.91
41	Mean Monthly Temperature Range	11.2	11.37	11.32	0.17
42	Isothermality	39.96	40.42	40.27	0.46
43	Temperature Seasonality	601.59	618.85	611.59	17.26
44	Max Temperature of Warmest Month	27.7	30.3	28.63	2.6
45	Min Temperature of Coldest Month	-0.6	2.5	0.52	3.1
46	Temperature Annual Range	27.8	28.4	28.11	0.6
47	Mean Temperature of Wettest Quarter	5.83	8.95	6.97	3.12
48	Mean Temperature of Driest Quarter	19.65	22.37	20.63	2.72
49	Mean Temperature of Warmest Quarter	20.68	23.42	21.65	2.73
50	Mean Temperature of Coldest Quarter	5.83	8.95	6.97	3.12
51	Annual Precipitation	49	111	85.15	62
52	Precipitation of Wettest Month	15	32	25.03	17
53	Precipitation of Driest Month	0	0	0	0
54	Precipitation Seasonality (CV)	114.98	121.88	117.92	6.9
55	Precipitation of Wettest Quarter	32	73	56.19	41
56	Precipitation of Driest Quarter	0	2	0.77	2
57	Precipitation of Warmest Quarter	0	3	2.14	3
58	Precipitation of Coldest Quarter	32	73	56.19	41

Note: T (MIN, MAX, PREC) 1-12= Minimum Temperature, Maximum Temperature, and Precipitation from January to December,

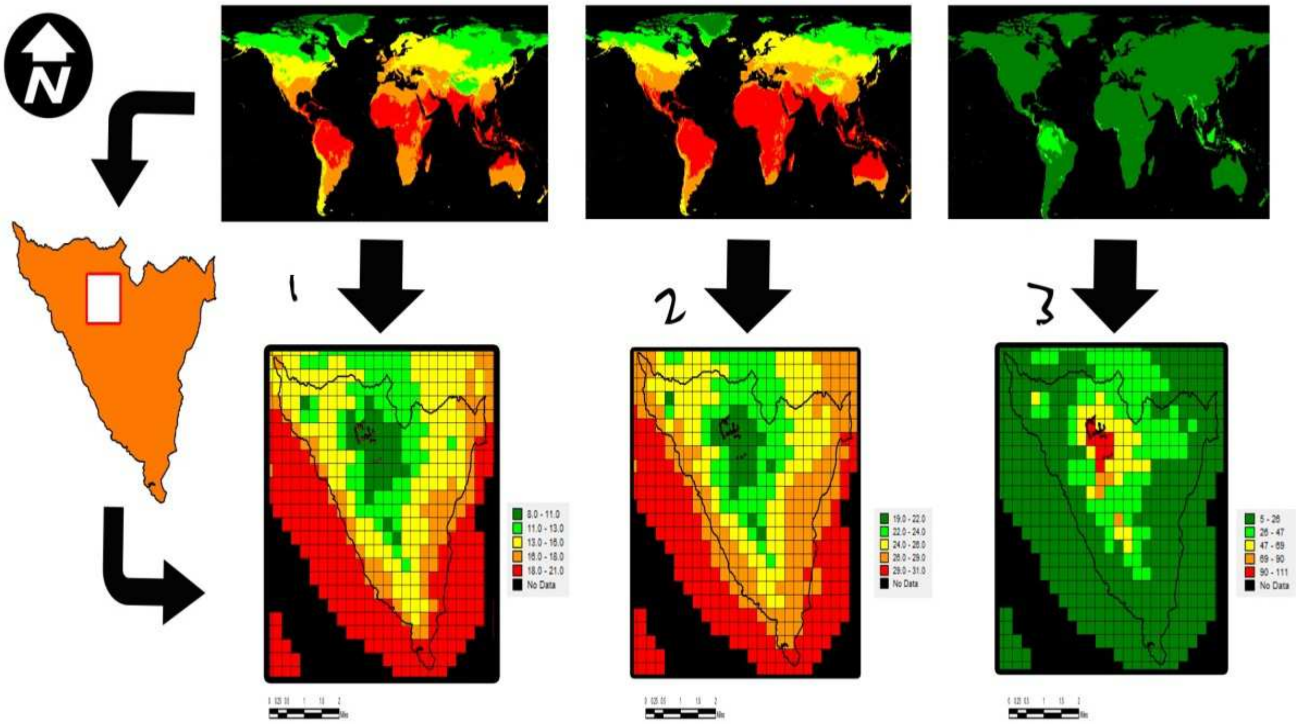

Figure 3. *Climatic variables within SKP, 1- Annual Minimum Temperature, 2- Annual Maximum and 3- Annual Precipitation.*

During the study we found that *H. sinaicum* affected by many threats that may case deterioration in population size by time. Feral donkeys, over collection and over grazing are the main observed threats. Its association with the presence of water makes the climate change and drought some of the main limited factors for its distribution. Being in restricted mountain ecosystem associated with altitudinal gradient, climate change will reflect its affect clearly as species shifting and fluctuation in population size. Many studies worked on this species ecology, but the real conservation status of it still not clear. The entire world distribution of this species is inside the St. Katherine Protectorate. Numbers of species subpopulations are already protected by fenced enclosures, and regular monitoring by SKP rangers takes place every two years to detect the effect of this protection on population trends. On average 48 checks are made every year to keep a watch on the current situation for the plant and its habitat, and to record any detrimental activities. Funded by UNEP, the Medicinal Plants Conservation Project tried to conserve some important species, *H. sinaicum* among them, using cultivation inside greenhouses as well as storing its seeds for future use. Studies were initiated of its ecological, morphological and reproductive ecology, and the threats to its existence. Much more is needed, however.

Consequently, it is necessary to carry out regular monitoring to keep updated on the population size, distribution & its trends. Researches and workshops must establish rabidly to start in Species Action/Recovery Plan. Both temperatures and acidification are expected to increase in the Mediterranean region in the next decades [83-85], and predictive models forecast a high extirpation risk for species in the mountains, especially in arid areas [86]. There are urgent needs to work fast in two directions to keep this species save; 1) *Ex-situ* conservation through a seed bank, genome resource bank, and artificial propagation, 2) *In-situ* conservation through rehabilitation and restoration, and fenced enclosures. It's important to carry out a wide range of educational and awareness activities in universities and scientific research centers about the sensitivity of this important threatened species.

4. Conclusion

In this study, we tried to detect the effect of environmental factors on the distribution of *H. sinaicum*. We test this species with different ecological and climatic variables and we found a different response to the different conditions. The population structure reflect that *H. sinaicum* highly affected by environmental conditions resulting from the spatial variation which lead to change in climatic conditions lead to change in edaphic factors which control the community structure. Shady and moist sites are the preferable habitat for target species. Results showed that most vegetation cover concentrated in areas with high amount of water and shade, also *Hypericum* presented as dominant species in sheltered and misted surface land as are recorded within field work. It's important to use the preferable ecological, climatic, and edaphic conditions extracted from this study when conservation process take place through rehabilitation. *Hypericum sinaicum* recommended from this study to be used as indicator species for measuring the changing in the surrounding environment especially global warming and drought. Rainfall irregularity in SKP and the correlation between this species and water mac the monitoring process is an important target for SKP management for detecting the changes in the plant community.

Acknowledgement

I would like to extend my thanks to all those who contributed time, suggestions and support during the planning, research and writing of this study. I am personally indebted to Eng. Mohammed Kotb the general manger of St. Katherine Protectorate, Prof. Dr. Om-Mohammed Khafagi, Dr. Elbially Hatab, Dr. Mohamed Metwally, and Mr, Hatem Shabana for their support and for the honest fruitful advice.

References

[1] B. Huntley, "Species distribution and environmental change". In: Maltby, E., Hodgate, M., Acreman, M., Weir, A. (Eds.), Ecosystem Management. Questions for Science and Society. Royal Holloway Institute for Environmental Research, Royal Holloway, University of London, Egham, 115–129. 1999.

[2] K. Brandon, "Policy and practical considerations in land-use strategies for biodiversity conservation". In: Kramer, R., van Schaik, C., Johnson, J. (Eds.), Last Stand. Protected Areas and the Defense of Tropical Biodiversity. Oxford University Press, New York, 90–114. 1997.

[3] R. Kramer, C. van Schalk, and J. Johnson, (Eds.), "Last Stand. Protected Areas and the Defense of Tropical Biodiversity". Oxford University Press, New York, 242 pp. 1997.

[4] M.E. Soule´, and M.A. Sanjayan, "Conservation targets: do they help?" Science, 279: 2060–2061. 1998.

[5] Anonymous, "A handbook for botanic gardens on the reintroduction of plants to the wild". Botanic Gardens Conservation International, 31 pp. 1995.

[6] N. Maxted, M.W. van Slageren, and J.R. Rihan, "Ecogeographic surveys". In: Guarino L, Ramanatha Rao V, Reid R (eds) Collecting Plant Genetic Diversity. 255-285. 1995.

[7] A.S. Ouédraogo, "Conservation and use of forest genetic resources". In: Proceedings of the XI World Forestry Congress, 13–22 October 1997, Antalya, Turkey. FAO, Rome, Italy. pp. 173–188. 1997.

[8] V.H Heywood, and M.E. Dulloo, "In Situ Conservation of Wild Plant Species: A Critical Global Review of Good Practices". Bioversity International, 174 pp, 2005.

[9] USDA. "The American Wild Relatives of Crops: In situ conservation guidelines. In Situ Subcommittee, Plant Germplasm Operations Committee". USDA, Beltsville, MD, USA. 1999.

[10] L. Boulos, "Flora of Egypt". Al hadara publishing, Cairo, Egypt, Vol. 1: 419 pp. 1999.

[11] A. Fayed, and K. Shaltout, "Conservation and sustainable use of Medicinal plants in arid and semi-arid eco-systems project, Egypt (GEF, UNDP) (project no: 12347/12348), Flora of Saint Catherine protectorate, final report. And Floristic Survey of the Mountainous Southern Sinai": Saint Katherine Protectorate, final report. 2004.

[12] P. Brang, W. Schönenberger, E. Ott, and R.H. Gardner, "Forests as protection from natural hazards". In: Evans, J. (Ed.), The Forests Handbook. Blackwell Science Ltd., Oxford, 53-81. 2001.

[13] M.A. Oliver, and R. Webster, "Semi-variograms for modeling the spatial pattern of landform and soil properties". Earth Surface Processes and Landforms, 11: 491–504. 1986.

[14] R.L. Weiser, G. Asrar, G.P. Miller, and E.T. Kanemasu, "Assessing grassland biophysical characteristics from spectral measurements". Remote Sensing of Environment, 20: 141–152. 1986.

[15] N.L. Stephenson, "Climatic control of vegetation distribution: The role of the water balance". American Naturalist, 135: 649–670. 1960.

[16] C.L. Turner, T.R. Seastedt, M.I. Dyer, T.G.F. Kittel, and D.S. Schimel, " Effects of management and topography on the radiometric response of a tall grass prairie". Journal of Geophysical Research, 97(D17): 18855–18866. 1992.

[17] G.M. Henebry, "Detecting change in grasslands using measures of spatial dependence with Landsat TM data". Remote Sensing of Environment, 46: 223–234. 1993.

[18] B.A. Endress, and J.D. Chinea, " Landscape patterns of tropical forest recovery in the Republic of Palau". Biotropica, 33: 555–565. 2001.

[19] Y. Bai, K. Broersma, D. Thompson, and T.J. Ross, "Landscape-level dynamics of grassland–forest transitions in British Columbia". Journal of Range Management, 55: 66-75. 2004.

[20] P. Walker, and K. Cocks, "Habitat: a procedure for modelling a disjoint environmental envelope for a plant or animal species". Global Ecology and Biogeography Letters, 1: 108–118. 1991.

[21] J. Franklin, " Predictive vegetation figureping: geographic modelling of biospatial patterns in relation to environmental gradients". Progress in Physical Geography 19: 474–499. 1995.

[22] A. Guisan, and N.E. Zimmerman, "Predictive habitat distribution models in ecology". Ecol. Model. 135: 147–186. 2000.

[23] G. Shao, and P.N. Halpin, "Climatic controls of eastern North American coastal tree and shrub distributions". Journal of Biogeography, 22: 1083–1089. 1995.

[24] [24] S.N. Goward, and S.D. Prince, "Transient effects of climate on vegetation dynamics: Satellite observations". Journal of Biogeography, 22: 549– 563. 1995.

[25] L. Boulos, "Flora of Egypt". Al hadara publishing, Cairo, Egypt, Vol. 3: 373 pp. 2002.

[26] IUCN, "IUCN Redlist Categories". Prepared by the Special Survival Commission. IUCN, Gland, Switzerland. 1994.

[27] T. Rezanka, and K. Sigler, "Sinaicinone, a complex adamantanyl derivative from *Hypericum sinaicum*". Phytochemistry, 68: 1272–1276. 2007.

[28] C.S. Piper, "Soil and plant analysis", Univ. of Adelaide press. Australia, 85-91. 1950.

[29] M.L. Jackson, "Soil chemical analysis", Prentice-Hall of India private, New Delhi, India. 498 pp. 1967.

[30] M.G. Barbour, J.H. Burk, and W.D. Pitts, "Terrestrial plant ecology". 2nd edition. Benjamin/Cummings, Menlo Park, California. 604 pp. 1987.

[31] J. Braun-Blanquet, J. "Plant Sociology". Translated by G.D. Fuller and H.S. Connard, McGraw-Hill Book Co., Inc. New York, London. 439 pp. 1964.

[32] D. Mueller-Dombois, and H. Ellenberg. "Aims and Methods of Vegetation Ecology". John Wiley & Sons, New York, 547 pp. 1974.

[33] K.S. Shukla, and P.S. Chandel, "Plant Ecology and Soil Science". S. Chand and Co. New Delhi, India. 1989.

[34] IUCN, Guidelines for Using the IUCN Red List Categories and Criteria. Version 11. Prepared by the Standards and Petitions Subcommittee. Downloadable from http://www.iucnredlist.org/documents/RedListGuidelines.pdf. 2014.

[35] A. Nelson, G. LeClerc, and M. Grum, "The development of an integrated Tcl/Tk and C interface to determine, visualize and interrogate infraspecifc biodiversity". Internal CIAT document. GIS Laboratory, CIAT, Cali, Colombia, 104-140. 1997.

[36] S. Zalat, F. Semida, F. Gilbert, S. El Banna, E. Sayed, H. El Alqamy, and J. Behnke, "Spatial Variation in the biodiversity of Bedouin gardens in the Saint Katherine Protectorate, South Sinai, Egypt". Egyptian Journal of Biology, 3: 147-155. 2001.

[37] K. Omar, O. Khafagi, and M.A. Elkholy, "Eco-geographical analysis on mountain plants: A case study of *Nepeta septemcrenata* in South Sinai, Egypt". Lambert Academic Publishing, 236 pp. 2012.

[38] A.M. Abd Elazeem, "Operation Wallacea in Egypt I-Apreliminary study on diversity of fungi in the world hirtage site of Saint Katherin, Egypt". Assiut Univ. J. of Botany, 38 (1): 29-54. 2009.

[39] R. Guenther, F. Gilbert, S. Zalat, Selimk and the volunteers of operation wallacea in Egypt, "Vegetation and grazing in the St Katherine Protectorate, South Sinai, Egypt". Egyptian Journal of Biology, 7: 55-65. 2005.

[40] R.H. Abd El-Wahab, "Landforms, Vegetation, and Soil Quality in South Sinai, Egypt". The Egyptian Society for Environmental Sciences. 1(2): 127-138. 2006.

[41] E. Ezcurra, M. Equihua, and J. Lopez-Portillo, "The desert vegetation of El Pinacate Sonora Mexico". Vegetatio 71: 49–60. 1987.

[42] S.K. Sharma, and V. Shankar, "Classification and ordination of vegetation of the Kailana catchments in the Indian Thar Desert ii. Woody Vegetation. Tropical Ecology 32: 269–286. 1991.

[43] E. Maarel, "Vegetation ecology". Blackwell Publishing company, 107-335. 2005.

[44] D.R. Taylor, L.W. Aarssen, & C. Loehle, "On the relationship between r/K selection and environmental carrying capacity: a new habitat templet for plant life history strategies". - Oikos 58:239-250. 1990.

[45] M. Zobel, "Plant species coexistence - the role of historical, evolutionary and ecological factors". –Oikos, 65:314-320. 1992.

[46] L.W. Aarssen, and B.S. Schamp, "Predicting distributions of species richness size in regional floras. Applying the species pool hypothesis to the habitat templet model". - Perspectives in Plant Ecology, Evolution and Systematics 5:3-12. 2002.

[47] J.L. Harper, "Population Biology of Plants". Academic Press, London, 892 pp. 1977.

[48] A.E. Magurran, "Ecological diversity and its measurement". Princeton University Press, Great Britain. 179 pp. 1988.

[49] M. El-Nennah, M.A. El-Kadi, R.N. Kamh, and S. El-Sherif, "Forms of copper and zinc in soils of Sinai". Desert Institute Bulletin, A.R.E. 31(B):129- 139. 1981.

[50] A.A. Ramadan, "Ecological studies in Wadi Feiran, Its Tributaries and The Adjacent Mountains". Ph.D. Thesis, Botany Department, Faculty of Science, Suez Canal University, Ismailia, Egypt. 1988.

[51] R.N. Kamh, M.A. El-Kadi, A.H. El-Kadi, and M.S.A. Dahdoh, "Evaluation of Mn forms in selected soils of Sinai". Desert Institute Bulletin, A.R.E. 39(1):183-197. 1989.

[52] A.M. Balba, "Management of problem soils in arid ecosystems". Lewis Publishers, CRC Press, Inc., New York. 250 pp. 1995.

[53] A.M. Moustafa, and A.M. Zayed, "Effect of environmental factors on the flora of alluvial fans in southern Sinai". Journal of Arid Environments 32: 431-443. 1996.

[54] A.A. Moustafa, and J.M. Klopatek. "Vegetation and landforms of the Saint Katherine area, Southern Sinai, Egypt". Journal of Arid Environments 30: 385-395. 1995.

[55] M.A. Helmy, A.A. Moustafa, R.H. Abd El-wahab, and K.H. Batanony, "Distribution behavior of seven common shrubs and trees growing in South Sinai, Egypt". Egyptian Journal of Botany 36(1): 53- 70. 1996.

[56] A. Khedr, "Assessment, classification, and analysis of microhabitats supporting globally significant Plant species": Abdel-Hamid A. Khedr, May-September 2007, 1-37. 2007.

[57] K.H. Batanouny, "Human impact on desert vegetation. In: Man's Impact on Vegetation", W. Holzner, M.J.A. Werger, and I. Ikusima, (eds.), Dr. W. Junk Publishers, London, 380 pp. 1983.

[58] Z.A.R. El-Karemy, and K.M. Zayed. "The vegetation and habitat types of Baha plateau, Saudi Arabia". Journal of Islamic Academy of Sciences 5 (4): 256-264. 1992.

[59] M.M. Abd El-Ghani, "Weed plant communities of orchards in Siwa Oasis–Egypt". Feddes Repertorium, 105 (5-6): 387-398. 1994.

[60] M.M. Abd El-Ghani, and W. Amer, "Soil-vegetation relationships in a coastal desert plain of southern Sinai, Egypt". Journal of Arid Environments, 55: 607-628. 2003.

[61] M.A. Ayyad, and M.Y. Ammar, "Vegetation and environment of the Western Mediterranean Coastal Land of Egypt". II. The habitat of inland ridges. J. Ecol., 62: 439-456. 1974.

[62] A. Danin, "Desert Vegetation of Israel and Sinai". Cana Pub. House, Jerusalem, Israel, 148 pp. 1983.

[63] M. Kassas, and K.H. Batanouny, "Plant Ecology in Sahara Desert". In: Cloudsely–Thompson, J. (ed.), Sahara–Desert, Oxford, Pergmon Press, 77–90. 1994.

[64] A.A. Moustafa, "Environmental gradients and species

distribution on Sinai Mountains". Ph.D. Thesis, Bot. Dept., Suez Canal Univ., Ismailia, Egypt, 115 pp. 1990.

[65] M. Kassas, “Certain aspects of landform effects on plant water resources". Bulletin de la Societe de Geographie d'Egypte, 29: 5-52. 1960.

[66] R. El-Ghareeb, and M.S. Shabana, “Distribution behavior of common plant species along physiographic gradients in two wadi beds of Southern Sinai". Journal of Arid Environments 19: 169-179. 1990.

[67] M.A. Ayyad, A.M. Fakhry, and A.A. Moustafa, “Plant biodiversity in Saint Catherine area of the Sinai Peninsula, Egypt". Biodiversity and Conservation 9: 265-281. 2001.

[68] G.P. Robertson, D.C. Coleman, C.S. Bledsoe, P. and Sollins, “Standard Soil Methods for Long-term Ecological Research". Oxford University Press, New York, 258-271. 1999.

[69] J. Benton-Jones, “Laboratory Guide for Conducting Soil Tests and Plant Analysis". CRC Press, Boca Raton, Florida, 256 pp. 2001.

[70] M. Pansu, J. Gautheyrou, and J.Y. Loyer, "Soil Analysis – Sampling, Instrumentation and Quality Control". Balkema, Lisse, The Netherlands 489 pp. 2001.

[71] K.H. Tan, “Soil Sampling, Preparation, and Analysis". CRC Press, Boca Raton, Florida. 2005.

[72] P.H.A. Sneath, and R.R. Sokal, " Numerical taxonomy — the principles and practice of numerical classification". (W. H. Freeman: San Francisco.) 573 pp. 1973.

[73] F.P. Day, and C.D. Monk, "Vegetation patterns on a Southern Appalachian watershed". Ecology, 55: 1064-1074. 1974.

[74] R.B. Allen, and R.K. Peet, "Gradient analysis of forests of the Sangre de Cristo Range, Colorado". Canadian Journal of Botany, 68: 193-201. 1990.

[75] R.T. Busing, P.S. White, and M.D. MacKende, "Gradient analysis of old spruce-fir forest of the Great Smokey Mountains circa 1935". Canadian Journal of Botany, 71: 951-958. 1992.

[76] P. Walker, and K. Cocks, " Habitat: a procedure for modelling a disjoint environmental envelope for a plant or animal species". Global Ecology and Biogeography Letters, 1: 108–118. 1991.

[77] B.H. Braswell, D.S. Schimel, E. Linder, and B. Moore III, "The response of global terrestrial ecosystems to interannual temperature variability". Science, 278: 870–872. 1997.

[78] H. Tian, J.M. Melillo, D.W. Kicklighter, A.D. McGuire, J. Helfrich, B. Moore III, & C.J. Vorosmarty, "Climatic and biotic controls on annual carbon storage in Amazonian ecosystems". Global Ecology and Biogeography, 9, 315– 335. 2000.

[79] L. Zhou, C.J. Tucker, R.K. Kaufmann, D. Slayback, N.V. Shabanov, and R.B. Myneni, "Variations in northern vegetation activity inferred from satellite data of vegetation index during 1981 to 1999. Journal of Geophysical Research, 106 (17): 269–283. 2001.

[80] J. Kindermann, G. Wurth, G.H. Kohlmaier, and F.W. Badeck, "Interannual variation of carbon exchange fluxes in terrestrial ecosystems". Global Biogeochemical Cycle, 10: 737–755. 1996.

[81] H. Tian, J.M. Melillo, D.W. Kicklighter, A.D. McGuire, J. Helfrich, "The sensitivity of terrestrial carbon storage to historical climate variability and atmospheric CO2 in the United States". Tellus, 51B: 414– 452. 1999.

[82] C.S. Potter, S.A. Klooster, and V. Brooks, "International variability in terrestrial net primary production: Exploration of trends and controls on regional to global scales". Ecosystems, 2: 36–48. 1999.

[83] P. Alpert, S.O. Krichak, H. Shafir, D. Haim and I. Osetinsky, "Climatic trends to extremes employing regional modeling and statistical interpretation over the E. Mediterranean". Global Planet Change 63:163–170, 2008.

[84] F. Giorgi and P. Lionello, "Climate change projections for the Mediterranean region". Global Planet Change 63:90–104, 2008.

[85] A.S. Issar, "The impact of global warming on the water resources of the Middle East: past, present and future". In: Zereini F, Ho¨tzl H (eds) Climate changes and water resources in the Middle East and North Africa. *Springer, Heidelberg*, pp 145–164, 2008.

[86] C.M. McCain and R.K. Colwell, "Assessing the threat to montane biodiversity from discordant shifts in temperature and precipitation in a changing climate". Ecol Lett 14:1236–1245, 2011.