Monitoring and controlling sand and dust storms in the Middle East

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Abstract. Satellite images from May 1968 to March 2023 identified two major hotspots (source areas) for sand and dust storms (SDS) in southern Iraq. Around 40 million people in the region are momently affected by the SDS hotspots in Kuwait, southern Iraq, southern Iran, Qatar, eastern Saudi Arabia, Emirates, Bahrain, and northern parts of Oman. The two SDS hotspots cause approximately 40% of the total SDS in the region (SDS data from 1993-2023). The two SDS hotspots are shrinking with time by 85.5% in 2023 (3 373 km^2) compared to 23, 331 km^2 in 1984. A rehabilitation project (2023-2026) between Iraq and Kuwait Institute for Scientific Research (KISR) funded by UN-Habitat and Kuwait Fund for Arab Economic Development (KF) uses mechanical and biological fixation for SDS hotspots. Both SDS intensity and counts were reduced during 2023 in most of the Arabian Gulf countries compared to the years 2012 to 2021.

1 Introduction

Dust acts as a major socioeconomic challenge in the region [1-12]. In the Middle East, the Mesopotamian Flood Plain is one of the major sources of SDS [13]. It was observed that two regional areas in the southern part of the Mesopotamian Flood Plain act as major SDS hotspots [14-16]. Both SDS hotspots (1) and (2) occupied 18 003 km^2 total surface area in 1968 (Fig. 1), but shrinking with time.

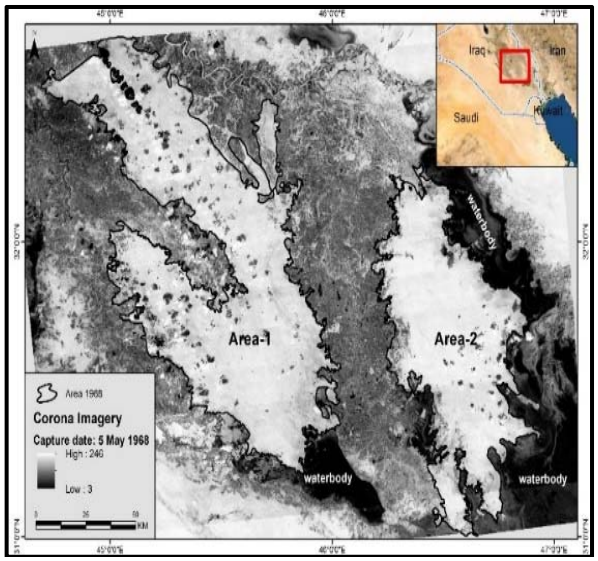

Fig. 1. The two SDS hotspots on 5th of May 1968 using Corona Satellite imagery.

The hotspots are located within hot and dry areas with annual rainfall of around 120 mm [1]. Satellite images detect changes in severity and count for the storms originating from SDS hotspots in the Middle East [14-19]. The two SDS hotspots affect around 40 million people in the region, in Kuwait, southern Iraq, southern Iran, Qatar, eastern Saudi Arabia, Emirates, Bahrain, and northern parts of Oman. Few studies covered the change in intensity and counts of the SDS in the region [20-23]. Also, few studies covered dust physical and chemical characteristics for the study area [24-25]. Therefore, this study aims to monitor the spatial and temporal changes of the surface area for the two SDS hotspots.

2 Methodology

Satellite images from May 1968 to March 2023 identified two major hotspots (source areas) for sand and dust storms (SDS) in southern Iraq. The Satellite imagery data was collected from more sensor types and more sources the following table shows details of all sources: Atmospheric Correction (AC) was used to remove the atmospheric effects on the image reflectance values. A standard image processing and analysis software called ENVI was used for image radiometric calibration. The Digital Elevation Model (DEM) for both SDS hotspots (Fig. 2 and 3) shows higher topography towards the north. The counts and intensities of the SDS were monitored. Also, the two hotspots' total area variations were detected.

3 Results and Discussion

SDS data from 1993-2023 show around 40% of the total SDS in the region originate from the two SDS hotspots.

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The Data from meteorological stations in and around the SDS hotspots show active wind speed (Fig.4) compared to the surrounding areas. Both hotspots are arid land, bare of vegetation, and act as a major source of clay and silt particles which is a preferable component to be carried by wind in the form of dust. The two hotspots are shrinking with time by 85.5% in 2023 (3 373 km^2) (Table 1) compared to 23, 331 km^2 in 1984 (Fig.5). A rehabilitation project (2023-2026) between Iraq and Kuwait Institute for Scientific Research (KISR) funded by UN-Habitat and Kuwait Fund for Arab Economic Development (KF) uses mechanical and biological fixation. Both SDS intensity and counts were reduced during 2023 in most of the Middle Eastern countries compared to the years 2012 to 2021 as mentioned by Al-Dousari et al. (2022) [14] (Fig.6 and 7). Therefore, a four-year plan project led by the Kuwait Institute for Scientific Research (KISR) will be implemented to put control plans for hotspot (B) as it acts as the major source of SDS in southern Iraq (Fig.8). The activities that will be implemented to address the challenge will include:

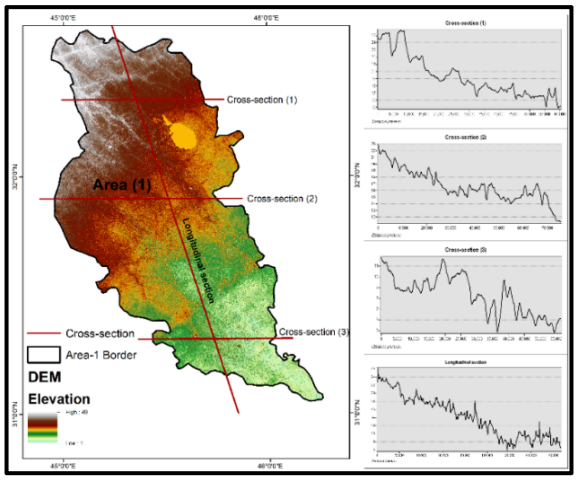

Fig. 2. The SDS hotspot (Area 1) in the Digital Elevation Model (DEM).

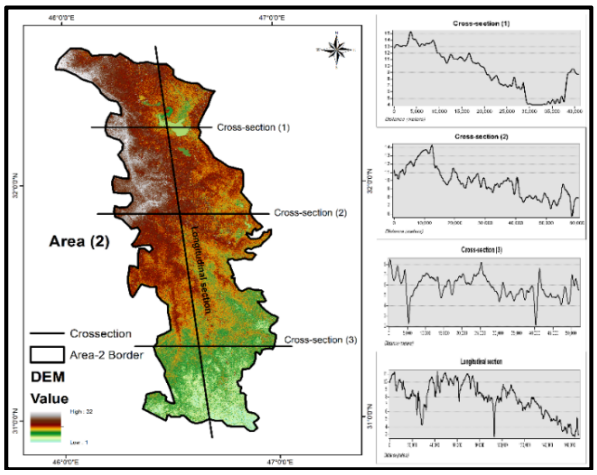

Fig. 3. The SDS hotspot (Area 2) in the Digital Elevation Model (DEM).

- Covering active aeolian sediments in area 1 with mud during September before the rain season (October-April) using heavy machinery (bulldozers and shafts, where a layer of 25 cm thickness is placed) to reduce the shift chances of dust particles by wind and thus allows natural growth of native plants.
- Native plantations (*Atriplex halimus, Tamarix artaculata*) and drought-resistant trees (*Prosopis juliflora*) will be planted as a windbreak to reduce wind action.

Covering with mud began in September 2022 and is still in progress (Fig. 7), while the second stage (plantation or afforestation) is in progress since September 2023 with around 150 000 native plantations. Conducting a comprehensive soil and aeolian samples survey and assessing their physical and chemical properties are essential to develop a success story in controlling SDS, and enhancing air quality in the Middle East region (Fig. 8). Research studies done in the region [26-30] show that that the first stage is more efficient as a solution compared to the second stage, as it stands on the ecological enhancement by mud covering that contains native plants seeds which acts as a praiseworthy healing factor in the region (Fig. 9).

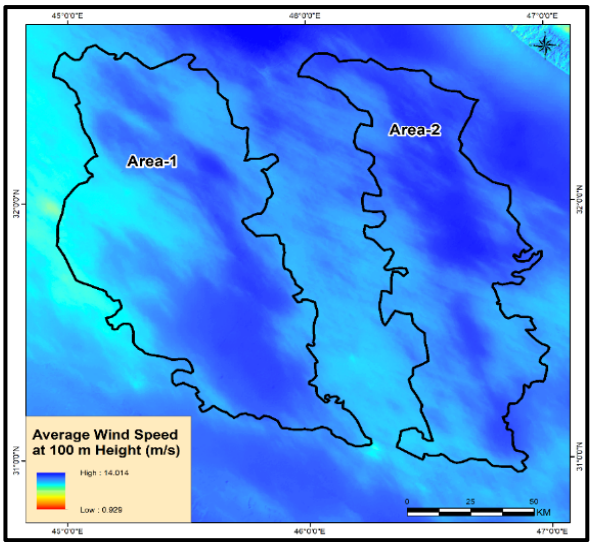

Fig. 4. Average wind speed (m/s) for the two SDS hotspots and surrounding areas.

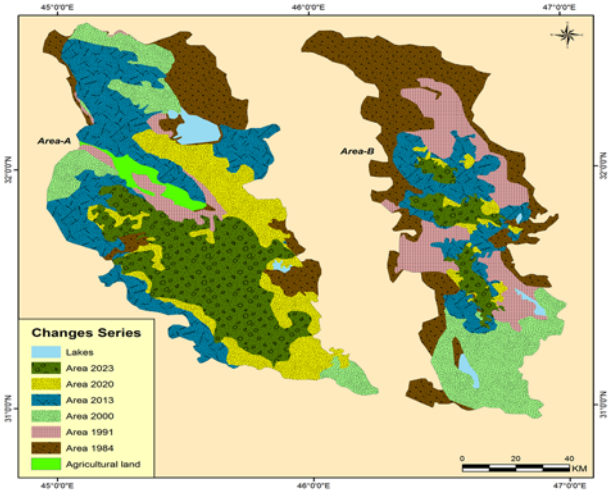

Fig. 5. The shrinking of the two SDS hotspots with time from 1984 (brown) until March 2023 (dark green).

Table 1. Surface area (km2) change percentages for SDS hotspots (Area 1 and 2) 1991-2023 in reference to 1984.

Year	Area 1	Area 2	Total	Change %
1984	12824.7	10506.6	23331.3	….
1991	11499.1	6989.1	18488.2	-20.76
2000	11482.7	4948.4	16431.1	-29.57
2013	10429.5	2964.5	13394	-42.59
2020	6446.6	1181.4	7628	-67.31
2023	2741.8	631.2	3373	-85.54

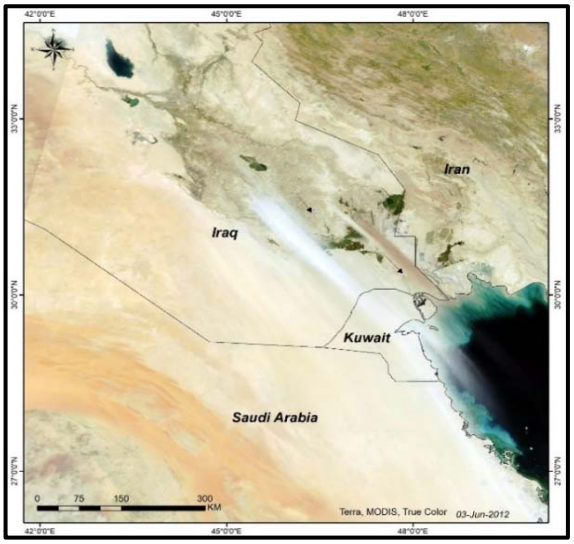

Fig. 6. A MODIS true color, observation for a sand and dust storm (SDS) originated from the two hotspots on 03 June 2012.

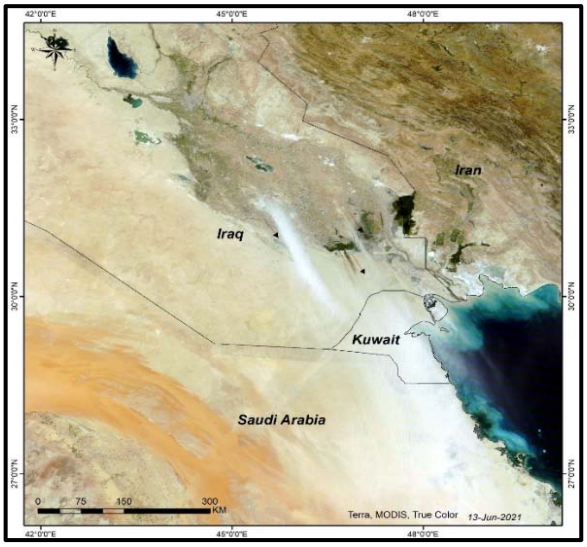

Fig. 7. A MODIS true color, observation for a sand and dust storm (SDS) originated from the two hotspots on 13 June 2021.

Fig. 8. Mechanical fixation by mud before rain season in September at SDS hotspot (Area 1).

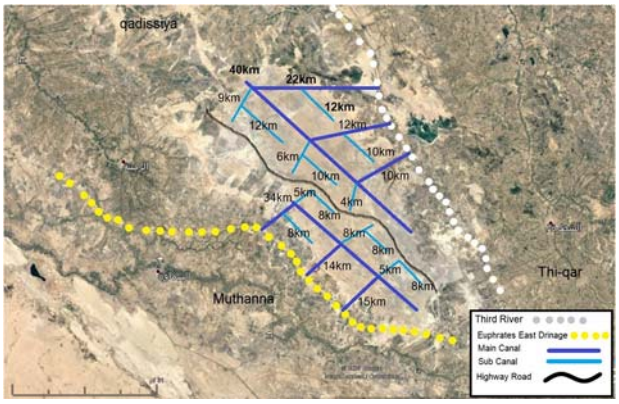

Fig. 9. The plan controlling map for the SDS hotspot (Area 1) that includes establishing water channels from the main river.

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