Anthropogenic Disturbance on Vegetation Dynamics

Subjects: Plant Sciences
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Irresponsible human interventions, encroachment of natural habitats, and climate change negatively affect wildlife. In this study, the effects of human influence on Wadi Hagul, an unprotected area in the north of the Egyptian Eastern Desert that has recently been subjected to blatant encroachments of vegetation, were studied. The most important of these threats is the construction of the new road Al-Galala–Wadi Hagul–Zafarana. In Wadi Hagul, 80 species are reported in this study; the most represented plant families are Asteraceae (15 species) and Brassicaceae (6 species). Perennial, chamaephyte and Saharo-Arabian species were recorded in the highest percentage. Detrended canonical correspondence analysis showed that latitude, longitude, altitude, silt, sand contents, pH, and CO_3^{2-} content are the factors that have the highest effect on vegetation distribution in the studied stands. Several invasive and alien species such as Euphorbia prostrata have been listed; these species typically have a negative effect on native species. The Soil Adjusted Vegetation Index (SAVI) indicated a decrease in plant cover during the study period, as compared to previous years. In 2013 and 2020, SAVI ranged from −0.02 to 0.42 and from −0.18 to 0.28, respectively. Recently, the violation and destruction of wildlife have increased, therefore, preserving it along with general biodiversity has become an urgent necessity.

Keywords: plant diversity ; anthropogenic impacts ; vegetation dynamics ; wildlife ; Wadi Hagul ; DCCA ; SAVI

1. Introduction

Land degradation and vegetation reduction caused by external stresses, affect biodiversity and natural ecosystems and the numerous services they provide [1]. Environmental deterioration, habitat changes, inappropriate vegetation management, translocation, fragmentation, and deforestation modify biotic and abiotic ecosystem components, resulting in changes in ecological processes such as vegetation dynamics [2][3][4]. Overgrazing, road building, overharvesting, solid wastes, salinization, industrialization, urbanization, and military activities are considered to be the main anthropogenic activities that lead to changes and transformation of vegetation and natural habitat loss in arid and semi-arid environments [5][6][7].

In terrestrial ecosystems, climate and land cover changes such as cover, height, biomass, relative humidity, soil temperature, moisture, fertility, and erosion affect the structural properties of vegetation [8]. Biodiversity decline is influenced by various types of human activities, including land cover changes, the introduction of invasive species, overexploitation, and pollution [9][10][11]. Alteration of vegetation growth is the result of climate variation, and human activities can modify atmosphere–biosphere interaction, causing changes in the hydrological cycle, either directly or indirectly [12][13][14].

Environmental issues, including soil fertility decline, heavy winds, increase in the evaporation rate, high temperature, and heavy rainfall, lead to dramatic changes in plant species community structure [7][15][16]. Ecosystem services and biodiversity contribute approximately 57% of gross domestic production [17], therefore, there is a pressing need to save biodiversity, especially endangered species through convert these locations to protected areas [18]. There are a variety of approaches that are able to reverse biodiversity loss, ranging from economic, through ecological, to ethical [19].

Human pressures in Africa, include agricultural and pasture activities, illegal timber harvesting, and bush fires. All of these stresses have a negative impact on the plant ecosystem [20]. From the middle of the last century, the human population of the earth doubled [21]. Population growth and urbanization are the most important causes of ecosystems collapse [22]. Rapid population growth leads to many problems such as fire prevalence, air pollution, light pollution, loss of genetic diversity, the prevalence of invasive species, and wildlife destruction [23]. Human activities, through the civilizational and agricultural expansion and by the destruction of natural habitats, have increased extinction rates up to 500 times [24] (Baillie et al., 2004). Over the ages, human activities have caused three powerful waves of extinction [25]. It is estimated that nearly 8390 plant species are listed as endangered [26]. Approximately 32% of the existing plant species are classified as either critically endangered or extinct [27], nearly 20% being extinct because of human activities [28]. In China, nearly 11% of the plant species that were evaluated are extinct [29].

Species with a narrow distribution range are more likely to be lost, while widespread species are more likely to survive [30]. Some wild plants have adapted to the conditions and survived in their natural habitats [31]. However, invasive species spread causes disturbance in communities and may lead to the extinction of endemic and native species [32].

Anthropogenic activities are causing changes in natural plant communities in Egypt from ancient times through draining of lakes and marshes and reduction of species number in aquatic communities [33]. Remote sensing is one of the most unique techniques used for estimating environmental changes [34]. Some characteristics of vegetation detected using remote sensing techniques are photosynthetic activity, chlorophyll content, plant density, green leaf biomass, the leaf area index, and plant health [35]. The second factor that includes climatic measures includes air temperature and solar radiation [36][37][38]. SAVI is one of the most common vegetation indices used as a tool to discriminate vegetation covers [39]. SAVI can be used efficiently in arid regions [40]. In areas where vegetative cover is low (i.e., <40%) and the soil surface is exposed, the reflectance of light in the red and near-infrared spectra can influence vegetation index values. This is especially problematic when comparisons are being made across different soil types that may reflect different amounts of light in the red and near-infrared wavelengths (i.e., soils with different brightness values). The soil-adjusted vegetation index was developed as a modification of the Normalized Difference Vegetation Index (NDVI) to correct for the influence of soil brightness when vegetative cover is low [41]. The output of SAVI is a new image layer with values ranging from −1 to 1. The lower the value, the lower the amount/cover of green vegetation [42].

A wadi is a natural depression on the earth’s surface. Wadi Hagul is a morphotectonic depression located between Gebel Ataqa’s southern scarps in the north and El-Galala El-Bahariya Plateau’s northern scarp in the south. Wadi Hagul is one of the unprotected wadies in Egypt and is one of the most anticipated project areas in Egypt to alleviate congestion. As a result, several integrated development projects are being worked on that implement many critical infrastructure areas such as quarries, roads, power plants, mines, landfills, and resorts. The most important national project is the development of the northern part of the Gulf of Suez pipeline surcharge, implemented through the main track of the study area and its environment [43]. Three main sectors can be recognized based on the vegetation and geological aspects of Wadi Hagul: upstream, middle, and downstream. Two distinct plant communities can be found in the upstream section of Wadi Hagul’s main channel: one is dominated by *Zilla spinosa* on elevated terraces of mixed deposits. The other is dominated by *Launaea spinosa* and represents a further stage in the building up of the wadi bed. In the middle section, *Leptadenia pyrotechnica* community occurs. In the downstream section, the vegetation is dominated by *Hammada elegans* with individuals of *Launaea spinosa* and *Lygos raetam* [44].

2. Discussion

In Wadi Hagul, 80 plant species belonging to 30 families were recorded. Among them, Asteraceae, Brassicaceae, and Zygophyllaceae were the most frequent families. These results are very similar to those reported in 2009 by Zahran and Willis [44] (31 species recorded) and in 2000 by Marie [45] (37 species recorded), who found that Asteraceae and Zygophyllaceae were the most common plant families in Wadi Hagul. By contrast, in 2016, Abdelaal [46] recorded 98 species, where Asteraceae and Poaceae were the most frequent families. Eight families (Aizoaceae, Cistaceae, Cleomaceae, Liliaceae, Neuradaceae, Polygonaceae, Urticaceae and Verbenaceae), each represented by only one plant species, were recorded in Abdelaal [46], and none of them were recorded in this study. Asteraceae were reported as the most common family in other Eastern desert wadies (Wadi Asyouti and Wadi Habib) [47]. Asteraceae was known for having a proportion of salt-tolerant and xerophytic species [48]. Asteraceae makes up the bulk of floristic composition in Egypt. It is represented by 98 genera, and 234 species [49][50]. Mashaly [51] reported a list of 62 species, with no alien species found.

The perennial plant group was most represented (67.5%) in the current study; this is consistent with the results of Zahran and Willis [44], Marie [45], and Abdelaal [46], who studied vegetation in the same study area during previous years. Regarding the number of annual species in Wadi Hagul, it has changed over the years of the study. This may be due to variation in the total rainfall during the studied years.

Life forms of species depend mainly on adaptation to the environment, particularly climate [52][53][54][55]. Life forms of desert plants are closely related to precipitation [56][57] and are correlated with both landform and topography [58][59][60]. In the present study, the chamaephyte life form was most represented (40%). Therophyte was the second most common life form (31.3%). These results are in accordance with the results of Abd El-Galil [61], who studied the floristic composition of Wadi Al-Assiuty, Eastern Desert, Egypt. In arid and semi-arid regions, chamaephyte and therophyte were found to be the most common life-forms [62][63][64].

Saharo-Arabian species captured the highest percentage in the floristic categories (43.75%). This result is concordant with Zahran and Willis [44], Marie [45], and Abdelaal [46]. It is worth noting that Saharo-Arabian species are good indicators for desert environmental conditions [65][66][67].

Species richness, which refers to the number of various plant species in the stands, is one of the most important indices of species diversity. In the studied stands, the average of species richness recorded three species, which is a low number. This could be due to a variety of factors, including the severe environment and climate that characterize the study area, which may be an obstacle to the growth of some plant species. Species evenness is a description of the distribution of species abundance in a community. The average of species evenness was 0.7. Species evenness is measured on a scale of 0 to 1, with 0 representing the lowest evenness (one species has 100% coverage) and 1 representing the highest evenness (coverage is evenly spread among a number of species). This may be due to the presence of a very dominant species in a community causes the less competitive species to be suppressed [68]. Shannon index depends strongly on species richness [69]. Simpson index is not a very intuitive measure of diversity since higher values indicate lower diversity [70].

The results of DCCA analysis indicated that latitude, longitude, altitude, silt and sand contents, pH, and CO_3^{2-} content are the most important factors affecting the distribution of vegetation in Wadi Hagul. These results are somewhat consistent with those of Mashaly [47], who stated that the most influential soil factors for the distribution of vegetation in Wadi Hagul are soil texture, Na^+, pH, and organic matter. Abdelaal [46] mentioned that K^+, Na^+, organic matter, moisture content, pH, E.C., and Cl^- were the most affecting soil parameters for the distribution of vegetation in Wadi Hagul. Plant species associated with the increase in the proportion of sand in the soil and soil pH were *Tamarix nilotica, Ochradenus baccatus, Launea nudicalus, Launea nudicalus* and *Rumex vesicarius.* The longitude and the amount of Mg^{2+} in the soil were the most important factors associated with many plant species such as; *Zilla spinosa, Zygophyllum simplex* and *Zygophyllum coccineum*. Most of the salinity factors (E.C., T.D.S., Ca^{2+}, Cl^- , Na^+ and K^+), CO_3^{2-} , HCO_3^- and the percentage of silt in soil were associated with some species such as; *Lycium shawii, Leptadenia pyrotechnica, Panicum turgidum* and *Haloxylon salicornicum.* Latitude, altitude and the amount of organic carbon in soil were important factors in the distribution of some plant species such as *Echinops spinosus, Erodium laciniatum, Erodium glaucophyllum* and *Reaumuria hirtella*.

Many of the threatened plant species recorded in previous studies were not recorded in this study, including Aizoon canariensis, Artemisia judaica, Ifloga spicata, Silene viviani, Sphaerocoma hookeri, Helianthemum lippi, Astraglus spinosus, Senna alexandrina, Salvia aegyptiaca, Schismus barbatus, Hyoscyamus muticus, and Verbena officinalis. As a result, action must be taken to safeguard threatened species by a variety of measures, including the establishment of protected areas, criminalizing exposure to endangered plants, creating a gene bank for these plants, and attempting to increase their numbers in practice.

In this study, many alien and invasive species, such as *Euphorbia prostrate*, were recorded [71]. The introduction of invasive and alien species into natural habitats represents a threat to existing species. Assaeed et al. [72] indicated that invasive and exotic plants may pose a threat to natural resources and biodiversity, especially in arid habitats. Successful invaders often exhibit great degrees of adaptability, allowing them to thrive in a variety of environments [73][74]. Plant shoot and root system features are thought to be good morphological criteria for predicting successful invasion in many habitat types [75]. Many invasive species contain allelopathic chemicals that enable them to invade and control plant communities [76].

Climate changes, in addition to human encroachments such as the construction of roads and the establishment of new cities, pose the main pressure on vegetation. Climate changes and human impact negatively affect biodiversity in several Wadies in the Egyptian Eastern Desert [77].

In this study, SAVI decreased during 2013 (from −0.02 to 0.42), 2015 (from −0.011 to 0.32), and 2020 (from −0.18 to 0.28). This result could be due to various human impacts in Wadi Hagul such as the construction of the new road Al-Galala–Hagul–Zafarana, which is 84 km long and 24 m wide and crosses Wadi Hagul, in addition to many other threats such as overgrazing, plant collection, and increasing demand for energy, which have led to exploration for oil and natural gas near Wadi Hagul. Large population growth in recent times has also led to increasing demand for building materials and opening quarries inside Wadi Hagul, which resulted in a local increase in transport and pollution. Finally, it was discovered that if environmental conditions (such as human interventions and climate changes) alter and become unsuitable for plant growth, they have a negative impact on vegetation cover, thus lowering the SAVI values.

In recent times, the preservation and protection of wildlife have become an urgent necessity, especially in the light of misuse of natural resources and encroachment of wildlife. Economic development and wildlife conservation can be simultaneously achieved by following the principles, rules, and requirements of sustainable development for balanced usage of available resources.

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