13. Sand and dust storms impact response and mitigation

Chapter overview

This chapter reviews approaches to address and mitigate the impacts of sand and dust storms (SDS) on humans and the economy. After an overview of SDS preparedness and emergency response procedures, the chapter identifies sector-specific measures to address SDS impacts.

13.1 Introduction

This section of the Compendium looks at ways to mitigate the impact of sand and dust storms (SDS) through preparedness and emergency response procedures (see **chapter 3** for overview of disaster risk management.) To date, most efforts to manage the risks posed by SDS have focused on understanding the mechanisms and origins of SDS (**chapter 2**), monitoring, forecasting and warning of SDS (**chapters 9** and **10**) and mitigation of SDS development at their source (**chapter 12**).

Less attention has been paid, as part of the disaster risk management process, to mitigating the impacts of SDS either as they occur or once they have occurred. This is likely due to the low profile of SDS (see Middleton et al., 2018) and the diverse impacts of SDS across sectors, which together make developing a unified approach complicated. It is expected that, over time, additional examples of responses to SDS will become available and can be integrated into a more comprehensive approach to SDS risk management.

The identification of specific measures for response and impact mitigation should be based on risk and vulnerability assessments (see **chapters 4**, **5** and **7**). The economic effectiveness and cost-to-benefit justification of each of these measures needs to be assessed based on local conditions (see **chapter 6**). In some cases, mitigation measures that are technically possible cannot be justified based on their expected benefits.

Following an overview of SDS preparedness (**chapter 13.2**) and response and SDS disaster planning (**chapter 13.3**), **chapter 13.4** provides an overview of SDS preparedness and response options and specific actions which have been identified to reduce SDS impacts through impact-based warnings, both during and in the immediate aftermath of SDS.

Chapter 13.4 should be read in conjunction with **chapter 12** as there can be considerable overlap between impact and source mitigation in practice.

13.2 Overview of SDS preparedness and response

Preparedness and emergency or disaster response play critical roles in mitigating disaster risk and minimizing impacts. Preparedness for and emergency response to SDS events take place at the individual, family, community and organizational (factory, school, etc.) levels.

As Ejeta et al. (2015) point out, preparedness strategies are developed through identification and mapping of the hazard in question, a vulnerability analysis and a risk assessment (see **chapters 5** and **7** on SDS risk and vulnerability assessments). Knowledge gained in these ways can then be used to develop protective actions.

Effective preparedness reduces vulnerability, increases mitigation levels and enables timely and effective response to a disaster event. These actions will shorten the recovery period from a disaster, while simultaneously increasing community resilience.

Preparedness, apart from building operational capacities and reserves, focuses on educating those at risk to adopt behaviours which reduce risk and increase coping capacities. An interesting example of using education to change behaviour is from the state of Arizona of the United States of America.

Box 22. Sand and dust storms and safe driving guidance

- Avoid driving into or through a dust storm.
- If you encounter a dust storm, immediately check the traffic around your vehicle (front, back and to the side) and begin slowing down.
- Do not wait until poor visibility makes it difficult to safely pull off the roadway – do it as soon as possible. Completely exit the highway if you can.
- Do not stop in a travel lane or in the emergency lane. Look for a safe place to pull completely off the paved portion of the roadway.
- Turn off all vehicle lights, including emergency lights. You do not want other vehicles approaching from behind to use your lights as a guide, possibly crashing into your parked vehicle.
- Set your emergency brake and take your foot off the brake.
- Stay in the vehicle with your seatbelts buckled and wait for the storm to pass.
- Drivers of high-profile vehicles should be especially aware of changing weather conditions and travel at reduced speeds.

Source: Arizona Department of Transport, n.d.

The Arizona state government and National Weather Service website Pull Aside, Stay Alive[1] provides information to drivers on how to respond to the very rapid deterioration in visibility during the sudden onset of dust walls typically associated with a haboob, which is a common cause of dust-related accidents on the Interstate 10 (I-10) highway (see **Box 22**; Day, 1993).

Monitoring, prediction, forecasting and early warning (see **chapters 9** and **10**) facilitate preparedness and emergency response. The development of SDS is monitored using data from satellites, networks of Lidar[2] stations and radiometers, air-quality monitoring and meteorological stations (Akhlaq et al., 2012). All of these sources contribute data to modelling efforts, which enhance our understanding of the processes involved and are used to produce predictions and early warnings (see **chapter 10**).

Operational dust forecasts have been developed at several WMO SDS Warning Advisory and Assessment System (SDS-WAS) centres (see **chapter 9**), as well as by national meteorological and hydrological services (NMHS). However, NMHS capacities to develop and issue SDS warnings vary considerably and warning procedures can vary between countries. Forecasts and warnings can be communicated to the public via a range of media, including television, radio, short message service (SMS) text alerts and smartphone applications, as discussed in **chapter 10**. Intrusive warnings can be provided via messages which break into radio or TV transmissions or send out blanket SMS.

Detailed SDS forecasts are not always needed for warning systems. Forecasting for localized haboobs, which occur at spatial scales of a few kilometres, is under development (Vukovic et al., 2014). However, systems designed to warn drivers of dusty conditions on susceptible highways have been used in the southwest of the United States of America for several decades (Burritt and Hyers, 1981). More recently, remotely-controlled signs are being replaced with systems linked to in situ sensors that detect poor-visibility conditions and alert motorists via overhead electronic signs.

There is evidence to suggest that media alerts of poor air-quality result in behavioural changes that tend to lower exposure to air pollutants (Wen et al., 2009).

1 See www.pullasidestayalive.org.

2 Light detection and ranging.

A similar finding was reached in assessments of the health impacts associated with a severe dust storm in Australia by Tozer and Leys (2013), which highlighted the importance of health alert SMS and emails sent to people advising of a high-pollution event. Further investigation of the Australian event by Merrifield et al. (2013) concluded that because the dust storm and consequent public health messages had widespread media coverage, the health consequences from this particular dust event were likely to represent the optimal health outcomes that could be hoped for in similar future events.

Nonetheless, significant challenges remain with the reception and uptake of SDS warnings. Research indicates that those receiving warning messages can be expected to follow a "milling" process before taking action to respond to a warning, which involves:

- understanding the warning
- believing the warning
- personalizing the warning
- deciding whether to take action based on the warning
- searching and confirming the warning.

The last step can involve visual verification of an SDS approach, which may provide limited time to take protective actions. Furthermore, an individual receiving a warning may not act until they are sure that their family members will be safe (National Academies of Sciences, Engineering, and Medicine, 2018).

While advanced technologies (mobile phones, satellites, etc.) are useful in disseminating warnings, it is not certain that these technologies will always reach all those at risk. In many parts of the world where SDS are common, these technologies are not available or have limited coverage, for example, only major urban centres. As a result, locally managed SDS warning systems are often required.

In many cases, source mitigation measures, as described in **chapter 12**, can be effective in reducing SDS impacts and should be included in preparedness measures.

For instance, increasing vegetation cover in urban landscapes, particularly with trees to slow wind speeds, may reduce the health problems associated with atmospheric PM_{10} and $PM_{2.5}$ concentrations, as well as biological and chemical aspects of pollution (see Janhäll, 2015). In both rural and urban areas, increased vegetation has the potential to reduce pollutants through filtration (see Hwang et al., 2011) and to regulate microclimatic conditions in a way that offers at least perceived benefits and well-being (Lafortezza et al., 2009).

13.3 SDS disaster or emergency planning

Current general good practice is for disaster or emergency plans to be developed at the individual, family, village, town, city, county, province or state and national levels, as well as for industry and business. These plans generally follow a similar model, with individual and family plans focusing on immediate survival after a disaster (for example, stocking food, water, medicine, etc.) and each higher level of plan focusing on providing support to the next lower group, for example, county plans defining support to cities, towns and villages, and state or provincial plans defining support to counties within the state or province.

Hall (2017) identifies four objectives of emergency and disaster planning:

- prevent injuries and fatalities
- reduce damage to buildings and materials
- protect the surrounding community and environment
- facilitate the continuation of normal operations.

Disaster plans can be developed for individuals, communities, public and private facilities, such as airports and hospitals, manufacturing and business units. Given the generally low profile of SDS as a hazard, only a few examples of SDS integration into the different levels of disaster or emergency planning are widely available. An example of guidance on family-level planning is provided in the **Be Prepared, Take Action, Be Informed**

video[3] and web page[4] developed by the state of Arizona Department of Emergency and Military Affairs of the United States of America.

An example of state (province) level SDS management planning is contained within the **Oregon Natural Hazards Mitigation Plan 2015** for the state of Oregon of the United States of America (State of Oregon, 2015).

The plan includes an assessment of SDS and historical examples of impacts, references to warnings and impacts, and source mitigation measures.

Box 23. Gender, preparedness and response

The Compendium's special focus section on gender and disaster risk reduction (see **chapter 3**) provides an overview of why including gender is important in addressing SDS and identified gender-related considerations across types of SDS risk management interventions. As a general rule, all public consultations should collect inputs using a gender-based perspective and from vulnerable individuals and groups, carrying out planning based on these perspectives.

In developing preparedness measures, gender, as well as factors defining vulnerability and vulnerable groups, should be incorporated in analysis and actions. Disaster response plans should also incorporate this type of analysis and should define specific impact mitigation measures and approaches which respond to the vulnerabilities identified.

Good practice is to include a gender specialist and disaster risk management in preparedness and response planning and during operations. Staff involved in preparedness or response should be trained on gender and disaster risk management in the normal course of their work.

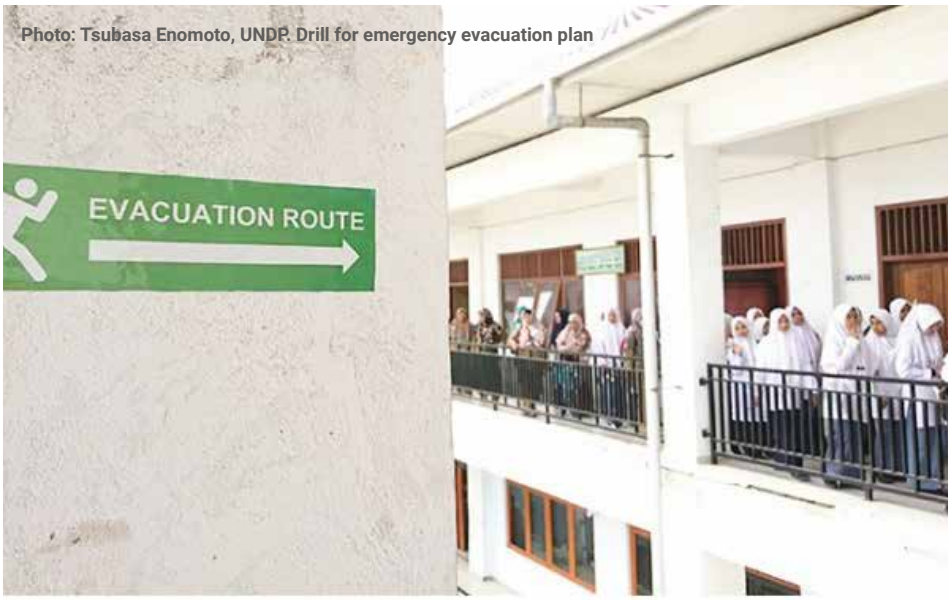

Photo: Tsubasa Enomoto, UNDP. Drill for emergency evacuation plan

3 https://youtu.be/X3qw5kr51eE.

4 https://ein.az.gov/hazards/dust-storms.

In general, an SDS disaster plan for a specific location or activity (city, school, factory, etc.) should follow the outline of other disaster plans for the same location or activity. Based on current good practice, an SDS disaster plan above the family level could be expected to include the following elements:

- Authorities for the plan (may be included in the overall plan for all disasters).
- An overview of SDS as a hazard in the area covered by the plan.
- A risk assessment (see **chapters 4**, **5** and **7**).
- Specific source and impact mitigation measures based on the risk assessment. This section may include references to subsidiary plans specific to individual sectors, for example, for a hospital or road transport (source mitigation measures would apply if the location is also a source of SDS).
- Warning, information dissemination and public awareness procedures. Warning procedures may include standard operating procedures to effectively disseminate warnings based on the impact-based forecasting approach (World Meteorological Organization [WMO], 2015).
- Operational details or examples of impact mitigation measures, where appropriate (see **chapter 13.4** and **chapter 12**). Providing details or examples can facilitate practising of plans before a disaster and implementation once a warning has been issued.
- Links to other programmes (such as soil conservation), which could play a role in SDS mitigation.
- Sources of information and contacts.

As appropriate, annexes to the plan can include specific procedures for source and impact mitigation and the identification of who takes primary and supporting responsibilities for implementing such procedures. In general, SDS disaster or emergency plans should include sufficient information to allow necessary actions to be taken, ensuring that no excessive details are added that may hinder the use of the plan.

13.4 Sector-specific options to address the impacts of SDS

13.4.1. Overview

The following sections provide summaries of possible impacts of SDS, as well as preparedness and mitigation measures which can be implemented for specific sectors. Source mitigation measures (**chapter 11**) are often also appropriate for impact mitigation, particularly where impacted locations may be also contributing to the overall load of atmospheric sand and dust load.

13.4.2. Agriculture

For sandstorms (for example, blowing sand and moving sand dunes), impact mitigation measures can include:

- installing sand fences near agriculture areas (Al-Hemoud et al., 2019)
- planting trees or shrubs to block the movement of sand and dust (Al-Hemoud et al., 2019)
- deploying equipment and personnel to clear irrigation and drainage channels from sand
- changing harvesting or planting procedures and timing to avoid the impact of moving sand.

In most cases, applying source mitigation measures to reduce the movement of sand before sandstorm conditions develop are more effective than large-scale impact mitigation. However, both may need to be applied in areas where sandstorms are common and threaten large areas.

For dust storms, impact mitigation measures can include:

- wetting crops after SDS to remove dust from plants (dust on plant leaves may affect development)
- closing vents in greenhouses to prevent dust entry
- removing or protecting machinery which may be affected by dust
- reducing the use of farm equipment which could need additional maintenance if used in high-dust conditions (for example, replacement of air filters, cleaning, etc.).

The use of agricultural machinery during SDS also needs to address the impacts of SDS on safe driving and operation, for example, ensuring that workers can be seen by equipment operators.

13.4.3. Construction

For road construction, consideration should be given to:

- safe operation of equipment during limited visibility
- safety of workers around equipment during limited visibility
- stabilization of road terracing and roadbed development so that the winds associated with SDS do not move the material.

Note that assuring good worker visibility is a normal method to improve safety when working near equipment. The nature of SDS may require additional measures to improve worker visibility, including:

- verifying that standard visibility vests work in high-dust environments
- assessing whether goggles and dust masks impact visibility and communication
- ensuring that equipment operators located in cabs have good visibility of work areas (for example, frequent window cleaning may be required).

Photo by REUTERS/Thomas Peter.

These measures are in addition to the health measures that may be needed when working in the hot and dry environments where SDS are common (hydration, protection from solar radiation, etc.).

For building construction, consideration should be given to:

- erecting physical cloth or plastic sheet curtains to limit dust entry into working areas (but with adequate air conditioning when needed)
- using water sprays or misters to reduce dust load in work areas
- assessing and addressing any limitations in worker visibility or ability to be seen or heard when using goggles and dust masks
- initiating the operation of air-conditioning systems early in a building's construction, along with permanent or temporary (for example, plastic sheeting) closure of openings to the outside of buildings or within them to reduce dust entry and remove dust from work areas (these measures need to take into account fire safety).

These measures can also improve overall working conditions within buildings.

In addition, for both road and building construction, source mitigation measures should be in place to limit the generation of dust during normal times and SDS events.

13.4.4. Education

In education facilities:

- procedures can be initiated before SDS events to reduce dust entry, by closing and sealing windows
- dust rooms[5] can be constructed onto entry ways
- misters can be used to reduce dust load at entry ways and within large open areas
- air-conditioning systems can be operated in a way to increase filtering (though filters would need to be cleaned or replaced more frequently)
- in-room air filter units can be used as needed to reduce dust loads
- schedules for collecting and returning students using buses or other means of transport can be modified to limit their exposure to SDS outside the education facility
- special procedures should be developed to assist students and staff with health conditions that can be affected during SDS (such as asthma, impaired vision, etc.).

For education institutions with dormitories, implementing an SDS response will need to include the participation of dormitory residents. Models for engaging students in SDS response addressing transport-related issues can be taken from procedures for dealing with severe weather, such as thunderstorms and tornadoes.

These measures can be integrated into school emergency plans and, with the exception of dust rooms, be put in place when an SDS warning is received.

Knowledge about SDS, their causes and impacts, can be integrated into school curriculum. Most curriculum include natural science and increasingly include core or supplemental topics on natural hazards and disaster management into which SDS management can be integrated.

In addition, education on SDS can be undertaken by interest groups in schools, such as an environment club, community organizations, including scouts and girls' or boys' clubs or other such organizations.

Note that these measures apply to all levels of the education system, from preschool to university. Facilities at each level in the education system should have disaster management plans, with this being a legal requirement in many countries.

5 A dust room would serve as an area where outside air would be physically isolated from inside air to limit dust from entry though doorways.

Photo: UNDP Indonesia

These plans should include SDS early warning and impact mitigation.

13.4.5. Electricity

Interventions to address the impact of SDS on electricity generation, transmission and use are most likely in the following areas:

- Generation – Clean solar panels of dust and protect equipment from short- and long-term impacts of dust by improving the filtration of air taken in directly by equipment, (for example, diesel generators), and in the environment where the equipment operates (for example, generator rooms), based on forecasts[6] and warnings.
- Transmission – Ensure that winds associated with SDS do not damage transmission lines or equipment, including measures taken before any severe weather to limit damage.
- Demand – Anticipate, based on previous SDS events, increases in electricity demand from cleaning activities after the event and during the event from increased use of air conditioners and other equipment.

13.4.6. Health

The two immediate threats to the health sector come from:

- the movement of dust into health facilities, which impacts hygiene in the facility, the operation of equipment and testing, and the health of patients
- an increase in the caseload of individuals with health conditions that are aggravated by sand or dust conditions.

6 Electricity generation planning can use weather forecasts to anticipate SDS and identify impacts several hours to several days in advance, incorporating this into operational plans.

Measures to reduce the impact of sand and dust on a health facility include:

- sealing windows and other openings before SDS to reduce air entry from outside
- using dust rooms at entry ways to physically isolate dust from inside air and limit it from entering though doorways
- using misters to reduce dust load at entry ways and within large open areas
- using air-conditioning systems to increase air filtering (filters would need to be cleaned or replaced more frequently)
- using in-room air filter units to reduce dust loads
- frequent use of wet mopping to remove dust from floors and other surfaces
- washing clothes exposed to sand and dust to reduce secondary entrapment, specifically inside areas that have been isolated from SDS events (such as rooms with sealed windows)
- modifying opening and closing schedules to limit exposure to SDS
- reducing movement into spaces where sensitive equipment is located or tests take place
- increasing the use of breathing apparatus designed to reduce air intake from ambient air, for example, using a face mask instead of a cannula.

Measures to reduce the impact of increased caseloads associated with an SDS event include:

- increasing staff based on an SDS warning
- increasing supplies of treatment drugs and equipment
- separating triage and treatment facilities from the main health facility, incorporating the aforementioned methods, such as dust rooms, misters and air conditioning
- increasing potential patients' knowledge of ways to reduce or avoid the impacts of SDS, which can involve long-term education for SDS-vulnerable patients, as well as messaging as part of SDS warnings on how to reduce SDS impacts.

13.4.7. Hygiene

Living facilities (houses, apartments, care facilities, public offices and commercial markets and places of assembly) can take actions similar to those for education facilities:

- sealing windows and other openings before SDS to reduce air entry from outside
- using dust rooms at entry ways to physically isolate dust from inside air and limit it from entering though doorways
- using misters to reduce dust load at entry ways and within large open areas
- using air-conditioning systems to increase air filtering (filters would need to be cleaned or replaced more frequently)
- using in-room air filter units to reduce dust loads
- wet mopping frequently to remove dust from floors and other surfaces
- washing clothes exposed to sand and dust to reduce secondary entrapment, specifically inside areas that have been isolated from SDS events (such as rooms with sealed windows)
- modifying opening and closing schedules to limit exposure to SDS.

For some public facilities, including shopping malls and closed markets, expanding hygiene efforts can be part of activities to provide safer places as refuge from SDS for those who may be outside when the event developed (such as a haboob). This activity would be similar to the establishment of warming spaces, such as tents, during extreme cold events, or to cooling spaces during extreme heat events. In some situations, cooling spaces will be needed at the same time as SDS events.

13.4.8. Livestock

SDS impacts on livestock, including cattle and other ruminants, horses, goats, sheep, ducks, geese and other animals kept in controlled situations (for example, not ranging without human intervention) include:

1. respiratory problems
2. difficulty accessing food if pastureland is covered in dust or sand
3. entering into traffic or water sources in an effort to avoid the dust or sand, or because of poor visibility.

Livestock owners or managers should develop a plan for managing SDS based on local conditions and also seek expert advice from specialists and veterinarians on animal health impacts and normal reactions to SDS by the animals of concern. Specific measures that can be considered to reduce impacts include:

- moving animals to enclosed areas before SDS events
- moving animals inside before SDS, but considering the need for adequate ventilation, water and food for the duration of the event
- providing additional food stocks if normal food supplies (for example, pasture) is covered by sand or dust
- allowing animals to move to open rangelands to reduce excitement that may be due to SDS, such as haboobs, and associated with thunder or heavy winds and rains (though care should be taken to ensure that moving animals does not put them at risk of lightning strikes)
- moving animals away from roads and waterways to avoid unplanned movements into these areas.

If animals are being kept inside a building, it is important to consider the environmental conditions (heat and humidity) within the building if a large number of animals are present and normal ventilation has been shut down because of the SDS. This could lead to hot and humid conditions which contribute to animal health issues.

If SDS are common, developing an understanding of common local practice is important as these animals may have adapted to this hazard from experience. Measures such as misters may be tested to reduce temperatures and dust loading. Masks are unlikely to be effective.

13.4.9. Manufacturing

Impact mitigation for manufacturing is likely to fall into three areas:

- reducing the entry of dust into facilities through closing and sealing windows and other openings, improving filtering and using air locks and positive pressure to block inward air movement
- reducing the dust load carried by employees and others entering facilities by requiring a change of clothes or the use of overalls
- increasing the cleaning of raw materials, parts supplied and items manufactured to reduce the presence of dust.

Although these measures are likely to be common practice during non-SDS periods, they can be expanded and upgraded through, for example, additional washing or resealing of openings, based on SDS forecasts and warnings.

13.4.10. Public awareness

Improving public awareness of SDS impacts can improve the uptake of warning messages (see **chapter 9**) and the overall adoption of impact mitigation measures. Awareness can be raised through:

- the education system (see **chapter 13.4.4**)
- information campaigns before and during expected SDS periods
- site-specific SDS information, usually integrated into early warning messages (see **chapter 10**).

Raising public awareness about hazards, potential disasters and impact mitigation is a major task of national and subnational disaster management offices, with considerable experience and documentation on these types of efforts available. See the document **Public Awareness and Public Education for Disaster Risk Reduction: Key Messages** (International Federation of Red Cross and Red Crescent Societies [IFRC], 2013) for a starting point on public awareness and impact mitigation.

13.4.11. Sport and leisure

In most cases, outdoor sports and leisure activities would be cancelled based on SDS forecasts and warnings. Due to the short lead time and short duration for haboobs, it can be useful to set up temporary refuges (for example, in a sports hall) so that people can avoid driving during the immediate passage of a storm (see **chapter 13.4.12** on transport).

In any case, the organizers of outdoor sports and leisure events during periods of possible SDS should:

- be in contact with weather and disaster management services to get timely forecast and warning information
- have plans on managing SDS events, coordinated with local authorities as needed
- have assessed and be prepared for the immediate health impacts of SDS on health-compromised individuals, including training immediate responders, stockpiling emergency supplies, planning evacuations to health facilities with local health authorities and providing warnings specifically for these individuals when SDS are expected.

Indoor events are less likely to be directly affected by SDS. However, plans should be developed to:

- seal windows and other openings before SDS to reduce air entry from outside
- open dust rooms at entry ways to physically isolate dust from inside air and to limit it from entering though doorways
- use misters to reduce dust load at entry ways and within large open areas
- use air-conditioning systems to increase air filtering (filters would need to be cleaned or replaced more frequently)
- use in-room air filter units to reduce dust loads
- wet mop frequently to remove dust from floors and other surfaces
- modify opening and closing schedules to limit exposure to SDS
- identify how to adjust participants' road transport plans to limit driving in severe dust conditions, including driving at night when dust can have the same impact as fog on visibility.

13.4.12. Transport

The transport sector has received considerable attention with respect to reducing the impact of SDS. For air transport, civil aviation regulations, company operation procedures, advances in technology and improved SDS forecasting and modelling have been generally effective in reducing the risk posed by SDS in their various forms (see Baddock et al., 2013, for an example from Australia).

The greatest risk to air transport likely comes from aircraft flying into unanticipated SDS conditions (such as haboobs or the Harmattan front) and attempting to land with limited visibility. This seems less likely to occur with scheduled air services, which are supported by dedicated weather

services, and more likely with private or small commercial operations, based on experiences in the Sahel.

Specific measures to reduce the impact of SDS on aircraft (and their users) include:

- using forecasts to identify whether SDS are possible at the destination or on-route
- deciding not to fly to a destination where SDS may occur during the flight or close to the expected landing
- landing in advance of forecasted SDS or at an alternative airport where SDS conditions are severe at the intended destination
- plugging or covering vents, intakes and tubes to prevent dust from entering and sealing windows and doors, if possible
- ensuring that all intakes are clear of dust, plugs and covers before starting the aircraft
- vacuuming the inside of the aircraft after SDS to improve hygiene, limit secondary dust entrapment, reduce the need to replace air filters and reduce impacts on sensors and instruments (adapted from SKYbrary, 2019).

Conditions similar to those found in SDS can also develop for helicopters in the final stages of landing or on taking off from unimproved landing sites (for example, no pavement). These "brown-out" events are the result of the helicopter blades causing dust, sand and other small items to become airborne when the aircraft is very close to the ground. These events can cause pilot disorientation and difficulty in landing (Rash, 2006).

Ways to address this problem include:

- pilots being ready to use instrument landing procedures when brown-out is expected
- covering the landing area with a chemical treatment to prevent dust, sand and debris
- watering the area where an aircraft will land to remove conditions that allow dust and sand to be entrained in the downdraft from the aircraft (adapted from Rash, 2006).

Overall, the challenge in reducing the impact of SDS on road transport is significant. The greatest risk to this transport likely comes from haboobs or locally-blowing dust associated with agriculture (for example, ploughing fields).

Impact mitigation for road transport includes the following:

- risk assessments and the identification of specific SDS source areas and times of year (this applies to both haboobs and dust from agricultural activities, which can be time- and location-specific)
- public awareness (see **chapter 13.4.10**), including posting signs in possible SDS locations
- planning, including annual awareness campaigns, site mitigation measures (such as sand fences) and response to forecasts and warnings
- information collection, research and source mitigation plans to reduce long-term risk and improve the understanding of local conditions that can generate SDS
- site-specific warning messages, safety patrols and traffic controls (for example, warning lights or changes to speed limits when SDS are forecast).

An example of these steps comes from Arizona in the United States of America, where the National Weather Service and state and local authorities have developed a programme to collect research on SDS, disseminate the information to at-risk populations, use the information in impact and source mitigation and develop public awareness on how to manage SDS while driving. Information on the Arizona effort can be found at:

- Arizona Emergency Information Network, Dust Storms: https://ein.az.gov/hazards/dust-storms
- National Weather Service, Dust Storm Workshops: https://www.weather.gov/psr/DustWorkshops
- City of Phoenix, Storms and Monsoons: https://www.phoenix.gov/emergencysite/Pages/Storms-and-Monsoons.aspx

- Monsoon Safety, Thunderstorms and Dust Storms: http://www.monsoonsafety.org/facts/dust-storms.htm.

The Arizona programme also includes a public information video titled *Pull Aside, Stay Alive*.[7]

In addition, the Arizona State Department of Emergency and Military Affairs has developed an SDS video on the theme of preparedness, taking action and being informed, which includes specific guidance on what to do when driving near or into SDS, as well as other impact mitigation advice.[8]

13.4.13. Water and sanitation

SDS impacts on water quality are expected to primarily result in an increased sediment load as dust settles on water supplies. The impact is expected to be larger the greater the surface area of water covered by dust.

Reducing the impact of dust will require water filtration both at the water supply systems level and the individual (household) level for water storage containers. The need to filter SDS-contaminated water may reduce the throughput of large-scale treatment operations and increase the quantity and cost of deflocculating (pre-filtering removal of impurities) from the water. Filtering SDS-contaminated water at the household level may not be needed (for example, if the level of contamination is small) or can be done using normal water filters.

Efforts to remove dust from water supplies may be justified based on chemical or biological contaminants transported on or with dust. This risk should be assessed before SDS events.

If needed, measures for cleaning large and small water supplies can be developed, with public education on the need to clean household water supplies incorporated into the SDS public awareness process.

Some of the sanitation-related impacts of SDS are likely to be addressed through the measures described under the chapter on hygiene (**chapter 13.4.7**). However, based on actual SDS impacts and time and resources available, SDS-related sanitation measures will likely focus on:

- washing streets, sidewalks and public areas to remove dust
- clearing accumulated sand from drains and drainage systems (in urban areas)
- increasing sewage treatment plant operations to deal with additional greywater produced from hygiene-related activities (such as increased washing of clothes, floor cleaning, etc.).

13.5 Conclusions

There are a range of measures that can be taken to prepare for and mitigate the impacts of SDS. The selection of specific measures needs to consider the type of SDS that may occur, the extent to which a warning is possible, and the nature of the activities being undertaken when SDS may occur. Where not yet already in existence, SDS preparedness and response plans ranging from the individual to national levels should be developed as a normal part of disaster risk management, based on standard approaches to disaster planning. In all cases, education about SDS and impact mitigation measures should be provided to anyone at risk, even if for a short time, and should be supported by warning and preparedness plans.

7 Available at http://www.pullasidestayalive.org/.

8 The video is available at https://youtu.be/X3qw5kr51eE and is presented in sign language as well as spoken word with images.

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