

Community-based conservation and recovery program for the most threatened endemic plants in Egypt

CLP project ID: 8094

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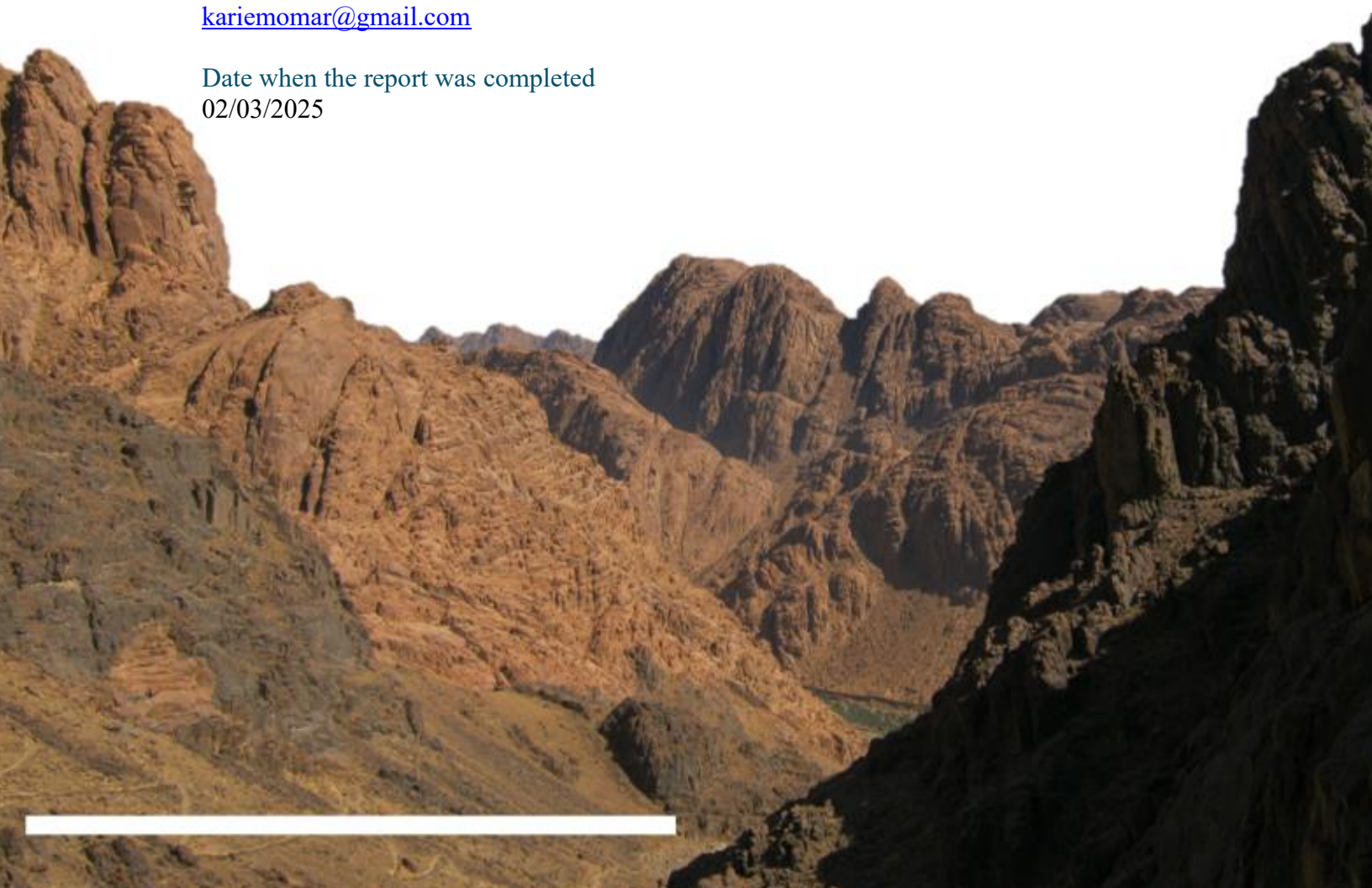
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Section 1

Summary:

Endemic plant species in Egypt are subject to significant deterioration, whether due to climate change or increasing human activities. Due to the confinement and isolation of these species in specific habitats, the impact of threats is more significant and faster. To improve knowledge about the conservation status of endemic species in the whole of Egypt as a baseline, followed by implementing a long-term conservation recovery program for the eight most globally threatened endemic plants in SCPA, a community-based management approach program based on research, capacity building, participation, and rehabilitation was established and implemented. Work was done to extract detailed information about the geographical distribution, population characteristics, ecology, habitat status, threats, and uses, in addition to suggestions for in situ and ex-situ conservation activities for the target species. This was followed by preparing management, work, operation, and monitoring plans for rehabilitation activities based on the results of field surveys, consultations, and analyses. Over 18 months, the seeds were collected, germinated in the laboratory, planted in greenhouses, transported, and outplanted in their natural habitats previously prepared with irrigation and protection from grazing as soon as they reached the appropriate age. Irrigation, monitoring, and evaluation operations are being carried out to measure success rates in survival. All of these parallel awareness-raising and capacity-building activities with relevant authorities.

Introduction

Plant biodiversity is rapidly declining due to increasing human activities, as well as climate change (Heywood & Dulloo, 2005; Brummitt et al., 2015; Prakash & Verma, 2022). When viewed from the perspective of conservation priorities, the threat is most acute and could lead to extinction for endemic plant species, which are often restricted to limited geographic areas, resulting in isolation and fragmentation (Stauder et al., 2020; Omar and Elgamal, 2021 a-d). As of now, Egypt hosts 2,145 plant species, along with 220 infraspecific taxa across 755 genera and 129 families (Boulos, 2009). The number of endemic plant taxa in Egypt shows significant variation among studies: Boulos (2009) reported 60 taxa, Hosni et al. (2013) identified 76, Abdelaal et al. (2018) noted 48, El-Khalafy et al. (2021) found 41, and Abd El-Ghani et al. (2024) recently indicated 70 endemic taxa.

These taxa encounter numerous escalating threats, both natural and human-induced. Threats encompass habitat loss resulting from urban, industrial, and agricultural expansion, in addition to road infrastructure development (Omar 2015, 2024; Omar & Nagi, 2017; El-Khalafy et al. 2021, 2024). Overgrazing, overcollection, mining, and logging activities contribute to habitat quality deterioration and the reduction of species distribution and population size (Shaltout & Eid, 2016; Omar & Elgamal, 2021 a-d). The impacts of climate change can be severe when interacting with these factors (Tolba & Saab, 2009; Kaky & Gilbert, 2017; Omar & Elgamal, 2021 a-d; Moustafa et al., 2024; Omar, 2024). This situation is identified as a primary factor contributing to species extinction in the region, necessitating urgent evaluation and prompt action to halt the degradation of natural resources (Shaltout & Eid, 2016; Valderrábano et al., 2018; Omar, 2024). As of now, 30 Protected Areas (PAs) have been established, encompassing approximately 14% of the total land area (Omar 2018 a,b; Ministry of Environment 2019), alongside the identification of 20 Important Plant Areas (IPAs - Shaltout & Eid, 2016). The objective of these efforts is to determine conservation priorities for the nation's critical plant biodiversity hotspots and to promote investment in Community-Based Natural Resource Management (CBNRM) (Omar & Nagi, 2017).

Despite numerous national and international measures, the threat persists, and in situ conservation efforts focused on the rehabilitation of endemic species in Egypt have been infrequently executed (Omar, 2024). Several activities received support from international organizations, including the Medicinal Plants Conservation Project funded by the UNDP, which focused on rehabilitating endemic and near-endemic species in the St. Catherine Protected Area (SCPA) from 2003 to 2012 (MPCP 2006; Ministry of Environment 2019). Additionally, individual initiatives aimed at conserving endemic species within the same protected area were also conducted (Omar and Elgamal 2014, 2021 b, c). Despite the initiatives undertaken, there remains a critical necessity to broaden the scope of field activities, particularly for species with limited geographical ranges that are at a heightened risk of extinction (Vallee, 2004; Maschinski et al., 2012; Volis, 2017; Valderrábano et al., 2018; Omar, 2024).

Conservation programs are notably improved through the utilization of tools such as the IUCN Red List and Species Distribution Models (SDMs). The IUCN Red List Categories and Criteria (IUCN, 2012) are widely recognized as the most comprehensive and authoritative framework for assessing the global risk of species extinction (Lamoreux et al., 2003; Omar & Elgamal, 2021 a; Cazalis et al., 2024). This method enhances objectivity and clarity in evaluating species extinction risk, offering a universally comprehensible framework for application (Rodrigues et al., 2006; IUCN, 2012). While species distribution models (SDMs) predict the geographic distribution of species, particularly in scenarios with limited data (Elith et al., 2006; Omar and Elgamal, 2021a–d). They evaluate habitat suitability across landscapes, aiding researchers and policymakers in formulating strategies to prioritize conservation efforts, identify hotspots, and determine suitable habitats for species rehabilitation (Ardestani et al., 2015; Cotrina Sánchez et al., 2020; Hunter-Ayad et al., 2020; Omar and Elgamal, 2021a–d; Elliott et al., 2022, 2024). SDMs have been extensively utilized to assess the effectiveness of protected area networks (Willis et al., 2009; Leach et al., 2013; Vale et al., 2018; Mi et al., 2023; Xin et al., 2024).

So, in this project, we will present a model to simulate a comprehensive conservation program to protect some endemic plant species in Egypt through the following steps: 1) Fully assess the ecological and conservation status of endemic plant species in Egypt, based on comprehensive in-depth review and detailed field surveys verification following the global IUCN Red List criteria; 2) Produce preliminary maps that can be developed later for potential hotspots of endemic species distribution based on SDMs; and 3) Implement a project to rehabilitate some endemic species at risk of extinction at t. Catherine Protected Area (SCPA) (Fig. 2), based on the information extracted from the previous steps. This, in turn, serves as an applied model that helps researchers in the region manage conservation programs and set priorities.

Overall Goal

Improving knowledge about the conservation status of endemic species in Egypt as a baseline, followed by implementing a long-term conservation recovery program for the eight globally threatened endemic plants in SCPA through a community-based management approach program, depends on research, building capacities, and participation.

Project Purpose

Focused conservation recovery actions based on new information for 8 globally threatened endemic plant species in the St. Catherine Protected Area are agreed upon and implemented with support from local communities and other key stakeholders as part of a new in situ and ex-situ national conservation strategy for Egypt's endemic plants (IUCN Red List).

Study area

The study is carried out in 2 locations:

- IUCN Red List Assessment: Whole Egypt (Fig. 1)
- Rehabilitation of threatened species: St. Catherine Protected Area (Fig. 2)

Egypt

Egypt is located mainly between the latitudes of 22° and 32°N and the longitudes of 25° and 35°E. The area spans 1,001,450 square kilometers, with elevations ranging from -133 meters in the Qattara Depression to 2,642 meters at St. Catherine Mountain (Fig. 1). Egypt is divided into three distinct climatic zones: the Mediterranean or semi-arid zone, the arid zone, and the hyper-arid zone (Shaltout, 2018).

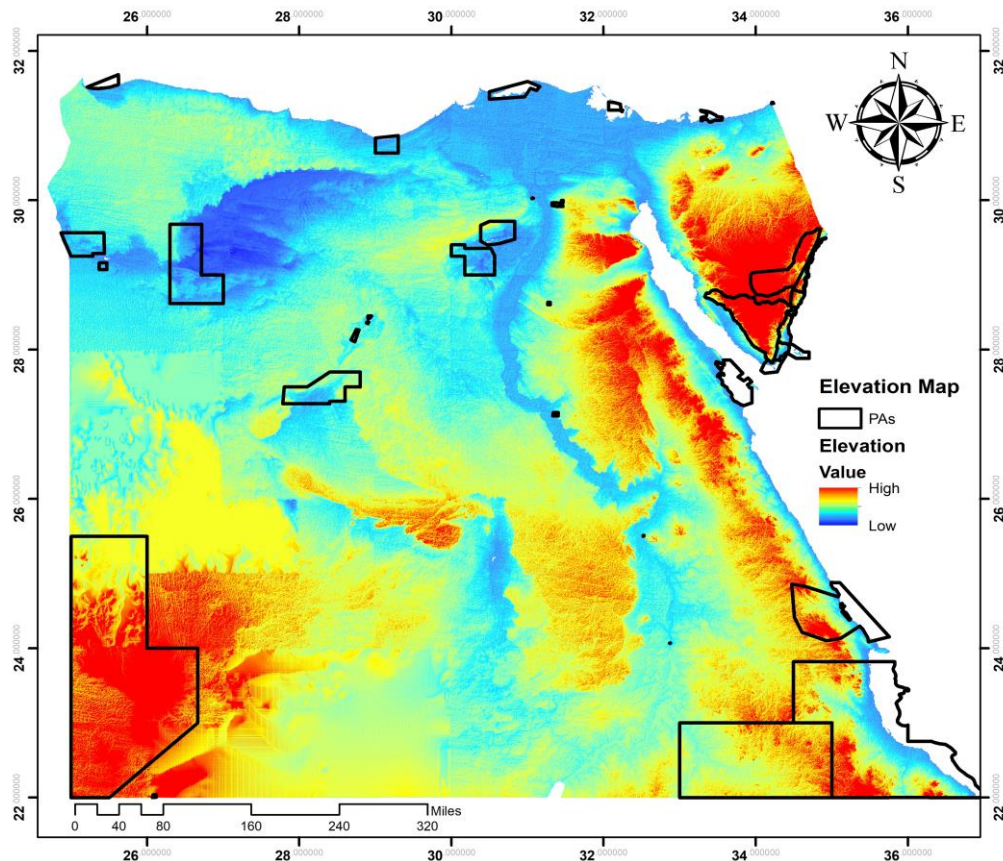


Fig. 1. Topographic map for the study area where the IUCN Red List Assessment taken place

St. Catherine Protected Area (SCPA): Rehabilitation Site:

Prime Ministerial Decree No. 613 established St. Catherine as a Natural Protectorate in 1988 under Law 102/1983 and established an Executive Council, headed by the Governor of South Sinai, to manage the Protectorate. In 1996, Prime Ministerial Decree No. 904 formally declared the St. Catherine Protected Area (Fig. 2); full protected-area status was given to approximately 4,350km² of largely mountainous terrain in South Sinai. The area includes the highest peaks in Egypt and contains a unique assemblage of natural resources, notably high-altitude ecosystems with surprisingly diverse fauna and flora and with a significant proportion of endemic species¹.

Protectorate's Values¹:

- The Protectorate includes the world-renowned Monastery of St. Catherine and Mt. Sinai, where Moses is said to have received the Ten Commandments; these places were listed as a cultural World Heritage Site in 2002.
- The protected area contains a unique landscape of high scenic quality, with diverse associated habitats, flora and fauna along with unique or traditional land-use patterns and social organisations as evidenced in historical human settlements, local customs, livelihoods, and religious beliefs.
- As much of the area is inaccessible to motor vehicles a major part of the Protectorate remains in a largely natural state.
- The Protectorate is included in the BirdLife International, *Directory of Important Bird Areas in Egypt*.
- A 641km² core area of the Protectorate has been listed as a World Heritage Status on "Cultural Criteria" and it will be further listed as an Associative Cultural Landscape under "Natural Criteria."
- The protected area provides opportunities for public enjoyment through recreation and tourism within its normal lifestyle and economic activities.
- The SCPA contains a wide range of micro-habitats and landscapes that are a consequence of varying microclimatic conditions, a wide range of altitudes, and variable topography.
- Recently, the Protectorate defined as one of 20 Important Plant Areas (IPA) in Egypt by IUCN (Radford *et al.* 2011).
- The St. Catherine Protected Area is an area of great biological interest; it has been recognized by IUCN, as one of the most important regions for flora diversity in the Middle East. It contains 472 plant species and about 31% of Egypt's endemic flora and a very high proportion of Egypt's endemic fauna, including butterflies.
- It is currently recognized as one of the central regions for flora diversity in the Middle East by the IUCN the World Conservation Union and Worldwide Fund for Nature (IUCN, 1994).

¹ (SCPA Management Plan 2003)

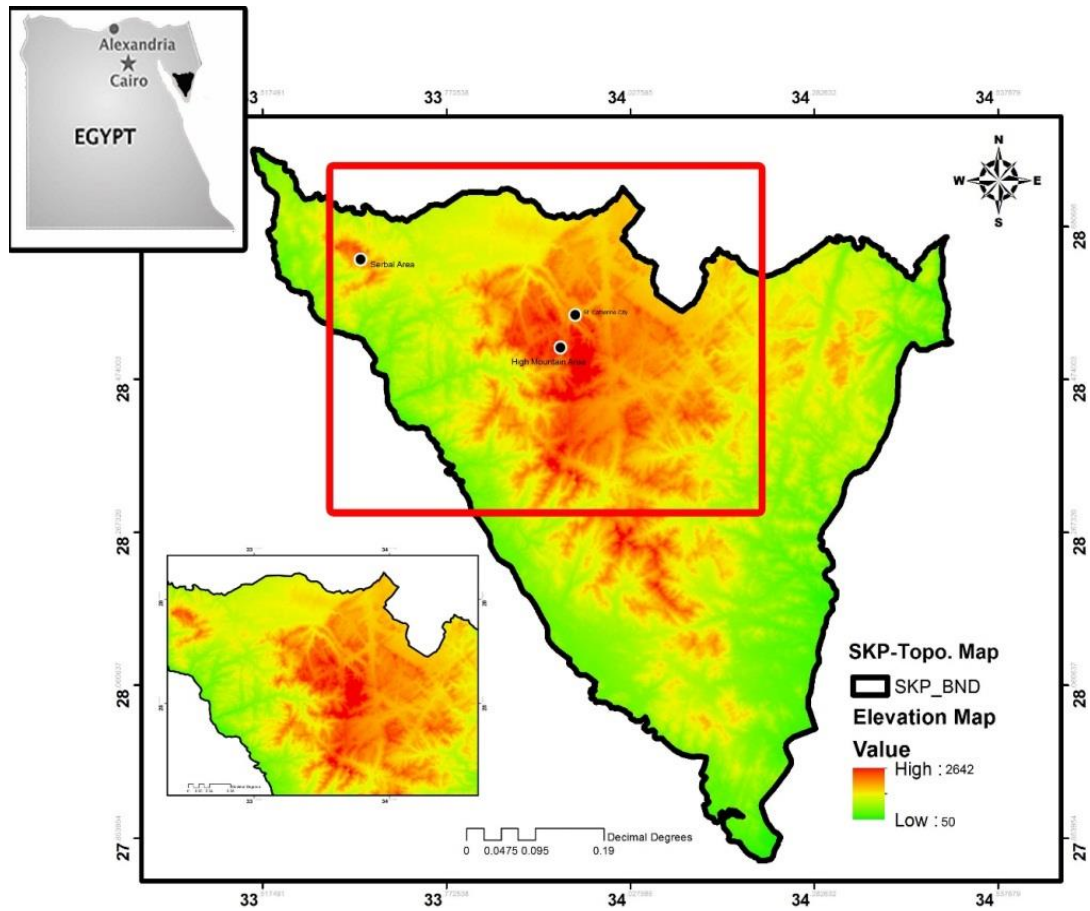


Fig. 2. Map for the rehabilitation area – St. Catherine Protected Area



Section 2

Aim and objectives

Improving knowledge about the conservation status of endemic species in Egypt as a baseline, followed by implementing a long-term conservation recovery program for the eight globally threatened endemic plants in SCPA through a community-based management approach program, depends on research, building capacities, and participation. This process includes:

1. IUCN Red List Assessment for all endemic plant species of Egypt (50 species), which includes geographical distribution, population characteristics, ecology and habitat, threats, conservation priorities, future and potentially suitable habitat, and suggests appropriate strategies for conservation (country scale);
2. Set up a recovery plan for the 8 most officially globally threatened species through community participation to select the appropriate sites for the recovery program approved by the local community (SCPA Scale);
3. On-site species recovery by increasing the Extent Of Occurrence (EOO), Area Of Occupancy (AOO), and population size through re/introduction and enrichment planting technique;
4. Raising awareness and capacity building among different stakeholders.

Changes to original project plan

- There was no change or amendment to the previously proposed plan. We surveyed Egypt transversely from the Red Sea to the Mediterranean Sea, and we also surveyed it longitudinally from north to south in search of the presence of endemic plant species. We expected from the beginning that we would not be able to find all of them, according to discussions with national authorities and experts in the field. They warned of the extinction of some plant species due to intense human activities in the lakes, the northern coast, and the Nile.
- The rise in the price of the dollar against the pound (300%) greatly affected some of the project's activities, especially those that require the presence of equipment, accommodation, and transportation expenses. However, we reduced the cost of activities, consuming a large portion of the money, and saved the original money as a deposit in the bank to recover what was lost and guarantee the sustainability of the project's activities.
- To reduce expenses and activate effective participation, we have participated in many environmental events and workshops in cooperation with bodies such as the Ministry of Environment, UNDP, the Library of Alexandria, and some universities.
- The team worked in every direction to reduce the time needed to achieve the project objectives.
- We did not face any administrative problems from the beginning.

Methodology

Objective 1: IUCN Red List Assessment for 50 endemic plants

Based on the previous desk review, the team visited hotspots of endemic plants of Egypt (Sinai, Red and Mediterranean Seas, River Nile, Eastern, and the Western Desert). They collected field data about geography (EOO, AOO), ecology, population size, preferable habitat, microhabitat status and threat trend, and extinction risk following the IUCN Standards and Petitions Committee (2024). The distribution of each target species was recorded using quadrat sampling techniques (Cox, 1990) based on history and species presence (2500-3000 quadrats). A GPS fix was recorded for mapping in ArcGIS 10.9. and Ecological Niche Modeling (MaExent) (Omar & Elgamal, 2021c). The Geospatial Conservation Assessment Tool (GeoCAT—<http://geocat.kew.org/>) calculated the EOO and AOO. Climatic features were recorded using the local weather station. Soil properties (chemical and physical) were analyzed based on Allen et al. (1976) and Jackson (1967). Vegetation characteristics (density, cover, abundance, and associated species) within each quadrat were recorded based on Braun-Blanquet (1964). Firstly, threat timing, scope, severity, and impact score were determined according to the IUCN Threats Classification Scheme ver. 3.2. This step was repeated after the project was finished to measure the changes. The team coordinated with the local community in the targeted areas to discuss the threats, the degree of their impact and spread, and ways to reduce them without affecting the social and economic activities of the community.

Objective 2: Recovery Plan for the eight most threatened endemic species

These species were chosen for several reasons, including their presence inside a nature reserve, tiny geographical and population size, rapid deterioration, international support urgency (Valderrábano et al., 2018), cost, and data availability needed for rehabilitation. Based on the available and updated field data and our MaExent model maps, the team, along with local community leaders and other stakeholders, met to select and approve the target recovery sites based on ecological suitability, accessibility, threat level, water availability, local community ownership, implementation cost, etc. (Omar and Elgamal, 2021 a,b).

Objective 3: Recovery program

After selecting the recovery sites, which were in the high mountain area (1600-2400 m), the team collected the seeds of the target species within the fruiting season (Sep.–Dec. 2022) following ENSCONET (2009). Seeds were then cleaned and treated for germination tests (Come, 1970; Yang et al., 1999). Seedlings were prepared (several germination treatments for the best products were done in the laboratory following Gutterman (2012), Omar, and Elgamal (2014)). The team transferred each site's recovery equipment and facilities and prepared the irrigation system for planting use. The recovery team established protective enclosures (fences) within each selected site (8–12 sites) to prevent external threats. After sufficient time from germination (2-4 months) in soil bags inside the greenhouse (from 10 to 100 individuals for each target species—seed availability), they were transported and transplanted into their selected recovery sites (specific holes). The recovery process followed what Hatab (2009), Abdullah et al. (2012), and Omar and Elgamal (2021d) had done in the same area. Based on seed

availability and germination rate results, from 300 to 600 seedlings for *Primula*, 5 to 10 for *Rosa*, 20 to 50 for *Micromeria* and *Silene*, and 100 for each of the rest were planted in the wild. After planting target species in the wild, the team and local community set and implemented an action plan for irrigation ratios and time intervals based on each species' needs—monitoring and evaluation (June 2023 to the end of the project and 5 years after). A monitoring schema with time visit intervals (weekly, monthly, semi-annual, and annual) was created and implemented by the recovery team, PA researchers, and local community guards. Adaptive management with an action plan was created to ensure the recovery program's sustainability after the project's end. Ex-situ conservation (Sep. – Dec. 2023): Seeds were collected and stored in the National Seed Bank based on ENSCONET (2009).

Objective 4: Awareness and capacity building

The team and volunteered experts in biodiversity conservation and data analysis engaged in a range of activities, including 8-12 training sessions, 2-4 meetings, 5 community field visits, 3-5 seminars, and 3-6 scientific articles. The places were determined based on the event (protected areas, universities, scientific centers, NGOs, etc.).

Output and Results

Objective 1: To assess the ecological and conservation status of all endemic plant species of Egypt (Red List for about 50 species) and to identify and rank threats, socio-cultural environment interaction, conflicts, conservation priorities, potential suitable habitat for better distribution and suggest appropriate strategies for conservation (country scale)

- Based on the spatial data extracted from the comprehensive desk survey, biogeographic areas and priorities for field visits were identified and mapped. The field surveys were conducted from July 2022 to March 2024, visiting more than 100 key sites and covering about 20 protected areas (St. Catherine, Ras Mohammed, Abu Gallum, Taba, Nabq, Red Sea Islands, Wadi El-Gemal–Hamata, Elba, Wadi Allaqi, Zaranik, El Bourollus, Ashtum El Gamel, El Omayed, Siwa, White Desert, Wadi Degla, Qarun, Wadi El Rayan, Wadi El Assuti, and Salouga and Ghazal PAs), with a total area of approximately 175 thousand square kilometers.
- Data about distribution, population characteristics, habitat/microhabitat preferences and status, threats, conservation actions in place, etc. were collected from more than 1000 points, covering a variety of habitats, including mountainous areas (such as Sinai and the Red Sea), desert (Eastern and Western Deserts), coastal (Red Sea and Mediterranean Sea), in addition to the Nile River, oases, swamps, marshes and lakes (both coastal and inland lakes).
- Among the many endemic species reported in previous studies, 49 were identified in the Egyptian flora during this study, distributed among 21 families and 45 genera. The major family Asteraceae was the most represented, with 7 species (15.5%), followed by the families Caryophyllaceae (6 species) and Fabaceae (5 species). Four species were recorded for each of the Brassicaceae and Lamiaceae families, and three species for each of the Asparagaceae, Plantaginaceae, and two species for each of Amaryllidaceae, Solanaceae, and Polygonaceae, while the other eleven families presented one species each.
- Based on the results of the field survey and the databases created from the sources mentioned in the methodology section, it was concluded that endemic plant species are distributed in about 20 governorates out of 27, i.e., 74%. The following governorates account for the highest number of species: South Sinai (18 species), Matrouh (13 species), Alexandria and North Sinai (12 species for each), and the Red Sea (7 species), whether the species are restricted to those governorates or shared with other governorates.
- Based on the IUCN Habitats Classification Scheme, endemic plants are listed to be distributed in rocky areas (e.g., inland cliffs, mountain peaks), deserts (Sahara), and artificial-terrestrial (e.g., arable land). It was observed that these taxa were mainly distributed within sandy formations (15 taxa—30.6%), mountains (13 taxa—26.5%), rocky surfaces and canal banks & well surrounds (7 taxa for each—14.3%), cultivated lands (5 taxa—10%), and calcareous land (2 taxa—4%) (Fig. 3). A total of 32 taxa were recorded in one habitat, 13 in two habitats, and 4 in three or more habitats.
- The type, degree, and impact of threats varied according to distribution areas, habitats, and human activities. It was observed that 44 taxa are impacted by both biological resource use (Gathering terrestrial plants and Logging & wood harvesting), and climate change & severe weather (drought, floods, extreme events), 29 taxa by agriculture & aquaculture (Livestock grazing & ranching, and Marine & freshwater aquaculture), 24 taxa by Human intrusions & disturbance (Recreational & work activities); 23 taxa by each of Residential & commercial

Objective 2: Set up a recovery plan for the 8 officially globally threatened species through community participation in the eco-geographical study (fieldwork) to extract the necessary information on the potential habitat to select the appropriate sites for the recovery program approved by local community (SCPA Scale)

Based on field studies, a review of previous research and reports, satellite images and field survey investigations, detailed information was extracted about geographical distribution, population characteristics, ecology and habitat status, threats, and uses, along with suggestions for conservation activities inside and outside the site.

- *Range Description:* It was noted that the target species are restricted to mountainous areas higher than 1,000 meters above sea level. Its extent of occurrence (EOO) ranges from 13 km² for *Primula boveana* to 330 km² for *Phlomis aurea*. The area of occupancy (AOO), based on a 2 x 2 km grid over these sub-populations, ranges from 6 km² for *Primula boveana* to 140 km² in *Phlomis aurea*.
- Target species populations are randomly located and dispersed in space. Dispersion and fragmentation have been observed among populations due to mountainous barriers and differences in topography. Population size varied considerably among the target species, from less than 100 individuals in the case of *Rosa arabica* to several thousand in the case of *Phlomis aurea*.
- The species density varies from site to site based on the target species. However, the highest density for all target species is concentrated in the high mountain areas, especially the Wady Gebal, *Elgabal* Elahmar, and Gabal Katherine areas.
- All target species are perennial with a woody base. All of them are herbs except *Phlomis aurea* and *Rosa arabica* (shrub). It has been observed that flowers mostly appear in late spring (in the case of *Rosa arabica*, it may be delayed), and reproduction is done by seed in late summer. Target species are restricted to montane wadis with granite rocky ground of mountain areas, especially at gorges, slopes, wadi beds, and cliffs (*Primula*, *Silene*, and *Micromeria*) with steep slopes of up to 90°.
- The population of the target species is considered severely fragmented as the mountainous habitat acts as a barrier between the small subpopulations, and as many of these subpopulations have low viability due to destructive overgrazing, causing loss of reproductive organs in the case of *Anarrhinum*, *Micromeria*, *Silene*, *Euphorbia*, and *Bufonia*.
- The optimum density and frequency for the target species (endemics and near endemics) were recorded at an elevation between 1600 and 2000 m asl. This can be explained by topography being a principal controlling factor in vegetation growth and soil type. Elevation, aspect, and slope are the three main topographic factors controlling vegetation distribution and patterns in mountain areas. Among these three factors, elevation is the most important. In many respects, elevation, aspect, and slope determine the microclimate and, thus, large-scale spatial distribution and vegetation patterns.
- St. Catherine Protected Area is one of the few protected areas where local communities work and live within its boundaries. These interactions sometimes cause conflicts and threats to the PA's natural resources. *Bufoniamulticeps*, *Micromeria serbaliana*, *Silene oreosinaica*, *Anarrhinum pubescent*, and *Rosa arabica* are the most negatively affected species by grazing and feral donkeys.
- Due to climate change, the wild population of these species could be in extreme danger shortly. The most important natural threats are long-lasting droughts, the difficulties of some species to reproduce new generations as a result of long seed dormancy (*Rosa arabica*), or overgrazing by herbivores that even eat the reproductive organs and decrease the chance for the possibility of creating new generations

(observed in *Euphorbia obovata*, *Bufo multiceps*, *Anarrhinum pubescens*, and *Micromeria serbaliana*, and *Silene oreosinaica*), the very scarce irregular precipitation during the year, the fragmentation inherent to its habitat, and the possibility that rare floods may cause harm such as uprooting (1-5% loss observed). Water is being relocated in some localities from elevated wadis rich in water to supply to low wadis. This activity leads to water consumption from wells and results in habitat deterioration and declines in population size.

- Most of the threat's root causes come from a lack of awareness, weak law enforcement, lack of suitable strategies, weak financial support, and lack of stakeholder cooperation. In general, these species are severely threatened by both the natural (aridity of the area and climate-flooding) and human factors (overgrazing by domestic animals and feral donkeys, over-collection, and unmanaged tourism activities). These factors are driving the target species towards the verge of extinction. *Euphorbia obovata*, *Bufo multiceps*, *Anarrhinum pubescens*, *Micromeria serbaliana*, and *Silene oreosinaica* are the species most negatively affected by these threats.
- Due to the presence of the target species in the high mountains, close to each other and sharing the same areas, the SDM results were relatively close in that the most suitable areas for the species presence are the areas located in the high mountains in the middle of the north of the SCPA.
- Based on the ecological and conservation status assessment and SDMs results, the proposed rehabilitation sites were chosen based on the specific criteria, the most important of which are suitability to the habitats, climatic and topographical conditions, availability of water, and protection from grazing and gathering (creating iron fences or planting inside Bedouin gardens), in addition to their proximity to the local communities who will carry out agriculture and irrigation water.
- Based on field surveys, consultations, and analysis results, a management, action, operation, and monitoring plan for rehabilitation activities was produced.



Fig. 4. Recorded threats according to different habitats in Egypt

Objective 3: On-site implementation of recovery plan by Increase the Extent Of Occurrence (EOO), Area Of Occupancy (AOO), and population size of the 8 target species through in situ conservation which include re/introduction, and enrichment planting technique (SCPA Scale)

- Due to the presence of the target species in the high mountains, close to each other and sharing the same areas, the SDM results were relatively close in that the most suitable areas for the species presence are the areas located in the high mountains in the middle of the north of the SCPA.
- Based on the ecological and conservation status assessment and SDMs results, the proposed rehabilitation sites were chosen based on the specific criteria, the most important of which are suitability to the habitats, climatic and topographical conditions, availability of water, and protection from grazing and gathering (creating iron fences or planting inside Bedouin gardens), in addition to their proximity to the local communities who will carry out agriculture and irrigation later.
- Based on the results of field surveys, consultations, and analysis, a management, action, operation, and monitoring plan for rehabilitation activities were produced.
- Based on these criteria, 8 main sites were selected (representing 10 cultivation points). The difference in species in microhabitats means that some sites include all species, and some include one or two species.
- The targeted species differed in their cultivation methods. All were grown from seeds placed in soil and bags, except for *Primula boveana* and *Rosa arabica*.
- *Primula boveana* is restricted to certain microhabitats, such as steep slopes, cliffs, or caves with a very high and very shallow rocky soil layer. This makes it impossible to transport them as complete seedlings, which "propagate inside greenhouses in plastic bags." Therefore, we treated the seeds and then planted them directly by scattering them in selected sites rich in water.
- Unfortunately, we were not able to collect *Euphorbia obovate* Decne seeds during the two seasons (summer 2022 and 2023) because *E. obovate* individuals have very few fruits compared to the seeds and fruits destroyed by insects, especially ants.
- At the beginning of the growing season, temperatures were expected. Meanwhile, the germination and seedlings' survival results were within their normal range. *Micromeria serbaliana* and *Silene oreosinaica* were grown for the first time. The germination rate was 30%, and the survival rate was 22% and 17%, respectively. *Phlomis aurea*'s had a germination rate of 87%, while *Anarrhinum pubescens* and *Bufonia multiceps* had a germination rate of 50%. Each species' survival rate ranged from 84% to 47%.
- During the summer months, unexpected high heat waves caused the survival rate of seedlings to decline sharply. It decreased significantly until it reached zero in four species (*Micromeria serbaliana*, *Silene oreosina*, *Bufonia multi ceps*, and *Anrrhinum pubescent*). Then, we had to collect the seeds of those species again and plant them to reach the desired number of seedlings.
- After approximately one year of *Primula boveana* cultivation, we obtained 320 stable seedlings distributed in 5 subpopulations with different sizes.
- A total of 20 rooted branches from *Rosa arabica* were planted in 5 sites. After 16 months of planting and irrigation, the survival rate exceeded 85% (17 new individuals), and these individuals produced leaves, branches, flowers, and fruits.

- In October 2023, seedlings were transported by cars and camels through rough terrain, with 120 seedlings per site, 40 seedlings each for *Anarrhinum pubescent*, *Bufonia multiceps*, and *Phlomis aurea* in Wadi Gharba and Abou Walea. El—esbaia was planted with 110 seedlings: 42 seedlings for *Anarrhinum pubescent*, 40 for *Phlomis aurea*, and 30 for *Bufonia multiceps*.
- One year after planting in natural soil, the monitoring results showed differences in the responses of the target species, both in terms of survival rates and growth parameters. For survival rates, *Anarrhinum forskaohlii* subsp. *pubescens* ranged between 25% and 62.5%. As for *Phlomis aurea*, survival rates ranged between 37.5% and 62.5%. *Bufonia multiceps* had the lowest survival rate, ranging between 20% and 40%. The example of the *Silene* and *Micromaria* experiment is a prominent one, where the results showed that the average survival rate after 8 months was about 15% for *Micromaria* and 40% for *Silene*. The region was exposed to a wave of high temperatures that led to the collapse and death of all individuals in July 2024.
- For *Primula boveana*, one year after planting seeds directly in the moist suitable habitats, the survival rate ranged between 0.1% and 6.6%. After separating and transferring the 20 rooted branches from *Rosa arabica*, they were planted in 5 main sites. The monitoring results showed a very high survival rate in four sites, ranging from 66 to 100%. In the end, 13 new individuals (65%) remained in the wild after one year of planting.

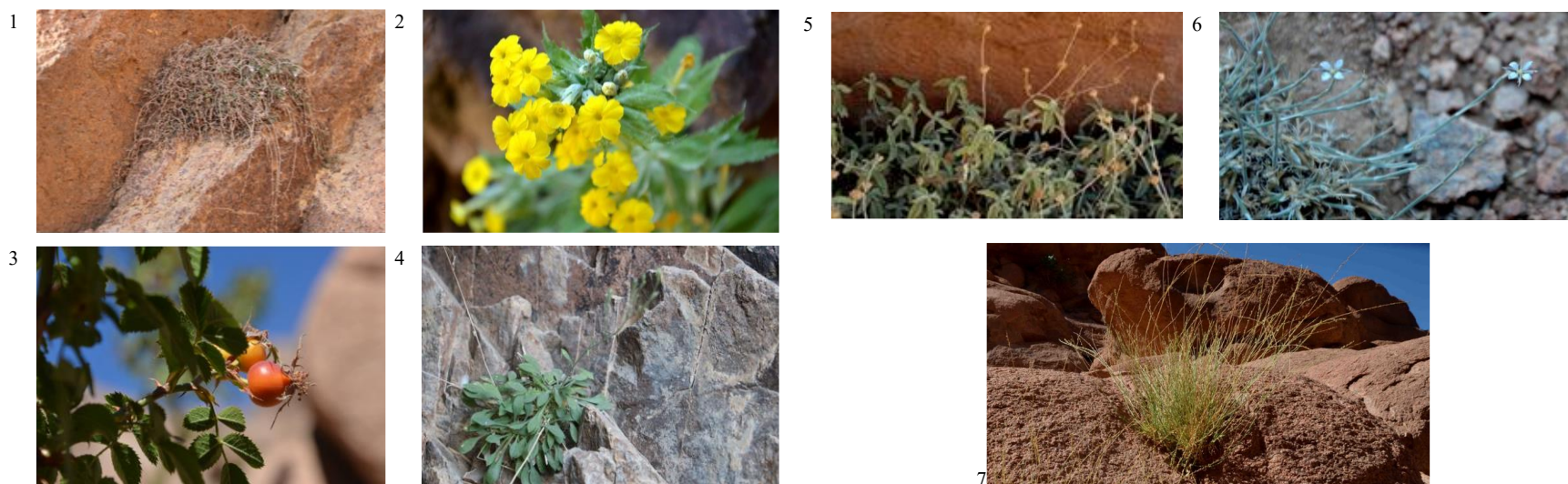


Fig. 5. Target species for rehabilitation; 1=*Micromeria serbaliana*, 2=*Primula boveana*, 3=*Rosa arabica*, 4=*Silene oreosinaica*, 5=*Phlomis aurea*, 6=*Bufonia multiceps*, and 7=*Anarrhinum forskaohlii* subsp. *pubescens*

Fig. 6. Rehabilitation process within St. Catherine Protected Area

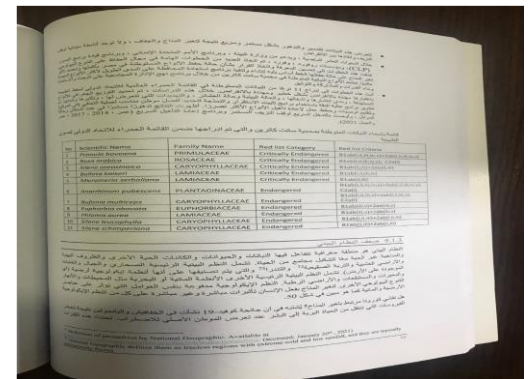
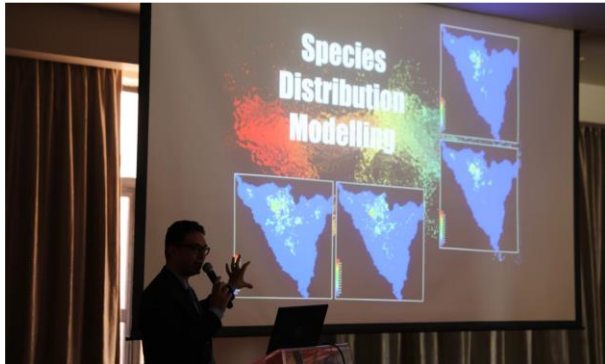
Objective 4: Raising awareness and capacity building among different stakeholders

Regarding the capacity-building and awareness program:

- In cooperation and coordination with the Ministry of Environment, we have trained 35 male and female protected areas researchers in Egypt on monitoring, conservation of threatened species, geographical analysis, modeling, and planning programs for protected areas.
- We also trained 30 young men and women to monitor plant species and their importance in protected areas in southern Egypt.
- In cooperation with the Library of Alexandria and the Ministry of Environment:
- We trained 80 male and female students from the faculties of science and agriculture at the universities of Alexandria, Kafr El-Sheikh, and Damanhour on conserving endangered biological diversity and assessing threats through a year-long series of discussion sessions.
- We also trained 16 male and female students from several governorates (Cairo, Alexandria, Minya, and Kafr El-Sheikh) on geographic information systems and modeling programs for managing and preserving biological diversity.
- Many lectures (4-6) were also given on conserving endangered species in environmental events and workshops targeting researchers, decision-makers, government agencies, and the private sector.

Regarding the documentation program:

- In cooperation with the Ministry of Environment and UNDP-EG, we held a series of consultations with decision-makers to include the project activities, objectives, expected results, and the role of CLP in university and pre-university education curricula as a taught course. We produced an educational curriculum for postgraduate students under the title “Species Conservation Management Program.”
- Sections on the conservation of endemic plant species and the role of CLP were also added to the primary education curricula.
- To support the Nature Conservation Sector responsible for managing PAs in Egypt, a guide with planning steps for conserving plant species in Egypt’s PAs was prepared, and the Ministry of Environment officially approved it.
- The chapter “Climate Change and Endemic Plants—Reliance and Challenges” was published in a book entitled “Egypt and Climate Change,” which was presented on Science Day at the Conference of the Parties to the United Nations Climate Change Convention (COP27), Egypt 2022.



Communication & Application of results

In this project, we presented a model to simulate a comprehensive program for the conservation of some endemic plant species in Egypt through the following steps: 1) A complete assessment of the ecological and conservation status of endemic plant species in Egypt, based on a comprehensive and in-depth review and verification of detailed field surveys according to the IUCN Red List criteria; 2) Production of preliminary maps that can be developed later for potential hotspots of endemic species distribution based on species data models; and 3) Implementation of a project to rehabilitate some endemic species at risk of extinction in the St. Catherine Protected Area, based on the information extracted from the previous steps. This in turn was used as an applied model in achieving other goals such as education and raising environmental awareness for all segments of society, which helped researchers in the region understand conservation program management methods and set priorities in a practical way.

Monitoring and Evaluation

To assess the effectiveness of the project's activities, several Monitoring and Evaluation (M&E) measures were undertaken:

1. **IUCN Red List Assessment:**
 - Conducted for all 50 endemic plant species in Egypt.
 - Evaluated geographical distribution, population characteristics, ecology, habitat, threats, and conservation priorities.
 - Suggested appropriate conservation strategies at a country scale.
2. **Recovery Plan Development:**
 - Formulated a recovery plan for the 8 most globally threatened species.
 - Engaged community participation to select appropriate recovery sites, which were approved by the local community at the SCPA scale.
3. **On-Site Species Recovery:**
 - Implemented reintroduction and enrichment planting techniques.
 - Increased Extent of Occurrence (EOO), Area of Occupancy (AOO), and population size of the target species.
4. **Awareness and Capacity Building:**
 - Conducted training sessions, meetings, field visits, and seminars.
 - Raised awareness and built capacity among different stakeholders.

Achievements and Impacts

Main Achievements of the Project:

Ecological and conservation status:

- Conducted extensive field surveys from July 2022 to March 2024, covering over 100 key sites and about 20 protected areas, totaling approximately 175,000 sq. km.
- Collected data on distribution, population characteristics, habitat preferences, threats, and conservation actions from over 1,000 points across diverse habitats, including mountains, deserts, coasts, and the Nile River.
- Identified 49 endemic species in Egyptian flora, across 21 families and 45 genera, with Asteraceae being the most represented family.
- Found endemic species distributed in 20 governorates (74% of Egypt), with South Sinai having the highest number of species.
- Noted significant impacts from biological resource use, climate change, agriculture, human disturbance, and other threats on 44 taxa.
- It is concluded that 38 out of 49 endemic species are threatened with extinction (77.5%) globally, including 6 CR, 27 EN, and 5 VU species.

Conservation Planning:

- A comprehensive recovery plan for the 8 officially globally threatened species was established through community participation. The eco-geographical study extracted vital information on geographical distribution, population characteristics, ecology, habitat status, threats, and uses.
- Based on field surveys, reviews, satellite images, and consultations with local community leaders, detailed conservation strategies were devised.
- The plan included selecting suitable recovery sites, increasing the Extent of Occurrence (EOO) and Area of Occupancy (AOO), and implementing robust management, action, operation, and monitoring plan to ensure the successful rehabilitation of these threatened species.

Site Selection and Rehabilitation:

- Selected 8 main sites for species rehabilitation based on ecological suitability, climatic and topographical conditions, water availability, and protection from threats.
- Implemented detailed management, action, operation, and monitoring plan for rehabilitation activities.

Cultivation and Planting:

- Cultivated target species from seeds and treated seedlings, except for *Primula boveana* and *Rosa arabica*.
- Successfully established 320 stable seedlings of *Primula boveana* and 20 rooted branches of *Rosa arabica*.

Monitoring and Survival Rates:

- Monitored survival rates and growth parameters of planted species, showing varied responses to environmental conditions.
- Achieved high survival rates for *Rosa arabica* (up to 85%) and positive germination and survival rates for other species despite challenges.

Community and Stakeholder Engagement:

- Coordinated with local communities to implement irrigation and agricultural practices.
- Established protective enclosures to safeguard planted species from external threats.

Education and Awareness

- Trained 50 researchers and 50 youth on monitoring and conservation in cooperation with the Ministry of Environment.
- Trained 100 students on biodiversity conservation in coordination with the Library of Alexandria.
- More than 1500 individuals benefited from lectures, seminars, workshops direct and indirect
- Published educational curriculum and guidelines, presented at COP27.

Capacity Development and Leadership capabilities

The project significantly contributed to the capacity development and leadership capabilities of team members through various activities:

Training and Skill Development:

- Trained 50 researchers on monitoring, conservation of threatened species, geographical analysis, modeling, and planning programs for protected areas in cooperation with the Ministry of Environment.
- Provided training to 50 young individuals on monitoring plant species and their importance in protected areas in southern Egypt.
- Collaborated with the Library of Alexandria and the Ministry of Environment to train 100 students from universities on conserving endangered biological diversity and assessing threats.
- Offered training to 16 students from various governorates on geographic information systems and modeling programs for managing and preserving biological diversity.

Leadership and Collaboration:

- Organized lectures, seminars, and workshops on conserving endangered species, targeting researchers, decision-makers, government agencies, and the private sector.
- Conducted consultations with decision-makers to include project activities, objectives, and expected results in university and pre-university education curricula.
- Developed an educational curriculum for postgraduate students titled "Species Conservation Management Program" and added sections on endemic plant conservation to primary education curricula.

Documentation and Publication:

- Prepared a guide with planning steps for conserving plant species in Egypt's protected areas, officially approved by the Ministry of Environment.
- Published the chapter "Climate Change and Endemic Plants—Reliance and Challenges" in a book presented at COP27.



Section 3

Conclusion

This study identifies 49 endemic taxa distributed in about 20 governorates out of 27 (74%), with the most species exclusively found in South Sinai, Red Sea, Matrouh, North Sinai, and New Valley. They are also distributed in 13 phytogeographical regions out of 17 (76%), predominantly in the mountainous South Sinai–St. Catherine Protected Area, the Mareotis sector of the Mediterranean coastal belt, and the Nile Valley sector. The expansion of tourism, urban and industrial development, overgrazing, overharvesting, mining, and climate change pose significant threats, leading to habitat degradation and loss, impacting geographic distribution and population size. The study concludes that out of 49 endemic species, 38 are globally threatened with extinction (77.5%), including 5 critically endangered (CR), 27 endangered (EN), and 5 vulnerable (VU) species. One species is classified as Least Concern (LC), while 10 species are listed as data deficient (DD) and require further field surveys. Suitable habitats for endemic species are concentrated in the Mediterranean, Nile River, South Sinai, the Red Sea, and parts of the New Valley, covering up to 4.5% of Egypt's area.

To address the declining rate of endemic species, conservation and rehabilitation activities have been conducted for seven threatened endemic species in SCPA. Survival rates varied, ranging from zero for *Micromeria serbaliana* and *Silene oreosinaica* to 73.2% for *Rosa arabica*. Despite positive results under fluctuating climate conditions, more research is needed to improve conservation planning, involving local communities and stakeholders, and integrating results into state plans and strategies to enhance financial support for institutions, civil society organizations, and individuals.

Problems encountered and lessons learnt:

1. **High Heat Wave Impact:** In July 2023, St. Catherine PA experienced a high heat wave with temperatures exceeding 45 degrees Celsius, resulting in the death of many seedlings. We addressed this by replanting new seedlings, which incurred additional costs. This highlighted the need for adaptive strategies to mitigate the effects of extreme weather conditions.
2. **Difficulty Accessing Border Sites:** Accessing some border sites was challenging due to their sensitivity. We relied on previous studies to compensate for the lack of direct field access. This underscored the importance of alternative data sources and collaboration with local authorities to navigate access issues.
3. **Budget Constraints:** Upon receiving the fund in 2022, we converted it into the local currency at a rate of 15 pounds per dollar. However, the pound dropped by over 300%, reducing the budget's value to a third. To address this, we deposited the funds in a bank to generate monthly income, which helped compensate for the currency devaluation and supported the project's sustainability.

These challenges reinforced the importance of flexibility, resourcefulness, and strategic financial management in conservation projects.

During this project, we faced many challenges, but we succeeded in overcoming them all. We summarized many lessons, such as:

- A detailed operations plan should be prepared before planting starts, including site description, restoration measures, planting techniques and timing, zonation, seedling quality, work schedule, organization, equipment, budget, and monitoring plan.
- Site assessment is crucial for accurate and sustainable rehabilitation. Sites with severe habitat loss need appropriate, site-specific, and affordable restoration methods.
- Traditional knowledge in local cultivation is vital for the success and sustainability of rehabilitation programs.
- Planting techniques based on species ecology are important, but restoring hydrologic patterns and topography ensures natural regeneration.
- Site selection for rehabilitation must consider environmental conditions, access, community proximity, and threat distance.
- Closer spacing enhances seedling survival against wave impact. Higher planting density increases seedling survival.
- Planting techniques vary among species. Timing is crucial; for example, planting before the flooding season can lead to burial by sediment.
- Legal protection is often ineffective due to limited resources and local community antagonism. Community participation in species management is critical.
- Co-management or shared governance involves sharing decision-making, responsibility, and accountability between government agencies and local communities, enhancing natural resource governance.
- Target species co-management in SCPA effectively maintains protection, provides livelihoods for local communities, and improves natural resource governance.

Future planned activities

During the coming period, two research articles will be published summarizing the results of this study, which will be used as a database to build upon, market, and publish to open new areas and relationships with donors inside and outside Egypt, in addition to using them as educational and awareness materials for communities surrounding protected areas.

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