A sandstorm hovering over the African Union-United Nations Mission in North Darfur, El Fasher, Sudan
Photo credit: UNAMID/Adrian Dragnea

Sand and Dust Storms: Subduing a Global Phenomenon

Invasion by sand and dust

In 2010, Chinese authorities issued a level-five pollution warning as a massive sandstorm moved from Mongolia and northern China towards Beijing, hovering over an area of 810 000 square kilometres and threatening 250 million people.[1] In May 2016, a series of massive sand storms swept across Rigan County in southeast Iran, burying 16 villages and causing USD 9 million in losses.[2] A few months later, heavy dust and sand clouds engulfed Abu Dhabi, reducing the visibility in the city to 500 metres and increasing the number of asthma patients admitted to hospitals by 20 per cent.[3,4] These are just a few examples of recent threats and damages that sand and dust storms delivered to many parts of the world. Other examples abound throughout human history.[5]

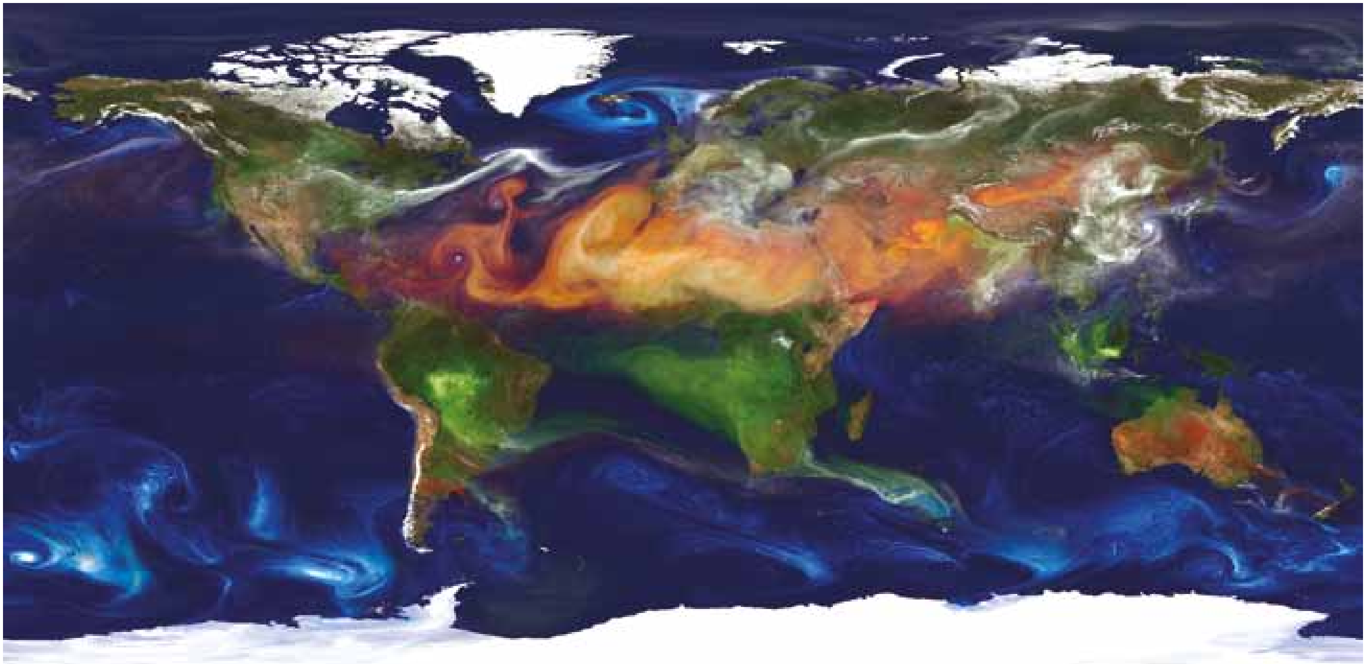
Sand and dust storms result when strong turbulent winds erode sand and silt particles from arid and semi-arid landscapes and then launch them into the air. Sand storms move relatively close to the ground and both particle size and wind speed constrain the distance each particle travels. Dust storms raise large quantities of fine silt particles and smaller clay particles higher into the atmosphere.[6]

Dust storms can travel thousands of kilometres across continents and oceans, entraining other pollutants on the way and depositing particles far from their origin. Winds spread the dust of the Sahara—the most significant source—west to the Americas, north to Europe and east to China.[6] Central Asian and Chinese sources reach the Korea peninsula, Japan, the Pacific Islands, North America and beyond.

A 2003 case study traced large amounts of dust from a 1990 Chinese plume that reached the European Alps—travelling eastward more than 20 000 kilometres within two weeks.[7] Dust plays an important role in biogeochemical processes throughout the Earth system. It forms a source material for vast expanses of loess soils.[8] Mineral dust deposition provides nutrients such as iron and other trace elements to terrestrial and marine ecosystems, boosting primary productivity and phytoplankton growth.[9] Saharan dust is a natural fertilizer of the Amazon rainforest, providing phosphorus inputs that balance losses through river discharge.[10] Similarly, Hawaiian rain forests receive nutrients from the dust of Central Asia.[11] At the same time, dust from Africa and Asia may damage Caribbean coral reefs.[12]

Dust can also harm animals and humans, especially in arid and semi-arid regions. For humans, inhaling fine particles can generate and aggravate asthma, bronchitis, emphysema, and silicosis.[13] Finer dust also can also deliver a range of pollutants, spores, bacteria, fungi and allergens. Other common problems include eye infections, skin irritations and Valley Fever. In countries of the Sahel, dust loads arriving from the Sahara correlate strongly with meningitis outbreaks.[14] Chronic exposure to fine dust contributes to premature death from respiratory and cardiovascular diseases, lung cancer and acute lower respiratory infections.[15]

Other socioeconomic damages follow dust storms.[16-19] Short-term costs include disease and death in livestock, crop destruction, damage to buildings and other infrastructure, transport shutdowns and expensive removal of tonnes of deposits. Economic losses from a single storm event can be hundreds of millions of dollars. Longer-term costs include erosion of soils, pollution of ecosystems, chronic debilitating health problems, and desertification.



A portrait of global aerosols produced by a GEOS-5 simulation at a 10-kilometre resolution. Dust emission can be seen in brown/red colour.
Photo credit: William Putman, NASA/Goddard Space Flight Center

Drivers from nature, land mismanagement, and climate change

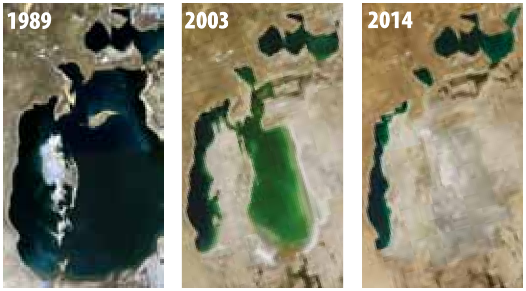
Dust activities vary significantly on a variety of time scales, such as seasonal, annual, decadal or multi-decadal scales.[20] A 2012 study of satellite data from 2003 to 2009 in comparison with similar analyses of data from earlier periods suggests that over the past three decades, substantial changes have occurred in Australia, Central Asia and the US high plains; whereas dust events over Northern Africa, the Middle East and South America have remained at the same level of activity.[21,22] Further studies show that these regions experience frequent high dust intensity as storms or haze events derived from both natural and anthropogenic causes.[21-23]

The anthropogenic causes, responsible for about 25 per cent of global dust emission, result from land use changes that include excessive water extraction and water diversion for irrigation, leading to drying out of water bodies; and deforestation and unsustainable agricultural practices, which expose soils to wind erosion. These are all forms of land degradation. In drylands, when agricultural soils are tilled too often and too deeply and crop residues are removed, soils are left exposed. Removal of hedges and windrows to allow for larger equipment increases wind erosion. Overgrazing of rangelands results in loss of soil cover. When the soils have no ground cover, winds lift away the finer particles containing much of the soil's nutrients and organic matter. Model simulations suggest that globally, dust emissions have increased between 25 to 50 per cent due to a combination of land use and climate change since 1900.[24]

In every dust-prone region, the relationship between human activities and increased dust is visible and sometimes palpable. The Owens (dry) Lake dust source in California was desiccated after water diversions to the Los Angeles Aqueduct began in 1913.[25] Patagonia in the southern half of Argentina has become a major anthropogenic dust source from desertification caused by unsustainable ranching.[26] The Indo-Gangetic basin is a principal dust source in South Asia, resulting from intensive agricultural activities.[22] In Australia, land clearing and water demand for agriculture has disrupted the hydrological regime and led to significant increase in dust.[27] Lake Balkhash in Kazakhstan has been rapidly drying since 1970 after completion of a dam upstream on the Ili River.

Shrinking Aral Sea from 2000 to 2013

Following decades of large-scale water diversion, the Aral Sea has dried up and become active sources of dust



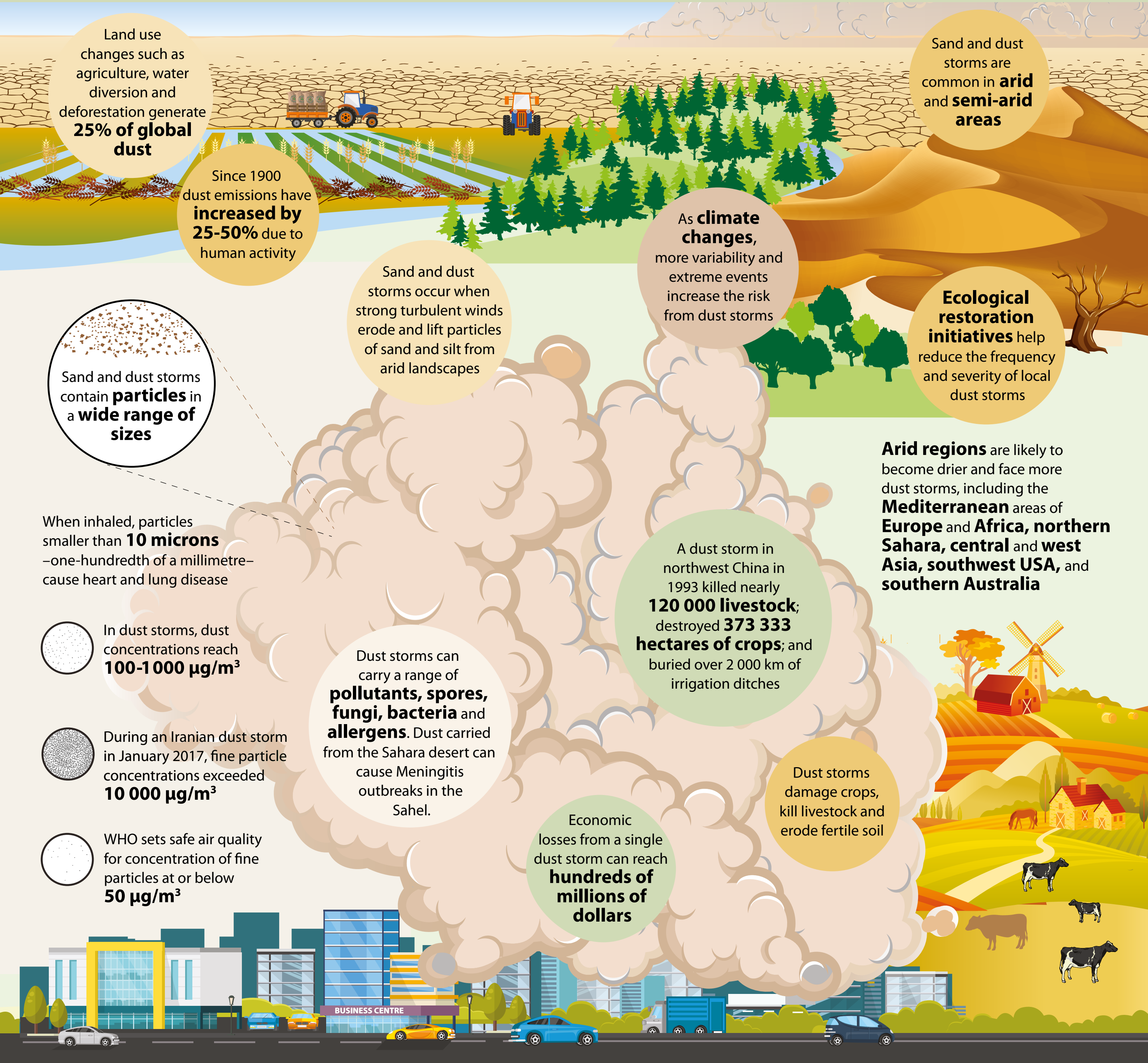
Credits
1989 - University of Maryland Global Land Cover Facility
2003 - Jacques Descloitres, NASA/Goddard Space Flight Center
2014 - Jesse Allen, NASA Earth Observatory

And finally, decades of large-scale diversions–from the region's main rivers, the Syr Darya and Amu Darya, to extensive irrigation schemes–reduced river flow reaching the Aral Sea, with consequent desiccation and desertification throughout the region.[28] Vast areas of the Aral Sea Basin are now active sources of noxious dust polluted with the persistent residue of artificial fertilizers and pesticides that were banned from use decades ago.[29]

Anthropogenic climate change is an important driver of dust generation, in addition to that produced naturally and by unwise land management. Many regions that are currently dusty areas will likely become drier and contribute more atmospheric dust. These include most of the Mediterranean areas of Africa and Europe, northern Sahara, West Asia, Central Asia, southwest USA, and southern Australia.[30,31] In turn, increased dust in the atmosphere can influence the climate system. It can disturb the earth's radiative balance, intensifying droughts in arid areas.[32] On the other hand, dust could enhance precipitation in some areas, by seeding clouds.[33]

Sand and dust storms are thus inter-connected with a range of environmental and development issues that extend across national, regional, and continental bounds. Anthropogenic climate change will further exacerbate decades of unsustainable land and water resource management in regions that generate sand and dust storms. This threat can be diminished by quick and effective action.

Sources and impacts of sand and dust storms



Reducing damage through focus on smaller scales

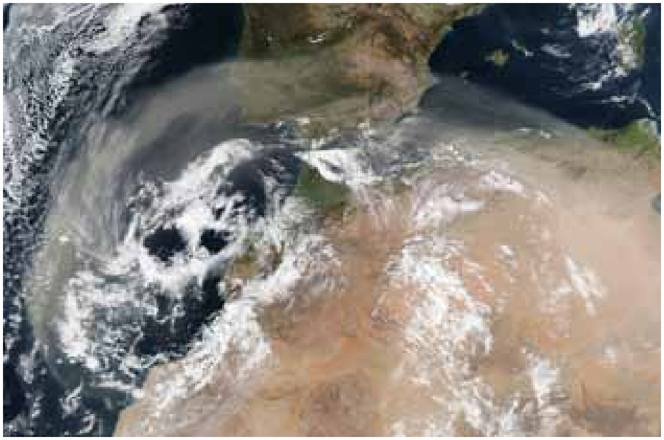
In the short to medium-term, successful efforts to reduce threats from sand and dust storms should focus on protective strategies.[34] Of course, early warning systems and disaster reduction procedures are essential components of preparedness, and regional programmes are evolving to refine these services. Procedures for coping in real time with sand and dust storms include advisory communications to public services; school, airport, rail and road closures; and hospital emergency services.

Preparedness starts with public awareness of sand and dust storm risks through education in schools, media and social networks and telecommunication. Preparedness should also include techniques that provide physical protection of valuable assets such as planting or erecting barriers upwind of populated areas and essential infrastructure to encourage dust deposition outside those areas. Some actions, such as aligning roads and removing traps, channel dominant winds and their burden away from sites needing protection.

In the medium to long-term, reducing the threat from sand and dust storms should focus on preventive strategies that promote sustainable land and water management across landscapes. This level of scope addresses cropland, rangelands, deserts, and urban areas. Such strategies should integrate with measures for climate change adaptation and mitigation, as well as for conserving biological diversity. These crucial integrated strategies are currently deficient in many vulnerable regions.[34]

Video: Africa's ambitious "Great Green Wall"

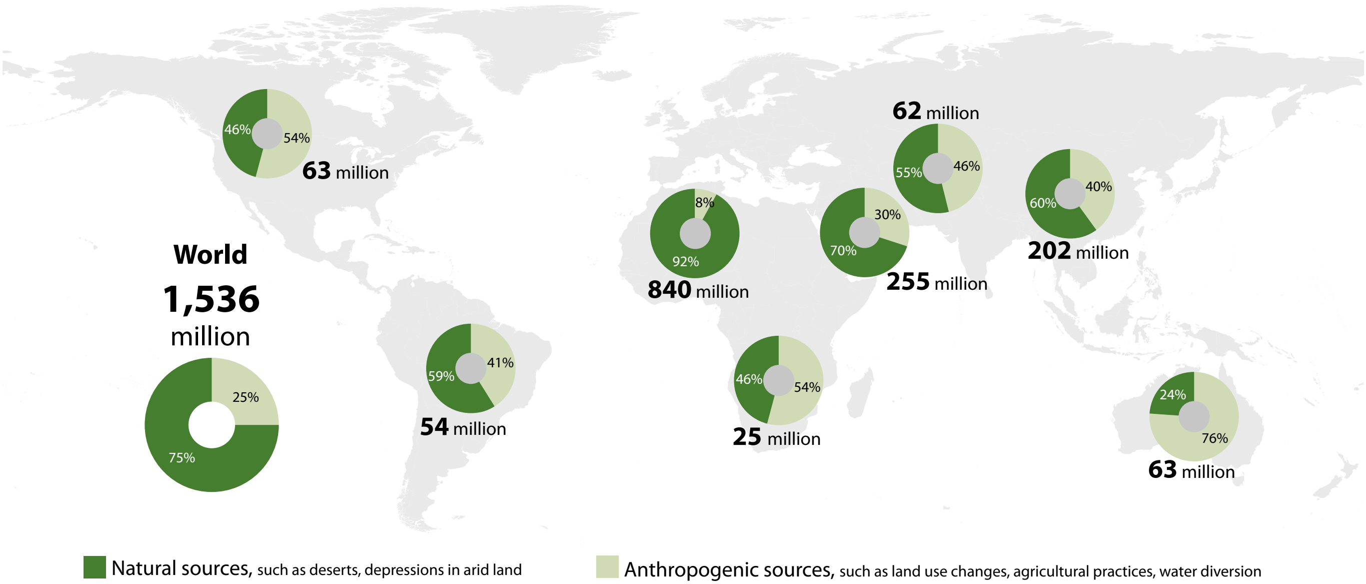
Video Link: https://www.youtube.com/watch?v=jl_nRHg-0l4 *© TIME*
Photo Credit: Tilling soil in Senegal by IFPRI/Milo Mitchell, licensed under CC BY-NC-ND 2.0



A dust plume blowing from Northern Africa towards Europe and the Atlantic Ocean, 21 February 2017
Photo credit: NASA image by Jeff Schmaltz, LANCE/EOSDIS Rapid Response

The Three North Shelterbelt Program in China, sometimes called the Green Great Wall, is an integrated effort that began in 1978 to address rampant soil erosion, which exacerbated existing problems with flooding and dust storms over large expanses, after decades of unsustainable natural resource exploitation. Research results and lessons learned suggest that a focus on what works at community and local levels, with local plant species already adapted to specific locations, brings success when linked and scaled up.[35] These insights renew emphasis on actions that promote ecosystem services such as food production, carbon sequestration, soil and water retention, flood mitigation, and provision of habitat for biodiversity conserving natural capital, as well as prevention of sand and dust storms.[36] Observations on Green Great Wall efforts show significant improvements in the surrounding vegetation index and deduce these efforts have effectively reduced dust storm intensity, after accounting for influences from climatic change and human pressures.[37,38]

Sources of dust emissions (tonnes/year)



Data source: Ginoux et al. (2012)[22]

In the Kubuqi desert of Inner Mongolia, private-public-community investments to plant local species of trees, shrubs and grasses on more than 5 000 square kilometres of desert land reduced the frequency of dust storms and the amount of related damage to homes and infrastructure.[39]

In Africa, the Great Green Wall for the Sahara and the Sahel Initiative is also finding success by working at local and community scales.[40] The initiative has graduated from a tree planting vision to focus on broader sustainable development: In Senegal they started by planting more than 270 square kilometres of indigenous trees that do not need watering. Later, other plants and animals are reappearing to restore the ecosystem. Communities in Mauritania, Chad, Niger, Ethiopia and Nigeria are growing market gardens along the dryland edge giving the young population work and reasons to reject migration. Once again, to succeed these projects carefully select plant species that are well adapted to local conditions, matched to water resource availability, and familiar to local residents who will ultimately be responsible for maintaining the restoration and the landscape.[41]

Economic losses due to sand and dust storms

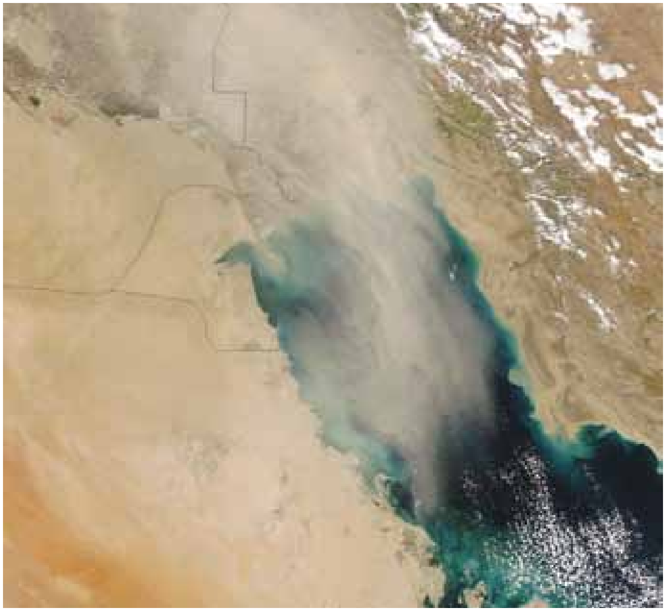
Multilateral support for reducing sand and dust storm damage

Integrated strategies that address sand and dust storm threats reflect recommended actions to contain land degradation, terrestrial biodiversity loss, and climate change threats under the three Rio Conventions: the UN Convention to Combat Desertification (UNCCD), the UN Convention on Biological Diversity and the UN Framework Convention on Climate Change, respectively. Supported by the UNCCD, West Asia and Northeast Asia have developed Regional Action Plans on sand and dust storms and the Northeast Asia plan is in full operation.[42]

Each Rio Convention supports land and water management efforts in partnership with appropriate multilateral institutions and agencies. International unity on these issues is reflected in the Sustainable Development Goals–particularly Goal 1, 2, 5, 13 and 15–that address the integrity and management of land and water resources, and specifically Target 15.3: "By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world."

Video: Combatting desertification: Chinese herdsmen dedicated to turn desert into oasis

Video Link: https://www.youtube.com/watch?v=giTXPUrYYJ0 *© CCTV English*
Photo credit: Preventing desertification in Ningxia, China by Bert van Dijk, licensed under CC BY-NC-SA 2.0



A dust storm over the Persian Gulf, 19 February 2017
Photo credit: NASA image by Jeff Schmaltz, LANCE/EOSDIS Rapid Response

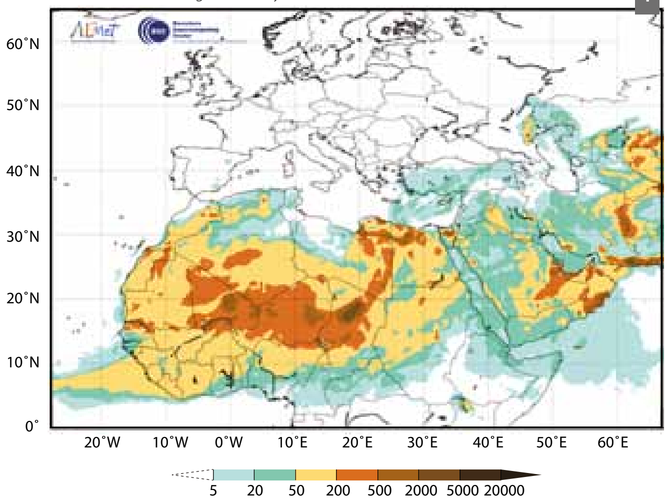
Regional frameworks, agreements and action plans such as the Regional Master Plan for the Prevention and Control of Dust and Sand Storms in Northeast Asia and national action plans, such as those required by the UNCCD, also establish policies for reducing sand and dust storm threats.

The World Meteorological Organization has established the Sand and Dust Storm Warning Advisory and Assessment System to enhance the ability of countries to deliver early and accurate sand and dust storm forecasts, observations, information and knowledge to users.[43] This system provides global and regional forecasts of dust threat and has established regional centres for the Americas, Asia, and Northern Africa, Middle East and Europe.[44]

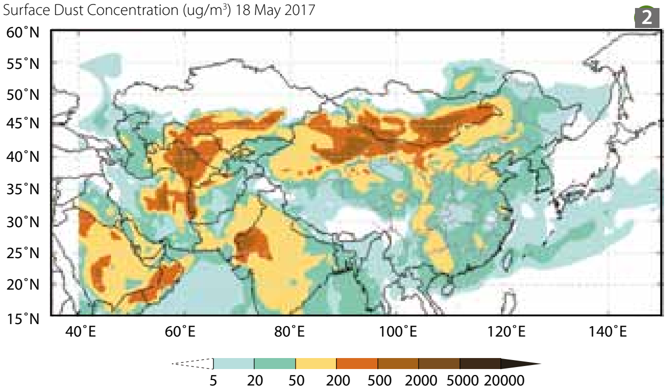
Integrated land and water management efforts encompass agricultural activities, and the Food and Agriculture Organization promotes conservation agriculture to address threats in arid regions. In 1992, a network called the World Overview of Conservation Approaches and Technologies (WOCAT) began to collect information about conservation

Online dust forecast by the World Meteorological Organization Sand and Dust Storm Warning, Advisory and Assessment System Regional Centres

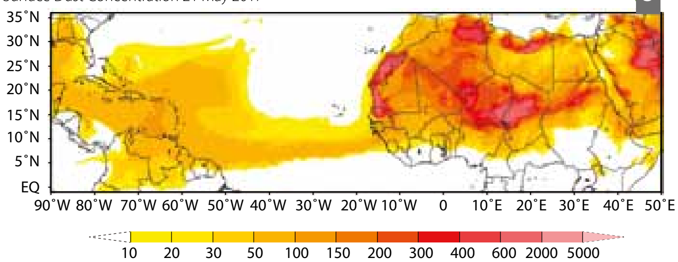
Dust Surface Concentration (ug/m³) 18 May 2017



Surface Dust Concentration (ug/m³) 18 May 2017



Surface Dust Concentration 21 May 2017



agriculture and sustainable land management practices from specialists. In 2014 the network was formalized into a consortium and recognized by the UNCCD as the recommended source of data on best practice. In 2017, WOCAT involves more than 2 000 registered users, over 60 participating institutions, and around 30 national and regional initiatives.[45]

Agriculture is responsible for nearly 70 per cent of all freshwater withdrawals.[46] Conservation agriculture also promotes water use practices that prevent water scarcity and desertification and that reduce the formation of sand and dust storms. The 2030 Water Resources Group has brought together case studies from around the world of currently available, replicable and practical solutions for water management. The solutions have been collected in an online catalogue 'Managing Water Use in Scarce Environments' that is meant to inspire action and use by policy and decision makers.[47] Many of the solutions have clear relevance to reducing sand and dust storms.

Finally, improved international integration and coordination of research is needed to reduce critical uncertainties on the interaction of dust with global biogeochemical processes and climate systems; to improve methods for monitoring, prediction and early warning systems; to assess the economic impacts and costs of sand and dust storms and related mitigation measures; and to improve the effectiveness of measures before, during and after interventions.

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https://sds-was.aemet.es/

2. WMO SDS-WAS Asian Center
http://eng.nmc.cn/sds_was.asian_rc/

3. Pan-America Regional Center
http://sds-was.cimh.edu.bb/

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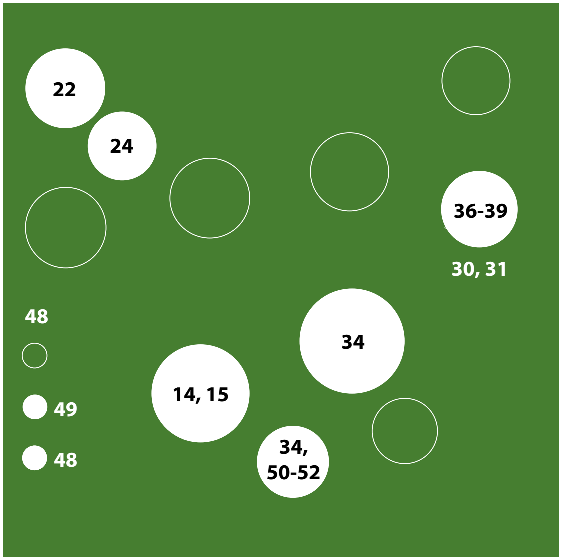

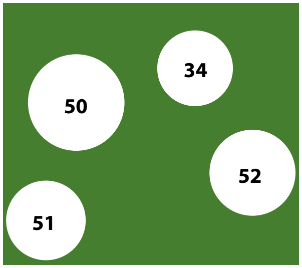

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A dust plume blowing from western Africa towards the Amazon Basin and the Gulf of Mexico, 25 June 2014. At least 40 million tonnes of Saharan dust is delivered to the Amazon Basin each year. Photo credit: Norman Kuring/NASA OceanColor Group