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The Effect of Drought on the Biodiversity of Sawa Lake (Iraq)

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ABSTRACT The research was performed in the Sawa Lake region, situated in the southwestern part of Samawa City, in the central portion of Muthanna Province (Iraq). Because of its shallow nature, the lake was deemed a favorable environment for the development of biodiversity before the drought. Biodiversity is a crucial natural asset of the lake, and the loss of any form of biodiversity would result in the ecosystem's inability to recover and disrupt its natural equilibrium, Sawa Lake was designated as an international wetland by the Central Committee of the International Ramsar Convention on September 15, 2015, after satisfying all necessary environmental and hydrological standards. However, it has been severely impacted by rapid changes and a substantial decrease in water levels, resulting in the loss of large biodiversity species. The purpose of this study was to assess the effects of drought on the lake's biological ecosystem. This was achieved by field observations conducted by the researchers in the study region, as well as by analyzing data from previously published studies and research on this topic. Before the drought, the lake and its surrounding areas included the following living organisms: 1 fish, 4 mammals, 2 reptiles, 16 birds, 9 plants, and 63 phytoplankton belonging to five different categories. Most of these organisms have now disappeared due to changed environmental conditions.

KEY WORDS Algae; biodiversity; causes of drought; drought; Sawa lakes; plants.

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INTRODUCTION

Climate change is playing an increasingly important role in the decline of biodiversity. Some animal and plant species could lose their habitat and face extinction, which has altered terrestrial and freshwater ecosystems around the world. Lake Sawa (Iraq) is the latest victim of a water shortage that experts say is caused by climate change, which has included record low rainfall and successive droughts (Adamo et al., 2021).

Sawa Lake has biological and environmental importance due to the presence of several types of plankton and phytoplankton in it, and birds such as the grouse, the harrier, and other local birds. Migratory birds also come to it, and there are wolves, wild rabbits, hedgehogs, red foxes, and snakes,.As for its waters, they contain one type of fish (the Bigeye fish), and as for the plants, the Camelthorn (*Alhagi maurorum*) is widespread on the dunes, and there are also many Athel pine (*Tamarix aphylla*) plants around the lake, as well as other plants (Sharif, 2021). Muhammad (2014) mentioned other types of wild plants that prevail in the lake, such as the shrubs of Ajram, Sweet Annie (*Artemisia annua*), wormwood, Sala, Fardaq, Bos, and Samar. As for algae, Mohammed (2008) found that their abundance varies with environmental

conditions and low water levels around the lake, which prompted researchers to study the causes of lake drought.

Therefore, this study took the initiative to understand the effects of drought on the biological life of the lake through investigations, especially the biodiversity present before and after the drying up of the lake's basin area (5.5 km^2) and circumference (12.7 km^2), which was submerged in water until 2010 (Hussin & Ghazal, 2020; Marine Science Center, 2022). The decrease in the lake's water level has resulted in the lake drying up, leading to an ecological imbalance and depletion of natural resources.

MATERIAL AND METHODS

Study area

Sawa Lake is an endorheic basin situated in the arid region of Iraq, some 23 km to the west of Al-Samawa city. It is precisely located at 31.91 degrees north latitude and 45 degrees east longitude. The lake has a longitudinal shape of 4.47 km length and 1.77 km width and the area surrounding the lake has also been studied (Al-Abdan & Al-Abbadi, 2018).

The lake does not get water from any rivers or streams but instead relies on water flows. Groundwater moves through permeable layers and geological fractures (Mohammed, 2014). The hydrological conditions are influenced by the structural and geological characteristics, the composition of rock formations, and the properties of the aquifer rocks. The study region is situated inside the Najaf Sea Basin, as determined by the hydrological division of Iraq. The waters of Sawa Lake are found in two primary strata that hold groundwater: Quaternary sediments and Miocene sediments. As a result, the area where Sawa Lake is situated contains three groundwater reservoirs: Ras Formation Reservoir, Dammam Formation Reservoir, and Euphrates Formation Reservoir. The Dammam Formation Reservoir is a significant regional aquifer with a substantial water capacity. It serves as the primary source of nourishment for the lake (Al-Abadi, 2013).

Methods

The biodiversity of the Sawa Lake for animals, plants and algae was examined through direct observation and the study of existing literature.

The study comprises two sections. The initial section focuses on the genesis of Sawa Lake, as well as the occurrence of droughts and the factors underlying them. These factors include natural causes such as tectonic activity and climate change, as well as human-induced causes such as agricultural and industrial activities near the lake's water sources. The data interpretation was supported by the use of satellite imagery.

The second section encompasses the adverse impacts of drought on the biodiversity in Sawa Lake after drying up.

RESULTS

Animals

Biodiversity of Sawa Lake and its surrounding areas encompasses the species listed in Table 1 for the animals found by us. The abundance of these species varies depending on environmental conditions and the characteristics of the desert. The severe water scarcity led to the desiccation of the lake, resulting in a drought. Subsequently, the terrain became enveloped by arid vegetation that successfully acclimated to the altered surroundings. Ecosystem of Sawa Lake has been afflicted by a severe drought, leading to a disruption in the equilibrium of the environment and depletion of natural resources. The land was inundated by water. The area was deemed a crucial habitat for several creatures and abundant in vegetation, providing a sanctuary for mankind. Because of the drought, the species converted a habitat abundant in water to one lacking water. This led to the disappearance of all the elements that supported biological life in the lake. As many animals are closely tied to the environment of Sawa Lake, any alterations caused by the drought in humidity, temperature, and desertification pose a direct threat to their survival.

Plants

Flora of the Sawa Lake area and its environs comprises several plant species, such as the Alhagi, which thrives on the dunes surrounding the lake, the

Tamarix aphylla, *Anabasis aphylla*, the Sweet Annie (*Artemisia annua*), the Shih, the Sala, the Fardaq, the Bos, Acacia (*Vachellia tortilis*), and several others. The diagnosis was established using the research findings of Muhammad (2014), Alkarawi et al. (2018) and Sharif (2021). The alterations in the natural environment result in the breakdown of the interdependencies among its constituents. As a result, numerous plants cannot thrive because of insufficient water and humidity, leading to a decline in the insect population and reduced food availability for reptiles. Plants have specific requirements for growth, including a minimum threshold of water and humidity. Without meeting these conditions, certain plants cannot thrive. The inability to thrive in arid conditions for a long period is seen as a physiological adjustment to the desert ecosystem. As drought becomes more severe, the amount of plants decreases and the process of deterioration becomes more intense.

Algae

A quantitative comparison study was conducted (for algae species) and it was proven that differences were found in the numbers of algae (Table 2). Besides the low water level or the drought that affected the study area, many environmental conditions affect the temporal and spatial variability of plankton, such as temperature, dissolved oxygen,

N.	Plantae	Mammalia	Aves	Reptilia	Actinopterygii
1	*Rumex vesicarius*	*Hyaena hyaena*	*Accipter nisus*	Snakes	*Aphaniops dispar*
2	*Alhagi* sp.	*Herpestes edwardsii*	*Pterocles alchata*	*Eumeces* sp.	-
3	*Tamarix nilotica*	*Mellivora capensis*	*Columba palumbus*	-	-
4	*Anabasis* sp.	*Vulpes rueppellii*	*Streptopelia decaocto*	-	-
5	*Achillea millefolium*	-	*Athena noctua*	-	-
6	*Artemisia herba alba*	-	*Calidris alpina*	-	-
7	*Houttuynia cordata*	-	*Calidris alba*	-	-
8	*Phragmites* sp.	-	*Himantopus himantopus*	-	-
9	*Juncus acutus*	-	*Actitis hypoleucus*	-	-
10	-	-	*Tringa stagnatilis*	-	-
11	-	-	*Tringa totanus*	-	-
12	-	-	*Chroicocephlus genei*	-	-
13	-	-	*Larus armenicus*	-	-
14	-	-	*Charadrius alexandrinus*	-	-
15	-	-	*Charadrius hiaticula*	-	-
16	-	-	*Pluvialis squatarola*	-	-

Table 1. Biodiversity in Sawa Lake. Source: based on researchers' work of Republic of Iraq, Ministry of Health and Environment, Directorate of Environment, Muthanna Governorate, Department of Environmental Systems (unpublished data, 2020) and Sharif (2021).

and the density of aquatic plants that provide a suitable environment for some types of algae (Mohammed, 2008). Among the recent studies that have been conducted recently there is a survey of types of the microorganisms endemic to the soil and water of Sawa Lake studied by Al-Taee et al., (2018) and Jassim et al. (2023). They recorded 63 types of phytoplankton belonging to 5 classes, identified as Cyanophyceae, Chlorophyceae, Pyrrophyceae, Bacillariophyceae, and Euglenophycaea (Table 2).

This study showed the disappearance of some genera that were present in previous studies, due to the dry season. From these studies, Some physicochemical properties and biomass of algae in Sawa Lake studied by Mohammad (2005), found that blue-green algae represented by the species *Nodutaria* sp. are predominant, while the predominance of the *Chara canescens* algae was at the bottom of the lake, which is one indicator of hard water (Vollenweider et al., 1974). In addition, the results of the Phytoplankton composition of Sawa Lake studied by Hassan et al. (2006) recorded 51 algal taxa and 33 species of diatoms, followed by 12 species of blue-green algae, 4 species of green algae, and 2 species of Euglenoids. Of these, three species, namely, *Chlorella vulgaris*, *Scenedesmus bijuga*, and *Cyclotella meneghiniana*, were the most dominant in the studied lake. Three filamentous green algae were also identified, namely *Chara* sp., *Cladophora crispata*, and *Cladophora fracta* var. *lacustris*. This proves the disappearance of some types of algae, which were more numerous before the dry season. The results of the study previously conducted by Al-Saadi et al. (2008) found a total of 51 taxa in the studied lake, dominated by Bacillariophyceae (64.7%), followed by Cyanophyceae (23.5%) and Chlorophyceae (7.8%), and only two species (4%) of Euglenophyceae

Among the genera that were recorded in this study and did not appear after the dry season are: Cyanophyceae (*Chroococcus giganticus* West, *Gleocapsa aeruginosa* (Carm) Ktz., *G. punctata* Nag., *Johannesbaptistia pellucida* (Dickie) W.R. Taylor & Drouet, *Microcoleus paludosus* (Ktz.) Gomont, *Chlamydomonas salina* H.J. Hu & L.M. Luo, *Chlorella vulgaris* Breb., *Closterium microporm* (Naeg.) A. Braun (Euglenophyceae) *E. proxima* Dang. (Bacillariophyceae), *Cyclotella striata* (Ktz.) Grun., *Achnanthes hauckiana* Grun., *A. lanceolata* Hust., *A. longipes* Ag, *Amphora coffeaformis* (Ag.) Ktz., *Cymatopleura elliptica* (Breb.) W. Sm., *Cymbella tumida* (Breb.) Van Heurc, *Diploneis bombus* Ehr., *D. smithii* (Breb) Cleve, *Fragilaria tabulata* (Ag.) Ktz., *F. ulna* (Ntz.) Ehr., *Gyrosigma balticurn* Ehr., *Navicula crucigera* (W. Sm.) Cleve, *N. pupule* Ktz., *Nitzschia amphibia* Grun., *N. punctata* var. *coarctata* (Coarcata) Grun., *Surirrella ovata* Ktz., *S. striatula*.

The following genera were confirmed in the results of a study conducted by Hasan et al. (2018) but were not proven to be recorded in studies after the dry season: *Cocconeis placentula* Ehrenberg, *Spirogyra novae-angliae* Transeau, *Aphanothece bullosa*, *A. castagnei* (Breb.) Rabenhorst, *Aphanocapsa muscicola* (Menegh) Wille, *A. montana* Gramer, *A. littoralis* Hansigirg, *Lyngbya aestuarii* Lammermann, *Lyngbya* sp., *Merismopedia tenuissima* Lemmermann, *Nostoc carneum* Agardh, *O. formosa* Bory, *O. limnetica* Lemmermann, *O. limosa* Roth Agardh, *O. princeps* Vaucher, *O. tenuis*, *Euglena acus*, *Phacus pyrum*.

DISCUSSION

The genesis of Sawa Lake

Previous studies have suggested multiple possibilities for the formation of Sawa Lake. Muhammad (2008) found more than one possibility for its formation and it suggested that, because the depression is at the edge of ancient strata, a fracture occurred in the Shabija region of the Earth's crust, and the lower crust was twisted or folded, forming the domes. It can be said that Sawa Lake is a stratigraphic basin, or an erosional basin formed by wind action in a fragile stratum, or a basin formed by groundwater erosion in a soluble limestone stratum. The lake, as well as other depressions in the area, may have been formed because the lake height (11 meters) was higher than the water level of the Euphrates River. Complex and sandstone formations, the Miocene limestone formations are followed by other calc amphibolite limestone formations formed in the Eocene age.

On the other side, through another geological and tectonic description (report submitted to the Research Center for desert and Sawa Lakes, Muthanna University by Hussin & Ghazal, 2020

Algae	
Cyanophyceae	*Phormidium autumnale* Gomont
Anabaena affinis Lemmerm.	*Phormidium tenue* Gomont
Aphanocapsa sp.	*Spirulina major* Kütz. ex Gomont
Aphanocapsa sp.	**Chlorophyceae**
Chroococcus dispersus (Keissler) Lemmerm.	*Cladophora glomerata* (Linnaeus) Kütz.
Chroococcus limneticus Lemmerm.	*Cosmarium botrytis* Meneghini ex Ralfs
Chroococcus minor (Kütz.) Nägeli	*Cosmarium leave* Rabenhorst
Chroococcus minutus (Kütz.) Nägeli	*Cosmarium meneghinii* Brébisson ex Ralfs
Chroococcus turgidus (Kützing) Nägeli	*Clorterium* sp.
Gomphosphaeria aponina Kütz.	*Scenedesmus bijugus* (Turpin) Lagerheim
Gomphosphaeria lacustris Chodat	*Scenedesmus bijugus* var. *alternans* (Reinsch) Borge
Lyngbya limnetica Lemmerm.	*Scenedesmus dimorphus* (Turpin) Kütz.
Lyngbya martensiana Meneghini ex Gomont	*Scenedesmus quadricauda* (Turpin) Brébisson
Microcystis aeruginosa (Kütz.) Kütz.	*Oorystis borgei* J.W. Snow
Merismopedia elegans A. Braun ex Kütz.	*Spirogyra* sp.
Merismopedia glauca (Ehrenberg) Kütz.	**Euglenophyceae**
Merismopedia tenuissima Lemmerm.	*Euglena acus* (O.F. Müller) Ehrenberg
Microcystis sp.	*Phacus* sp.
Nostoc sp.	**Pyrrophyceae (Dinoflagellates)**
Oscillatoria agardhii Gomont	*Peridiniopsis pulvisculus* (Ehrenberg) J.Stein & Borden
Oscillatoria formosa Bory	*Peridinium cinctum* (O.F. Müller) Ehrenberg
Oscillatoria limnetica Lemmerm.	**Bacillariophyceae (Centrales)**
Oscillatoria limosa C. Agardh ex Gomont	*Cyclotella striata* (Kütz.) Grunow
Oscillatoria princeps Vaucher ex Gomont	*Melosira varians* C. Agardh
Oscillatoria tenuis C. Agardh ex Gomont	
Bacillariophyceae (Pennales)	
Mastogloia smithii Thwaites ex W.Smith	*Navicula inflata* H.P. Gandhi
Achnanthes minutissima Kütz.	*Navicula pygmaea* (Kütz.) Pantocsek
Rhopalodia gibba (Ehrenberg) O. Müller Kütz.	*Navicula radiosa* Kütz.
Amphora pedicalis (Kütz.) Grunow	*Nitzschia scalaris* (Ehrenberg) W. Smith
Amphora sp.	*Nitzschia tryblionella* Hantzsch
Diploneis ovalis (Hilse) Cleve	*Nitzschia obtusa* W. Smith
Cocconeis placentula Ehrenberg	*Nitzschia dissipata* (Kütz.) Rabenhorst
Cocconeis placentula var. *euglypta* (Ehrenberg) Cleve	*Nitzschia sigma* (Kütz.) W. Smith
Cymatopleura solea (Brébisson) W. Smith	*Nitzschia sigmoidea* (Nitz.) W. Smith
Cymbella affinis Kütz.	*Pleurosigma delicatulum* W. Smith
Cymbella gracilis (Ehrenberg) Kütz.	*Synedra acus* Kütz.
Cymbella helvetica Kütz.	*Synedra ulna* (Nitz.) Ehrenberg
Cymbella turgida W. Gregory	*Synedra ulna* var. *biceps* (Kütz.) Kirchner
Cymbella ventricosa (C. Agardh) C. Agardh	*Gomphonema longiceps* Ehrenberg
Fragilaria capucina Desmazières	*Gomphonema olivaceum* (Hornemann) Ehrenberg
Gyrosigma acuminatam (Kütz.) Rabenhorst	*Gomphonema parvalum* (Kützing) Kütz.
Navicula bacillum Ehrenberg	*Epithemia sorex* Kütz.
Navicula cincta (Ehrenberg) Ralfs	*Diatoma elongatum* (Lyngbye) C. Agardh
Navicula cryptocephala Kütz.	*Diatoma vulgaris* Bory
Navicula gracile Ehrenberg	

Table 2. Shows the genera and types of identified phytoplankton.

and Marine Science Center, 2022), it seems that the origin of Sawa Lake is due to the tectonic and geological influences in the area, as there are several faults with different directions. Of these there are the Abu Qir fault and the Euphrates fault zone which result in a tectonic geological weak zone, with springs and spring water seepage along its northwest extension, and the separation between the Salman Mountains (stable shelf) and the Mesopotamian Mountains (unstable shelf) in a wide area. In fact, groundwater from the western and southern deserts (recharge areas) flows to the Euphrates River and the alluvial plain (drainage area).

Drought

As one of the natural disasters, drought has become a research subject for scientists of all professions. Drought and climate-related water scarcity are one of the most important problems faced by most arid and semi-arid regions. Numerous countries in the world are suffering, including Iraq, and Sawa Lake is proof of this. The geographical concept of drought refers to a long or short period of rainfall below the general average, resulting in a lack of running water in rivers and a drop in groundwater levels. It is defined as a temporary non-periodic natural phenomenon that may last for several years or decades, according to which drought can occur in any region when precipitation is below average, regardless of its climate. Following Al-Rikabi (2003) the drought can be divided into four types: type I = climatic drought, associated with a decrease in rainfall; type II = agricultural drought, which occurs when there is insufficient moisture in the soil.

Related to the reduction of water resources to meet human needs with water shortages in rivers, lakes, and groundwater (Al-Badiri, 2020), hydrological drought is also associated with a decrease in rainfall which affects the surface and groundwater reserves and reduces water levels in tributaries, reservoirs and lakes.

As for groundwater, as mentioned, its water level decreases because of drought. Drought-induced water shortages are caused by reducing recharge and increasing investment rates, but this does not necessarily happen at the same time (Al-Rikabi, 2003).

Causes of drought

The causes of drought in Iraq are mainly related to rainfall, besides other factors such as rising temperatures because of climate change and increased evaporation. However, it appears in Sawa Lake when groundwater levels decrease around the lake because of hydrological drought caused by human agricultural and industrial activities, which are among the largest factors controlling the determination of actual rainfall values and drought levels and thus the water deficit. The continuous shortage in Sawa Lake water resources did not occur randomly, but for several reasons, as previous studies on the lake have concluded.

Al-Abdan et al. (2018) showed that the reason for the decline in the lake level was the reduction in the flow of the three springs which were the main sources of water supply to the lake due to the cessation of pumping from the first main spring. Various factors were identified that contributed to this study:

1- tectonic activation of the active Euphrates fault is the basis for the formation of these springs, and the fault extends in a northwest-southeast direction, which may have led to a lateral movement along the fault or the collapse and fall of rock masses that closed the sources of the lake's spring;

2- depletion of water in the groundwater reservoirs that feed the lake, which are Dammam, Rass and Euphrates due to the lack of surface nutrition caused by drought or increased water consumption;

3- the source of recharge of the lake does not come from these three underground reservoirs, but from other deep reservoirs, which is confirmed because the water levels in the wells dug in these reservoirs around the lake (Daman, Ras and Euphrates) are stable and do not decrease alongside the water level of the springs of the lake. When measured in 2014, the water level dropped by 14.95 m, while the water level in the well located 1 km to the southwest of the lake, reached 15.46 m.

The movement of tectonic plates and earthquakes that occurred in northeastern Iraq from 2016 until now, the effects of which reached Muthanna Governorate, led to the blockage of the subsurface drains that feed Sawa Lake, which led to its drying up (Sharif, 2021).

In fact, Al-Abbadi (2021) shows that some earthquakes that occurred as a result of the colli-

sion of the Arabian plate with the Iranian plate had a direct impact on the rock formations. The main Al Ain cliffs of Sawa Lake are one sign of tectonic activity in the Euphrates Rift. The regressive carving of the Euphrates River in the study area, locally known as Al-Nakarat, and the erosional renewal of activity in the desert valleys of the western Iraqi plateau, indicate the changes in the paths of these valleys which terminate in the Euphrates Rift represented by the Sulaibat Depression. This activation led to the appearance of ground subsidence, which resulted in the elongation of the channels in the areas of these mouths, as well as the renewal of water erosion processes through the deepening of the rivers in their channels, and the collapse of rocks caused by ground movements, and the appearance of an early delta (Hadetha) located to the north of the ancient delta, which is an important indicator of the changes in the volume of sediments due to the flow rate. These valleys were formed because of the state of tectonic subsidence at the mouths of these valleys, which are located in the Euphrates rift zone. The result of these tectonic movements was the collapse of the rock cliff surrounding the lake; the collapse of these rocks had the effect of closing most of the channels of the aquifers that feed the lake. The rock layers can be considered as the result of the activity of the Euphrates Rift which led to the movement of these rocks and to the closing of some reservoirs such as the Dammam Formation and the Ras Formation, which are the main sources of recharge for the lake. It can be concluded that the tectonic factor has an important role in the decline of the water level of Sawa Lake.

Al-Abbadi (2021) has also found that other reasons have led to a decrease in groundwater levels around the perimeter of the lake because of hydrological drought, which are as follows:

1. There are gravel quarries in the upper basin that supply water to the lake, as the area is rich in minerals, especially important construction raw materials in industrial development and extractive activities of this territory; most of the quarries distributed in the area are informal and located in the upper valleys that supply water to the lake, thus the flood peaks do not reach the catchment area of the estuary, thus reducing the area of flooding.

2. Farmlands and wells in the headwaters of the region's sub-basins act as dams, retaining waters at the mouth of the valley, ultimately leading to flooding of the riverbanks near the rock barriers of the lakes, and the expected nourishment of the lakes by these surface waters as they seep through cracks in the rocks. Activating agricultural investments within the Daman Formation (the underground reservoir that feeds the lake) requires digging more wells to irrigate crops, and in recent years, as the percentage of cultivated land has increased, the number of wells (253 wells) and the number of wells in 1986 (11 wells) have increased since 2021 (53 km^2) and 1986 (600 m^2), because the increase in agricultural land is accompanied by a steady increase in the amount of water extracted from the ground, the number of wells and increasing the productivity of a well, because there are two irrigation methods: sprinkler method and irrigation method. The irrigation method is one method that causes groundwater waste. It is noteworthy that the intensive, haphazard and ill-considered drilling of wells has led to a drop in the groundwater level within the Daman reservoir that supplies water to Sawa Lake, and thus to a drop in the water level, which is probably one of the most important reasons that have led to the decline of the lake.

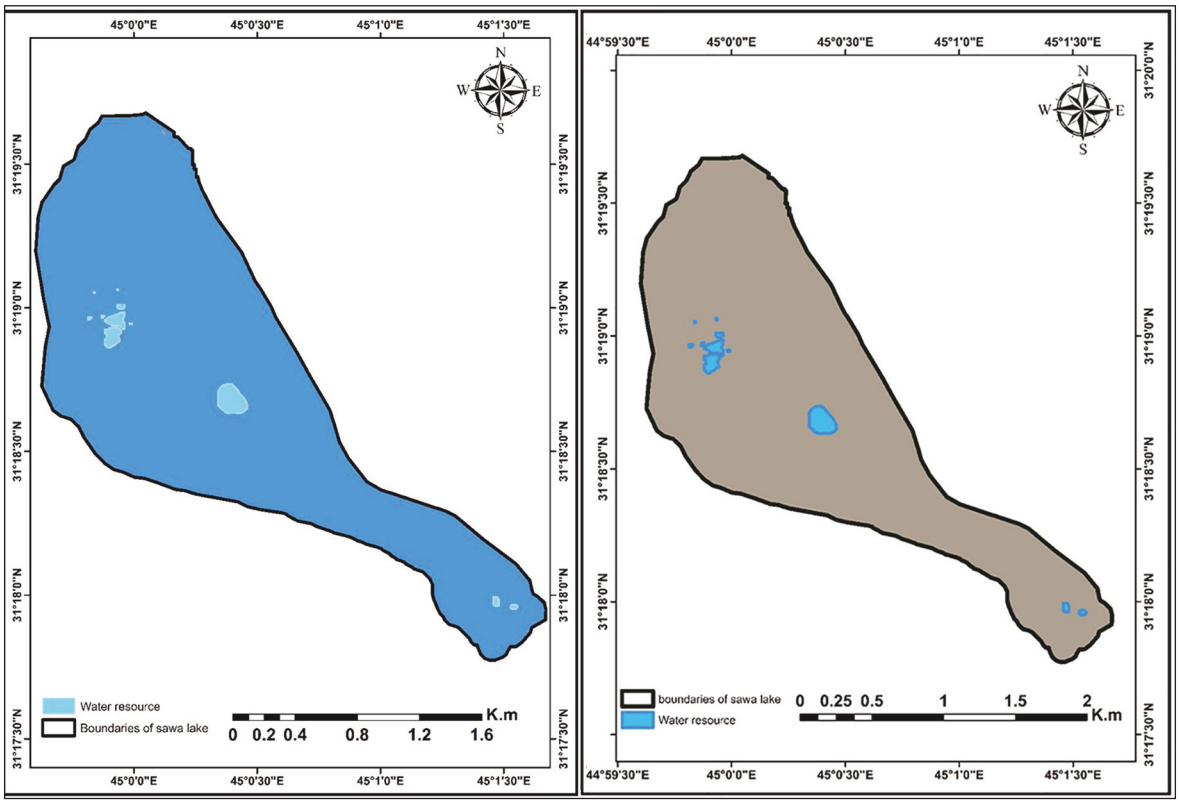
Al-Abbadi (2021) believes that climate factors have contributed to the decline in the water level of Sawa Lake to some extent, but it is not the main or only factor causing its drying up, because the climate of the study area is characterized by drought and high temperatures, which is reflected in the hydrological system of the region, The lake is one of the weakest and most vulnerable ecosystems in these climate zones, making it more vulnerable to the recent climate change with reduced rainfall and higher temperatures. The United Nations has warned that climate change is causing water shortages in the Tigris and Euphrates basins, which are sensitive areas that are more rapidly affected by climate change and have less rainfall. Following Al-Abadi (2021), the drought period that lasted from 2009 to 2019, except for 2013, led to a shortage of surface water and groundwater runoff in the study area and the amount of water in Sawa Lake began to decline in 2014 and continued to decline until it reached drought levels in 2021. April 2021 was the month when the lake completely dried up and the mainspring was drained. From the study of the surface water level in Figs. 1, 2, the results show that by visually comparing the two figures, it can be

found that the size of the water in the lake varies greatly.

Biological Diversity

Biodiversity is defined as the variation in all life forms of genes to species to ecosystems, or variation between terrestrial and aquatic organisms and the ecological complexes to which they belong, including variation within species and ecosystems (Mohammed & Ali, 2013). The United Nations General Assembly is concerned about biodiversity issues, and one of its concerns is the adoption of resolution 52/201, which directly addresses the 1992 Convention on Biological Diversity and the need for its implementation. The resolution emphasizes the protection of biodiversity, the equitable sharing of genetic resources, and the principle of sustainable development by linking biodiversity and development. The legislator's recognition of the importance of biodiversity and the necessity of protecting it is nothing more than a theoretical recognition unless it is supported by legal rules that work to protect it. Protection is the legislator's endeavor to provide the utmost care and consideration for the necessary interests in society as a source of development and advancement for that society (Al-Shabani, 2017).

Drought is one of the most important environmental factors that affect biodiversity. Since its birth, the environment of Sawa Lake has constituted a geographical environment with unique characteristics compared to surrounding areas. A field survey of the lake was conducted by Muhammad (2008) and microorganisms, bacteria, fungi, algae, plankton and small vertebrates were found, as well as fish and some species of local birds (16 species). Snails and insect larvae were also found, which constitute the food of small fishes, besides the presence of shrimps and algae recorded for the first time. Sharif (2021) stated that there are wolves, wild rabbits, hedgehogs, red foxes, and snakes. As for plants, her study showed the spread



Figures 1, 2. Water volume in Sawa Lake for the year 2018 (Fig. 1, left) and in 2024 (Fig. 2, right).
Source: Author's work based on visual interpretation of Lancet 2018 and 2024 satellite data).

of the Camelthorn (*Alhagi maurorum*) on the dunes, and other desert plants are found around the lake.

CONCLUSIONS

The ecosystem of Sawa Lake has been exposed to fundamental changes in its various elements because of two natural and human factors. Perhaps the most prominent natural factor is drought because of falling water tables, and a combination of factors (natural and anthropogenic) has led to increased pressure on biodiversity and the disintegration of lake ecosystems.

The drought has caused the complete removal of the essential ingredients in the lake that support biological life. The pertinent authorities should prioritize the lake by dispatching a task force to evaluate the extent of damage and requirements, devise remedies, halt the declining state of biodiversity in Sawa and its environs, and ascertain the necessity of safeguarding it by restricting industrial expansion and agricultural intensification that harm the natural habitat, a significant factor contributing to the lake's drought.

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