3. Sand and dust storms from a disaster management perspective

Chapter overview

This chapter covers how sand and dust storms (SDS) can be considered a hazard and how hazard and disaster risk management approaches apply to managing their risks and impacts. Also discussed is a unified approach to SDS management and a framework for SDS Risk Management Coordination and Cooperation.

This chapter should be read together with the following chapters:

- 2 – "The nature of sand and dust storms"
- 4 – "Assessing the risks posed by sand and dust storms"
- 6 – "Economic impact assessment framework for sand and dust storms"
- 7 – "A geographic information system-based sand and dust storm vulnerability mapping framework"
- 10 – "Sand and dust storms early warning"
- 12 – "Sand and dust storms source mitigation"
- 13 – "Sand and dust storms impact response and mitigation"

3.1 SDS as a natural hazard

SDS originate from a combination of individual elements, principally wind, sand and dust, but also soil moisture and other factors (see **chapter 2** and **Table 1. Factors associated with sand and dust storms** in **chapter 4**).

As they are triggered by weather conditions, SDS can be classified as a meteorological hazard. However, SDS only occur if specific geophysical and geomorphological conditions are met. This is in contrast with floods, in the sense that enough rain can lead to flooding despite the geology or geomorphology on which the rain falls.

No matter how strong the wind blows, if the geological and geomorphological conditions are not right, an SDS event will not develop. This distinction is not to belabour the uniqueness of SDS compared with other hazards, but rather to stress that assessing and managing the risks from SDS requires attention to be paid to a range of environmental conditions and changes to these conditions over time and space.

Hazards can be classed as rapid/sudden-onset or slow-onset events. SDS are generally linked to negative changes in air quality and land degradation, including soil erosion, and are considered as slow-onset hazards (UNEP, 2012). However, there is a significant question as to whether the rapid-/slow-onset dichotomy is appropriate for SDS. Incremental and cumulative impacts of SDS may be recognized as long-term and slow-onset. Yet, a single severe SDS event can develop in a matter of hours and have significant negative immediate impacts, for instance dust storms leading to large-scale traffic accidents. Understanding slow- and rapid-onset impacts of SDS helps define how and when to reduce these impacts, while paying balanced attention to slow, cumulative and rapid impacts.

The term "sand and dust storms" itself groups different events. Seasonal predominant winds across dry landscapes can lead to high levels of airborne dust and low visibility, as in the Harmattan season in West Africa, with this dust often traveling thousands of kilometres (Middleton, 2017). Haboob, the result of a convective frontal system passing over sand and dust which is entrained by storm winds, can be part of seasonal weather patterns or local changes in weather systems (Roberts and Knippertz, 2012). SDS also develop locally due to wind funnelling through or around mountain ranges for instance, leading to regular afternoons of sand blowing and low visibility that lasts several months. See **chapter 2** for more information on the different types of SDS.

The locations where SDS originate are often characterized as unvegetated or sparsely vegetated dry and subhumid areas. Typical of such areas are the Bodélé Depression in the West African Sahel (Middleton, 2017) and arid areas of Central Asia or Central Australia.

At the same time, SDS can originate from very local conditions. Fields, industrial and mining sites and coastal and urban drylands have all been identified as origins of SDS (Middleton and Kang, 2017). SDS have been reported in Iceland due to high winds blowing across volcanic ash (Dagsson-Waldhauserova et al., 2015) as well as sand and dust created by glacial retreat (Gisladottir et al., 2005). (See **chapters 2** and **8** for more on where SDS can originate.)

The lower limit of wind speed that can initiate an SDS event, in the order of 30 km/hour (NSW Regional Office, 2006), is less than the 62 km/hour or so that it normally takes wind alone to cause damage, based on the Beaufort wind scale (National Oceanographic and Atmospheric Agency, n.d.). Understanding how the right wind speeds and right-sized sand and dust particles come together, often with other factors, to create SDS is an essential step in defining and addressing the impact of this hazard. See chapter 2 for additional details on winds and SDS generation.

No strict distinction exists between sand storms and dust storms. In general, particle sizes in SDS can range from smaller than 60 micrometres (μm) (classified as dust) and from 60 μm to 2,000 μm (classified as sand) (Shao, 2008). The smaller the particle size, the longer the particle is likely to remain in the atmosphere and the further it is likely to travel compared with larger particles.

A single SDS event can be composed of a continuum of mineral particle sizes, although the type of particles at the source area can lead to an SDS event with a specific range of particle sizes. For instance, an SDS event that originates in very fine loess soils will be composed of these particles. Similarly, the particle composition of an SDS event may change as it travels over different types of soils. **Chapter 2** discusses the relation between particle size and entrainment in SDS, while **Figure 5** presents the various aspects that can contribute to a sand or dust storm.

SDS can be triggered by human activity at local to regional scales. The Dust Bowl of the United States is one example of human action that resulted in regional-scale SDS (Egan, 2006). On the local (subnational) scale, ploughing fields in the presence of winds can lead to localized SDS, at times contributing to fatal accidents (Tobar and Wilkinson,1991; Associated Press, 1991).

As a hazard affecting health, the particle size is the main determinant of where dust comes to rest in the respiratory tract once inhaled. A distinction is commonly made between PM_{10} particles, which can penetrate into the lungs, and $PM_{2.5}$ particles which penetrate into deep lung tissue (UNEP, WMO and UNCCD, 2016).

SDS source areas and transport pathways are an important issue given the health implications of the chemical composition of sand or dust, and the potential for contamination through SDS. Atmospheric pollutants can be mixed into SDS that move across heavily industrialized and polluted regions (Chin et al., 2007).

Dust can contain a wide variety of micro-organisms, including fungi, bacteria and viruses, that are capable of causing disease in a range of organisms, including trees, crops, animals and humans (Kellogg and Griffin, 2006). Other potential health-threatening substances that can be found in SDS include heavy metals and pesticide residues (Ataniyazova et al., 2001), polychlorinated biphenyls (Garrison et al., 2006), pollen (Al–Dousari et al., 2016) and arsenic (Soukup et al., 2012).

GLOSSARY OF KEY DISASTER-RELATED TERMS

Disaster: "A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts" (United Nations Office for Disaster Risk Reduction, 2017).

(Disaster) risk: "The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity" (United Nations Office for Disaster Risk Reduction, 2017).

(Disaster) risk assessment: "A qualitative or quantitative approach to determine the nature and extent of disaster risk by analysing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people, property, services, livelihoods and the environment on which they depend" (United Nations Office for Disaster Risk Reduction, 2017).

Hazard: an event "…that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation" (United Nations Office for Disaster Risk Reduction, 2017).

Mitigation: "… lessening or minimizing of the adverse impacts of a hazardous event" (United Nations Office for Disaster Risk Reduction, 2017).

Resilience: The "ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management" (United Nations Office for Disaster Risk Reduction, 2017).

Risk management: The "plans [that] set out the goals and specific objectives for reducing disaster risks together with related actions to accomplish these objectives" (United Nations Office for Disaster Risk Reduction, 2017).

Risk reduction: "… preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development" (United Nations Office for Disaster Risk Reduction, 2017).

Sand and dust storms (SDS): "atmospheric events created when small particles are blown from land surfaces" (Middleton and Kang, 2017). The UNCCD Policy Advocacy Framework to combat Sand and Dust Storms refers to mineral sand (particle size 63 microns to 2mm) and dust (particle size range < 1–63 microns) that originates from land surfaces.

SDS impact mitigation: Reducing the likelihood that sand or dust will have negative impacts at a location on persons, good, services, infrastructure, animals or the environment in general (Middleton and Kang, 2017).

Source mitigation: Reducing the likelihood that sand or dust will be emitted from a location (Middleton and Kang, 2017).

Vulnerability: "The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards" (United Nations Office for Disaster Risk Reduction, 2017).

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Measures to control the generation of SDS from human-caused conditions can be justified as reducing the impact of SDS triggered by human actions. On the other hand, interventions to limit SDS arising from natural (not human-induced) conditions raise questions as to whether these efforts could adversely affect any positive impacts SDS may have on the environment, in some cases at a considerable distance from a source area. Therefore, efforts to control SDS need to assess the risks arising from the events (see **chapter 4** and **5**) and the costs and benefits involved (see **chapter 6**).

Major global trajectory of airborne dust movement and its deposition is documented using GIS techniques and satellite imagery (Ginoux et al., 2012; Shao et al., 2011). Localized and high-resolution point source information on SDS development would help develop appropriate policy measures to reduce impacts. Source mapping is discussed further in **chapter 8**.

SDS can be transboundary hazards affecting source and destination areas separated by long distances. Heavier particles tend to stay in the vicinity of sources (for example sand encroachment and blowing sand). Most dust particles smaller than 20 microns can be transported hundreds of kilometres (Gillette, 1979). Smaller particles can move even further, often thousands of kilometres from the place of origin (Kutuzov et al., 2013; Muhs et al., 2007; Prospero, 1999; McKendry et al., 2011; Grousset et al., 2003; Uno et al., 2009).

The distinction between source and destination is an important aspect of SDS as a hazard as it can dictate the SDS management strategy in affected areas. For example, in source areas, policy priorities are to mitigate the impact of sand or dust being removed by an SDS event, building resilience to these impacts and managing sources, for example by reducing the potential for winds to entrain sand or dust. In destination areas, preparedness and resilience capacity, coupled with early warning, is the key policy component (Middleton and Kang, 2017).

Meteorological and atmospheric dust transport modelling is the key to understanding the relationship between source and impact areas (Benedetti et al., 2014; WMO, 2015). Modelling is discussed further in **chapter 8**.

3.2 Low recognition of the disaster potential of SDS

SDS are not currently well positioned in mainstream natural hazard or disaster research. Middleton et al. (2018) provide a broad overview of SDS as hazards, with some detail on the costs of SDS. The physics (Middleton, 2017; Goudie, 2009) and transport (Middleton, 2017; Baddock et al., 2013) and health (Goudie, 2014) impacts of SDS appear to have been well researched, although there does not seem to be the same level of research coverage for all SDS zones (Pérez and Künzli, 2011).

Much less research appears to have been conducted into economic impacts (Tozer and Leys, 2013; Middleton, 2017; and see **chapter 6**). Social vulnerability to SDS appears to have received little attention, other than in popular literature (Egan, 2006, for instance).

It seems that great attention is paid to SDS in North-East Asia, with the Republic of Korea developing an SDS management plan (UNEP, WMO and UNCCD, 2016). SDS have been the subject of long-term management efforts in the United States of America (Natural Resources Conservation Service, 2017) and Canada (Wang, 2001). At the same time, the disaster risk management priorities of Sahelian countries such as The Gambia, Mali and Niger do not appear to consider SDS as significant, despite Harmattan and haboobs being part of the annual weather cycle of these countries (Gambia, 2017; Niger, Office of the Prime Minister, 2017; Chad, 2017).

The absence of SDS in official statements on hazards facing The Gambia, Niger or Chad contrasts with the research into at least one health impact associated with SDS: the occurrence of meningitis in the Sahel, which suggests a strong link between periods of high atmospheric dust concentrations (and high temperatures) and outbreaks of this disease (Jusot et al., 2017).

Several reasons explain why there is little recognition of SDS. Firstly, SDS usually cause little major structural damage and any immediate physical damage that does occur is relatively minor when compared with other disasters such as earthquakes or floods. Fatalities can be associated with SDS, for instance through traffic accidents caused by haboobs. However, SDS do not usually result in large-scale direct human fatalities or injuries, unlike earthquakes or hurricanes. While SDS do, in fact, contribute to morbidity and mortality, these impacts are often hidden as indirect causes and buried deep in health statistics on respiratory or cardio-vascular diseases, for instance, rather than detailed in dramatic reports of high death tolls directly attributed to a single event.

The economic damage from SDS is often hidden in operating statistics (for example, a greater need to replace air filters during the dust season) or indirect costs of cleaning (see **chapter 6** for more on assessing the economics of SDS.) Other impacts, such as damage to crops or dust and sand covering roads or other infrastructure, are not normally captured in disaster damage reporting.

The EM-DAT[1] ***Annual Disaster Statistical Review 2016: The numbers and trends*** notes that 100 million persons in China were affected by SDS in 2002 but does not report any SDS in 2016 (Guha-Sapir et al., 2017). EM-DAT classes SDS as a meteorological disaster, but the publicly accessible database does not allow the number or impact of SDS as individual events to be identified.[2]
This lack of globally assembled data makes it difficult to provide evidence as to the scale or scope of SDS impacts. National-level data on SDS disaster-related impacts likely varies on a country-to-country basis.

Research into SDS, in terms of either hazards or disasters, is fragmented spatially and topically. Only limited research appears to have been carried out in the Sahel compared with elsewhere, despite it being a major SDS source. Furthermore, less research appears to have been done into the social or economic impacts of SDS than into the physics or health issues associated with these events in some parts of the world.

Reducing the impact of SDS would require the systematic assessment of SDS as a hazard and source of impacts, in order to develop a clearer and evidence-based understanding of these events from local to global scales. Such assessments can provide the knowledge to effectively reduce the negative impacts of SDS on lives and well-being.

1 http://www.emdat.be/.

2 EM-DAT database accessed on 24 November 2017.

SPECIAL FOCUS SECTION: GENDER AND DISASTER RISK REDUCTION

"Women and their participation are critical to effectively managing disaster risk and designing, resourcing and implementing gender-sensitive disaster risk reduction policies, plans and programmes; and adequate capacity-building measures need to be taken to empower women for preparedness as well as to build their capacity to secure alternate means of livelihood in post-disaster situations."

Paragraph 36 (a)(i) Sendai Framework for Disaster Risk Reduction 2015-2030 (United Nations, 2015a).

International laws and agreements are placing gender equality at the centre of disaster risk reduction (DRR) and resilience-building. At the normative level, the international community has committed to focusing on gender equality and women's rights in DRR.

These commitments are grounded in the **Convention on the Elimination of All Forms of Discrimination against Women** (CEDAW),[3] the **Beijing Declaration and Platform for Action**,[4] resolutions on gender equality and the empowerment of women in natural disasters by the Commission on the Status of Women, and other international agreements.[5] The **Sendai Framework for Disaster Risk Reduction 2015–2030** emphasizes the importance of engaging women in building disaster resilience (United Nations, 2015a).

Despite this focus on gender-responsive disaster risk reduction management, gender perspectives are rarely incorporated into disaster preparedness plans and strategies, vulnerability and risk assessments, and early warning systems (United Nations, 2015b) (see **Figure 12**). Consequently, many institutions and organizations – both national and local – working on disaster risk reduction do not engage women, girls, boys and men equally.

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The result is that:

- the impact of hazards on, and corresponding disaster risks faced by, women and girls are not recognized, and
- the needs and capacities of women and girls are not considered in planning and risk reduction and response activities.

3 The Convention on the Elimination of All Forms of Discrimination against Women (CEDAW), http://www.un.org/womenwatch/daw/cedaw/cedaw.htm.

4 Beijing Declaration and Platform for Action, http://www.un.org/womenwatch/daw/beijing/pdf/BDPfA%20E.pdf.

5 For example: Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters, https://www.unisdr.org/we/inform/publications/1037; Commission on the Status of Women resolution 56/2 and resolution 58/2 on gender equality and the empowerment of women in disasters, http://www.un.org/ga/search/view_doc.asp?symbol=E/2012/27&Lang=E, http://www.un.org/ga/search/view_doc.asp?symbol=E/2014/27&Lang=E

These results perpetuate gendered stereotypes and lead to an increase in women's and girls' vulnerability.

There is good reason to conclude that SDS impact men, women, boys and girls in different ways. Evidence from gender-sensitive disaster research shows that women and men suffer different negative health consequences following extreme events such as floods, windstorms, droughts and heatwaves (Plümper and Neumayer, 2007; IPCC, 2012; Goh, 2013). This effect is strongest in countries where women have very low social, economic and political status.

This highlights the socially constructed and gender-specific vulnerability of women to disasters, which is integral to everyday socioeconomic patterns and leads to relatively higher disaster-related mortality rates in women compared with men (Neumayer and Plümper, 2007).

The gender relations between men and women in disaster risk reduction have everything to do with the roles and responsibilities women and men have at home and in society.

These roles result in different identities, social responsibilities, attitudes and expectations. Such differences are, on the whole, unfavourable to women and lead to gender inequality that cuts across all levels of socioeconomic development, including differences in vulnerabilities to disasters, and different capacities to reduce risk and respond to disasters.

Differences between men and women exist at multiple levels, including:

Roles and responsibilities – Men and women have different roles and responsibilities assigned to them (or expected of them), which can influence their vulnerability to, as well as their capacity to cope with, an SDS event. For example, men are generally expected to secure property and infrastructure, which may lead to them risking their own lives to do this in precarious situations. Women, on the other hand, are expected to prepare the home and attend to children and sick family members.

Access to and management of strategic resources – The ability to access and manage information, training, land, finance, technologies, social networks, support and other strategic resources necessary for well-being and long-term resilience varies between men and women. For example, in some communities, young men may have greater access than women to mobile phones and computers, so they are able to obtain early warning messages or can keep track of an SDS event. Older men and women living on their own may have limited mobility and require the support of others in the community.

People living with disabilities may also require additional time and support to be able to respond to hazards. As women tend to have less access to resources such as cash, housing and vehicles, they have fewer options in responding to disasters.

Participation and decision-making – Men and women may not have the same opportunities when it comes to economic and social participation and political representation. They also have different decision-making powers at the household, community and societal levels. These differences need to be considered to ensure men and women can make choices about their safety, livelihood options and adaptation measures.

However, gender issues are often institutionally marginalized within organizations that do not have enough capacity to advance the issue organization-wide in a multidisciplinary way. Gender issues become perfunctorily treated as "just women's issues", there is a notable absence of male champions, and gender expertise is applied in isolation from processes such as DRR.

Box 3. Women and vulnerability

Women are often presented as a "vulnerable group", with little attention given to the great variety of ways in which they can actively participate in disasters and their role in fostering a culture of resilience. This means that the skills and knowledge that women possess and the powerful role they can play as agents of change within society are often overlooked. In addition, over-generalizations about the vulnerability of women prevent a deep analysis of why some people are more vulnerable than others when disaster strikes.

To be clear, it is not always the case that women are more vulnerable than men to SDS impacts. Some groups of men could also be particularly vulnerable, such as those whose livelihoods depend on agriculture, or who are unemployed, have a disability, are older persons or live alone.

Evidence-based assessment and gender analysis can identify the specific needs of individuals or groups within an affected population. In some circumstances, addressing the specific needs of women and girls may be best performed by taking gender-responsive action because in practice, women and girls may need different treatment to produce equality in outcomes, i.e. to level the playing field so that women can benefit from equal opportunities.

Gender-responsive actions should not stigmatize or isolate the targeted beneficiaries. Rather, they should compensate for the consequences of gender-based inequality such as the long-term deprivation of rights to own property, or of access to financial means, education or health care.

Gender responsive actions should empower women and build their capacities to be equal partners with men in working towards solving problems caused by SDS and helping with reconstruction. Each sector should identify specific actions that could promote gender equality and strengthen women's capacities to enjoy their human rights.

Cultural practices regarding gender provide some of the most fundamental sources of inequality and exclusion around the world. The underlying roots of gender injustice stem from social and cultural dimensions and manifest themselves through economic and political consequences, among many others.

These long-standing inequalities can be addressed as part of SDS preparedness work. Sound gender analysis from the outset is the key to effective SDS response in the short term and equitable and empowering societal change in the long term.

The needs and interests of women, girls, men and boys vary, as do their resources, capacities and coping strategies in crises. The pre-existing and intersecting inequalities referred to above mean that women and girls are more likely to experience adverse consequences in the event of a sand or dust storm.

In disaster and post-disaster settings, women often find themselves acting as the new head of their households due to separation or loss of male household members. At the same time, they are not always able to access resources and support because there is no assistance for childcare and tasks such as acquiring food or water can be dangerous. As men generally have greater control over income, land and money, their coping mechanisms differ.

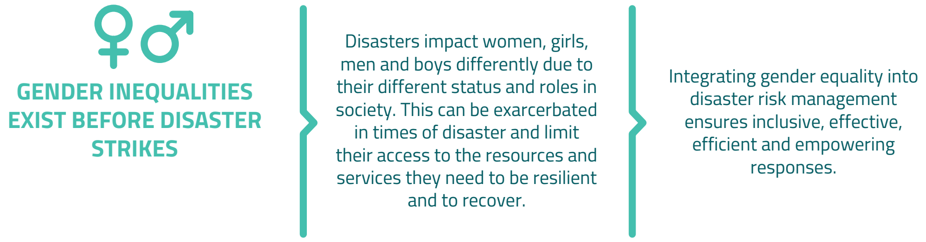
Thus, different people within a community may have different vulnerabilities to disasters. It is critical to understand why and how different groups of people may be vulnerable to SDS. Identifying and assessing the determinants of vulnerability will pinpoint where to direct the focus and interventions to reduce vulnerability and increase people's capacity to respond and prepare.

When women and men are included equally in disaster risk reduction, their entire communities benefit. A comprehensive approach to SDS risk management that integrates gender is better equipped to ensure that the particular needs, capacities and priorities of women, girls, men and boys related to pre-existing gender roles and inequalities, along with the specific impacts of the disaster, are recognized and addressed.

Both men and women bring a range of skills and talents to disaster risk reduction. It is vital to identify and leverage all of these available skills to support the long-term resilience of individuals and communities in affected regions.

Mainstreaming gender into SDS risk management can ensure that these efforts equitably benefit women and men while making optimal use of the unique knowledge and skills of both groups. Such equitable engagement is essential to achieving the **Sustainable Development Goals** (SDGs), particularly **SDG 5 – Gender Equality and Women's Empowerment**. Gender equality and women's empowerment are crosscutting issues and prerequisites for achieving many other SDGs, including **SDG 1 – No Poverty, SDG 11 – Sustainable Cities and Communities and SDG 13 – Climate Action**.

Figure 12. The importance of gender in disaster settings



Source: Adapted from Inter-Agency Standing Committee, 2018.

The following actions, drawn from UNEP (2013), are key to ensuring a gender-responsive approach throughout the integrated SDS risk management planning process:

- Incorporate gender perspectives into SDS risk management efforts at the national, local and community levels, including in policies, strategies, action plans and programmes.
- Increase the participation and representation of women at all levels of the decision-making process.
- Analyse SDS and climate data from a gender perspective and collect sex-disaggregated data.
- Carry out gender analysis as part of the risk profile by documenting the different roles that women and men play in sectors relevant to SDS. For example:
  - How are women and men's livelihoods affected by SDS?
  - How could gender-based differences in decision-making power and ownership of/access to assets lead to different abilities to respond the hazard?
  - What kinds of information do women have and need to better prepare for SDS?
  - What does this imply in terms of differences in vulnerability and coping capacity between women and men?
- Ensure that women are being prominently engaged as agents of change at all levels of SDS preparedness, including early warning systems, education, communication, information, and networking opportunities.
- Consider reallocating resources from the actions planned, in order to achieve gender equality outcomes.
- Take steps to reduce the negative impacts of SDS on women, particularly in relation to their critical roles in rural areas in the provision of water, food and energy by offering support, health services, information and technology.
- Build the capacity of national and local women's groups and provide an adequate platform that presents their needs and views.
- Include gender-specific indicators and data disaggregated by sex and age to monitor and track progress on gender equality targets.

GLOSSARY OF KEY GENDER TERMS

Gender "refers to the social attributes and opportunities associated with being male and female and the relationships between women and men and girls and boys, as well as the relations between women and those between men. These attributes, opportunities and relationships are socially constructed and are learned through socialization processes. They are context/ time-specific and changeable. Gender determines what is expected, allowed and valued in a women or a man in a given context. In most societies there are differences and inequalities between women and men in responsibilities assigned, activities undertaken, access to and control over resources, as well as decision-making opportunities. Gender is part of the broader socio-cultural context. Other important criteria for socio-cultural analysis include class, race, poverty level, ethnic group and age." (UN-Women, OSAGI Gender Mainstreaming - Concepts and definitions)

Gender analysis "is a critical examination of how differences in gender roles, activities, needs, opportunities and rights/entitlements affect men, women, girls and boys in certain situation or contexts. Gender analysis examines the relationships between females and males and their access to and control of resources and the constraints they face relative to each other. A gender analysis should be integrated into all sector assessments or situational analyses to ensure that gender-based injustices and inequalities are not exacerbated by interventions, and that where possible, greater equality and justice in gender relations are promoted." (UN-Women Training Centre, Gender Equality Glossary)

Gender-based evidence (or gender-disaggregated data) "consists of data that: (i) is collected and disaggregated by sex; (ii) reflects gender issues; and (iii) is based on concepts that adequately reflect diversity within subgroups (women and men) and captures all aspects of their lives. This type of data collection takes into account existing stereotypes, and social and cultural factors that cause gender bias." (UNDP/UN-Women (2018), Gender and Disaster Risk Reduction in Europe and Central Asia, Workshop Guide for Facilitators, p. 132)

Gender equality "refers to the equal rights, responsibilities and opportunities of women and men and girls and boys. Equality does not mean that women and men will become the same but that women's and men's rights, responsibilities and opportunities will not depend on whether they are born male or female. Gender equality implies that the interests, needs and priorities of both women and men are taken into consideration, recognizing the diversity of different groups of women and men. Gender equality is not a women's issue but should concern and fully engage men as well as women. Equality between women and men is seen both as a human rights issue and as a precondition for, and indicator of, sustainable people-centered development." (UN-Women Training Centre, Gender Equality Glossary)

Gender issue(s) "refers to any issue or concern shaped by gender-based and/ or sex-based differences between women and men. This may include the status of women and men in society, the way they interact and relate, differences in their access to, and use of, resources, and the impact of interventions and policies on women and men." (UNDP/ UN-Women (2018), Gender and Disaster Risk Reduction in Europe and Central Asia, Workshop Guide for Facilitators, p. 131)

Gender mainstreaming "is the chosen approach of the United Nations system and international community toward realizing progress on women's and girl's rights, as a sub-set of human rights to which the United Nations dedicates itself. It is not a goal or objective on its own. It is a strategy for implementing greater equality for women and girls in relation to men and boys. Mainstreaming a gender perspective is the process of assessing the implications for women and men of any planned action, including legislation, policies or programs, in all areas and at all levels. It is a way to make women's as well as men's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programs in all political, economic and societal spheres so that women and men benefit equally and inequality is not perpetuated. The ultimate goal is to achieve gender equality." (UN-Women Training Centre, Gender Equality Glossary)

Gender perspective "is a way of seeing or analyzing which looks at the impact of gender on people's opportunities, social roles and interactions. This way of seeing is what enables one to carry out gender analysis and subsequently to mainstream a gender perspective into any proposed program, policy or organization" (UN-Women Training Centre: Gender Equality Glossary). "By applying a gender perspective, we can:

- Analyse the causes and consequences of differences between women and men;
- Interpret data according to established sociological (or other) theories about relationships between women and men;
- Formulate inclusive policies and decisions;
- Design interventions that take into account, and address inequalities and differences, between women and men." (UNDP/UN-Women, 2018, Gender and Disaster Risk Reduction in Europe and Central Asia, Workshop Guide for Facilitators, p.30.

Gender-responsive approach "means that the particular needs, priorities, power structures, status and relationships between men and women are recognized and adequately addressed in the design, implementation and evaluation of activities. The approach seeks to ensure that women and men are given equal opportunities to participate in and benefit from an intervention, and promotes targeted measures to address inequalities and promote the empowerment of women." (The GEF, 2017, GEF Policy on Gender Equality)

Gender-sensitive approaches "attempt to redress existing gender inequalities." (UN-INSTRAW [now part of UN-Women], Glossary of Gender-related Terms and Concepts, quoted by Gender Equality Glossary)

Gender stereotypes "Gender stereotypes are simplistic generalizations about the gender attributes, differences and roles of women and men. Stereotypical characteristics about men are that they are competitive, acquisitive, autonomous, independent, confrontational, concerned about private goods. Parallel stereotypes of women hold that they are cooperative, nurturing, caring, connecting, group-oriented, concerned about public goods. Stereotypes are often used to justify gender discrimination more broadly and can be reflected and reinforced by traditional and modern theories, laws and institutional practices. Messages reinforcing gender stereotypes and the idea that women are inferior come in a variety of "packages" – from songs and advertising to traditional proverbs." (UN-Women Training Centre, Gender Equality Glossary)

Sex-disaggregated data "Sex-disaggregated data is data that is cross-classified by sex, presenting information separately for men and women, boys and girls. Sex-disaggregated data reflect roles, real situations, general conditions of women and men, girls and boys in every aspect of society. For instance, the literacy rate, education levels, business ownership, employment, wage differences, dependants, house and land ownership, loans and credit, debts, etc. When data is not disaggregated by sex, it is more difficult to identify real and potential inequalities. Sex-disaggregated data is necessary for effective gender analysis." (UN-Women Training Centre, Gender Equality Glossary)

Women's and girl's empowerment "concerns their gaining power and control over their own lives. It involves awareness-raising, building self-confidence, expansion of choices, increased access to and control over resources and actions to transform the structures and institutions which reinforce and perpetuate gender discrimination and inequality. This implies that to be empowered they must not only have equal capabilities (such as education and health) and equal access to resources and opportunities (such as land and employment), but they must also have the agency to use these rights, capabilities, resources and opportunities to make strategic choices and decisions (such as is provided through leadership opportunities and participation in political institutions)." (UN-Women Training Centre, Gender Equality Glossary)

FURTHER READING

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3.3 A comprehensive approach to SDS risk management

3.3.1. The disaster risk management overview

Disaster risk management (DRM) is the "application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses" (United Nations Office for Disaster Risk Reduction, n.d.). In practice DRM involves:

- **Preparedness**: the actions taken before a disaster to anticipate the impacts of a possible disaster and measures to reduce these impacts. Preparedness generally covers planning (incorporating results from assessing risks), education, training, stockpiles and ensuring equipment and human capacities are available to respond to a disaster. Educating people identified as "at risk" is a core preparedness task focused on enabling these people to reduce this risk through their own actions.
- **Warning:** the process of providing sufficient information in a timely manner to those at risk and those who provide assistance following a disaster, in order to enable actions to reduce exposure to – or impacts from – the disaster. Developing warning systems is part of preparedness.
- **Response:** the actions immediately after a disaster that save and sustain lives.
- **Recovery:** the set of activities that begin immediately after a disaster and continue through the post-disaster period as people affected by the disaster seek to return to normal life.
- **Risk reduction:**[6] the measures taken before a disaster to reduce risks, either as stand-alone activities or integrated into development efforts.

Disaster risk management is often presented graphically as a cycle, with one component following the other, for example response following warning following preparedness. However, different segments of a society faced with the same hazard may have different levels or depths of engagement with preparedness, warning, response, recovery and risk reduction on account of economic, social and other factors. The level of engagement needs to be considered when defining how each component is achieved and the degree to which one component is strongly or weakly linked to the others, for example warning may be only weakly linked to response for people living in informal settlements.

Chapters 4, 5 and **7** cover risk assessment, the basis for preparedness planning, warning (who should be warned?), response (who will need assistance?) and risk reduction (where is risk reduction needed?). **Chapter 6** provides guidance on how to assess the costs and benefits of risk reduction, **chapter 12** focuses on risk reduction from a source mitigation perspective, while **chapter 13** concentrates on preparedness and response and **chapter 9** covers early warning.

3.3.2. Global approach to SDS risk management

The **Sendai Framework for Disaster Risk Reduction 2015–2030** (United Nations, 2015a) sets out four priorities for action to reduce disaster impact:

1. Understanding disaster risk
2. Strengthening disaster risk governance to manage disaster risk
3. Investing in disaster risk reduction for resilience, and
4. Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction.

6 In some cases, efforts to mitigate hazard impacts are intended to reduce risk.

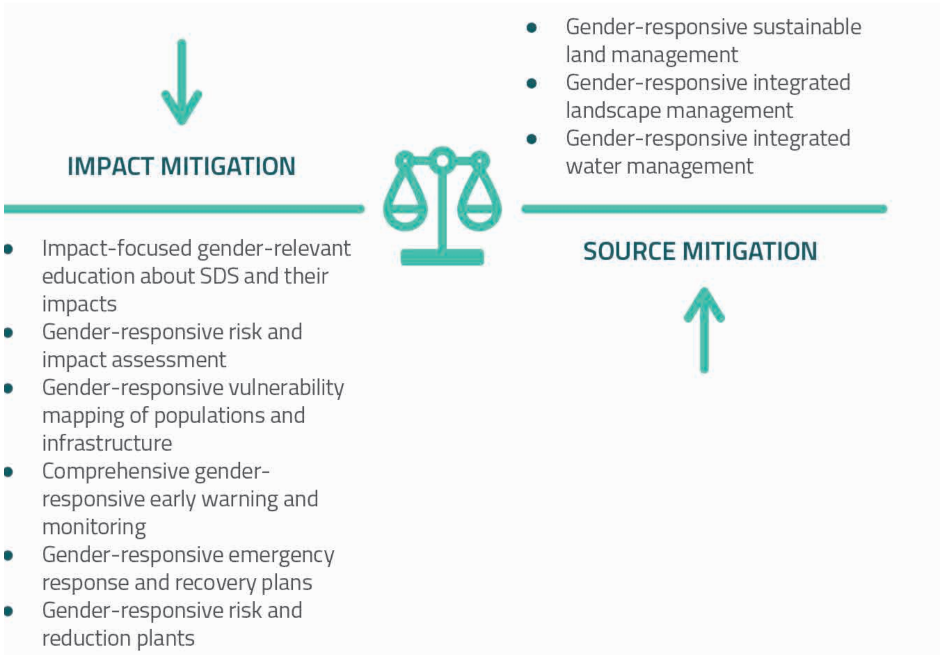
These priority action areas provide a basis for conceptualizing comprehensive SDS risk reduction management.

Drawing on the **UNCCD Policy Advocacy Framework to combat Sand and Dust Storms** (UNCCD, 2017), actions to reduce damage from SDS fall into two areas: impact mitigation and source mitigation. Together, source and impact mitigation activities provide a comprehensive approach to managing the potential disaster risks posed by SDS at local to global scales.
As indicated by **Figure 13**:

- **Impact mitigation** reduces the direct harm from an SDS event through:
  - » impact-focused, gender-relevant education about SDS and their origins and impacts
  - » gender-responsive risk and impact assessment
  - » gender-responsive vulnerability mapping of populations and infrastructure
  - » comprehensive gender-responsive early warning and monitoring
  - » gender-responsive emergency response and recovery plans
  - » gender-responsive risk reduction plans
- **Source mitigation** reduces the potential for harm from an SDS event through:
  - » gender-responsive sustainable land management
  - » gender-responsive integrated landscape management
  - » gender-responsive integrated water management

(See also **chapters 11** and **12** for more information on source and impact mitigation).

Figure 13. A twofold approach to mitigating sand and dust storm hazards for disaster risk reduction



Source: Adapted from Middleton and Kang, 2017.

Equal attention to both impact and source mitigation is required for two reasons. First, the majority of SDS are natural events. One hundred per cent source mitigation is unlikely to be practical and could have other negative impacts. As a result, the potential for harm from SDS cannot be avoided.

Second, SDS can arise from very local or distant sources. For local sources, even short gaps in mitigation can lead to deadly SDS events, as in the case of ploughed fields next to a highway during strong afternoon winds, where an SDS event can be generated in a matter of minutes and last less than an hour.

For distance sources, an SDS event thousands of kilometres from a location can have an impact, for instance on people with breathing problems. Given the uncertainty as to when and where SDS will develop and have impacts, prudence calls for preparedness to mitigate impacts.

For impact mitigation, most of the actions identified can be integrated into common practice approaches. In most cases, it is feasible for existing severe weather warning systems to include SDS.

Measures to reduce impacts can be included in existing school and community disaster awareness education efforts. Health care system standard operating procedures and traffic management protocols can be adjusted to incorporate measures for managing SDS impacts. This said, further work on recovery interventions is likely needed due to the range and diversity of SDS impacts in contrast to flooding, for instance, where considerable infrastructure repair can be required.

Risk reduction in impact areas will generally overlap with source mitigation interventions. This is because:

- some impacted locations may also be sources of SDS particles, and
- sustainable land management-related interventions are often linked to other risk reduction measures for floods and other hazards.

Thus, on the ground, impact mitigation and source mitigation may take place in the same location and be linked to other risk reduction interventions. The advantages of this situation are that:

- at-risk communities can engage in both preparing for and reducing the risk of SDS, and
- single risk reduction measures, such as tree planting or wetlands rehabilitation, may reduce the risk from several hazards at the same time

In terms of SDS source mitigation, it is worth noting that to be effective these activities generally have to take place at scales that are more comparable to river-basin-wide flood management (for example a system of flood management dams and several different types of land-use interventions). These large-scale interventions present specific challenges in terms of funding, engagement of the population in the target area, and the lag time between interventions such as tree planting and dune stabilization and reduction in SDS intensity.

The following sections review in more detail the approaches identified in the **UNCCD Policy Advocacy Framework to combat Sand and Dust Storms** (UNCCD, 2017) to reduce the impact of SDS (see **chapter 1**). These reviews provide an introduction to the more detailed technical materials in the following chapters of the report.

3.3.3. Risk knowledge

A precise understanding of disaster risk is a principal step in the disaster management process and facilitates appropriate decision-making on risk mitigation and adaptation strategies. SDS risk assessment results, based on a systematic and gender-responsive analysis, provide results that are useful throughout the SDS management lifecycle covering prevention and risk reduction, preparation and warning, and response and recovery.

Gender-responsive vulnerability mapping, as part of the risk assessment process, identifies the level of impact by SDS on at-risk populations. These results inform adaptation and mitigation strategies to help protect human health and prevent crop, property and other damage.

Vulnerability maps can be produced using geographic information system (GIS) software which combines satellite-derived Earth observation information with data on social conditions and status, occupations, economic conditions, institutions, health conditions, wealth, culture, and political conditions, disaggregated by age and gender, to provide detailed answers to the following questions:

- Who is vulnerable to SDS, with details related to sex, age and disability?
- What is the degree of vulnerability?
- What are the reasons for this vulnerability?

Vulnerability mapping:

- informs decision makers and policymakers on the severity and extent of the SDS risks, and who is most vulnerable, and
- provides information to local government; emergency, health and social welfare officials; civil society and other stakeholders on where to direct SDS risk management efforts

Risk assessments and vulnerability assessments are discussed further in **chapters 4, 5** and **7**.

3.3.4. SDS source mapping and monitoring

SDS are part of a small group of natural hazards where the origin of the hazard can be far away from the impact area. In some cases, impact areas are located thousands of kilometres away across country borders. Precise and up-to-date information on SDS sources is critical to forecasting and early warning, as well as to targeting where source mitigation will be the most effective.

Global trajectory and deposition of dust plume movements are relatively well documented. Major global dust sources include North Africa and North-East, East, Central, South and West Asia (Shao et al, 2011; Ginoux et al., 2012; Goudie and Middleton, 2006; Prospero et al., 2002). However, more work is needed to identify and map local and point sources with sufficient resolution, accuracy and local data and information to justify source mitigation efforts. The potential contamination of dust with pathogens and pollutants at source and in transportation also make the precise mapping of SDS dust sources and trajectories important in reducing the SDS risk to human health.

GIS software and models can bring together multiple data sets on precipitation, evaporation, drought, soil moisture, temperature, land and soil degradation, vegetation and land use to improve source area monitoring (Gerivani et al., 2011; Kim et al., 2013; Cao et al., 2015; Borelli et al., 2016). To this process can be added data and analysis from vulnerability mapping to provide a clearer picture of who might be more or less vulnerable during specific SDS events associated with specific weather and socioeconomic conditions. Source area and vulnerability mapping results can also be used in identifying which source mitigation measures can be used to reduce vulnerability. (See **chapters 2** and **8** for more information on source mapping.)

3.3.5. SDS forecasting

Combining SDS source mapping and monitoring, the detection of SDS occurrence and monitoring dust plumes movement and near- and long-term forecasting is core to comprehensive SDS management. Dust raising and transport is monitored using a combination of data from satellites, networks of light detection and ranging (LIDAR) and radiometers, air-quality monitoring and weather stations. Ground-based observations from weather stations provide a powerful, lengthy, standardized data set that extends in some parts of the world continuously for more than 50 years. **Chapter 9** discusses in detail the current global SDS monitoring and forecasting system.

The drawbacks of using dust weather data include the relatively sparse distribution of meteorological stations in key source regions, including the Sahara, parts of Arabia, the Gobi and Taklamakan Deserts and central Australia, as well as the low and often variable frequencies of observations.

However, there is the potential for establishing a citizen science approach to SDS monitoring and warning based on the nature of some SDS genesis in low pressure zones, their movement, knowledge about seasonal or diurnal wind conditions that can generate SDS, and access to weather satellite imagery and forecasts. See **chapter 9** for an example of citizen science SDS monitoring from Australia.

Using citizen science to monitor SDS does not displace official monitoring, forecasting and warning systems, but empowers at-risk populations to be more engaged in the management of the risks they face. This citizen science approach reflects the concept that risk management best starts at the individual level, rather than placing a reliance on top-down communication and on official directives before taking action.

3.3.6. Communication and dissemination of early warnings

For SDS early warning systems to have the desired results, early warning information needs to reach women, girls, men and boys. Equally, the effectiveness of modes of communication and information dissemination is critical to ensuring that vulnerable population groups are aware of, and able to prepare for, a hazard. Gender roles, social status, culture and traditions affect the processing and dissemination of information that people receive through community warning systems. Information flows often fail to reach women, especially those living in remote areas (UNISDR, UNDP and IUCN, 2009).

Disseminating warnings and other SDS-related information can use a range of communication channels, including mobile phone text messages, free-to-air and paid broadcast networks, website updates, emails, word-of-mouth, and open-air warning signals where appropriate (Harriman, 2014). However, care is needed to ensure that messages are clear, have practical value and address the social preference for confirming warnings with other information. Education before actual warnings are sent about the content of warning messages and what to do when a message is received is critical to success when actual warnings are issued.

Technologies such as SMS (short messaging service), WhatsApp, Twitter®, Instagram® or other commercial messaging services can be used in warnings. For instance, in South Korea, warnings of dust events are issued by the Korea Meteorological Administration using local media and SMS text alerts for users who register on their air-quality alert website (KMA, 2019).

However, evidently not all messages sent via SMS or similar technologies are received, or read, immediately and the content of these messages can be very limited. Further, these technologies rely on phone or Internet service, which may not be available in all at-risk locations, or may not be operational due to other factors when warnings need to be issued. SDS early warning is discussed in more detail in **chapter 10**.

3.3.7. Preparedness and response

Preparedness for SDS events is based on asking:

- What is the likely type, frequency and timing of an SDS event?
- Who will be affected, considering gender, age and disability?
- Which measures should be implemented before the event (prior to a warning) and regarding warnings to reduce the impact of an SDS event?

This process uses information from the SDS risk and vulnerability assessments, modelling and past disasters to develop scenarios of expected events. Risk assessment and vulnerability data are used to identify the location of at-risk populations, and why specific groups may be more or less vulnerable, for instance due to health, occupation, housing conditions, gender or wealth.

Preparedness plans generally include warning procedures, specific measures to be taken once a warning has been received as well as when the SDS event is taking place, and education and simulation plans. In general, plans are based on integrating government and civil society activities into the response to a potential disaster. For instance, a preparedness plan may identify that a health centre will call on Red Crescent or Red Cross volunteers to provide support when the number of people coming to the clinic for treatment following the SDS exceeds the human resources available to the clinic.

In many cases, a general preparedness plan for a community, region or nation is complimented by sector-specific plans with additional details for the expected user. For instance, a national preparedness plan would detail the sectoral responsibilities of different departments and services in the event of a sand or dust storm, while each of these parties would have more detailed plans based on the delegated responsibilities.

Globally, some level of disaster preparedness plan exists (whether formal or informal) for almost all towns or similar settlements. It is also common for disaster preparedness plans to exist at the regional and national levels. Given the likely existence of a disaster preparedness plan, the initial steps in preparing for SDS response is to integrate risk and vulnerability information into the plan, followed by developing SDS scenarios and identifying response options. The effectiveness of response options can be tested through a scenario-based simulation, with the whole SDS component complemented by a public education plan using schools, community events and other opportunities.

Actual response to SDS can vary considerably depending on the scale and impact of the SDS event, the level of preparedness and the timeliness of warnings and whether they were followed. As with other disasters, response to SDS is an adaptive process. Critical tasks are to:

1. Assess and document the impacts of the SDS.
2. Establish a response coordinating system (defined in advance in the preparedness plan).
3. Focus initial response on those groups that risk and vulnerability assessments have identified as at high risk (for example older persons, very young children, individuals with compromised health) and consider gender roles and vulnerabilities.
4. Allocate resources to those parties involved in the response that face the greatest need.
5. Initiate discussions and planning on recovery, which should be integrated into the initial response as far as possible. (Information for recovery planning should come from the first task of assessing impacts.)

The **Sphere Handbook**, especially page 11, provides further guidance on responding to disasters (Sphere Association, 2018). Preparedness and impact mitigation (response) are discussed further in **chapter 13**.

3.3.8. Risk reduction

Under the **Policy Advocacy Framework** (UNCCD, 2017), risk reduction takes place through source mitigation and impact mitigation (see **Figure 13**). Broadly, risk reduction focuses on two areas:

- Physical measures that can reduce or prevent the impact of an SDS event. These measures are often based on improved land-use planning and land-use management, as discussed further in **chapter 13**, but they can also include improvements to air supplies in buildings or improvements to roads to reduce SDS impacts.
- Socioeconomic measures that:
  - reduce the level of damage that an SDS event can cause at the individual or household level
  - improve the ability of at-risk individuals or groups to address the impacts of the SDS event

The socioeconomic measures include a wide range of possible interventions targeted at addressing a specific impact of an SDS event. For instance, less wealthy families can be provided grants or materials to improve windows and doors to reduce dust infiltration. Individuals with respiratory problems can be provided with breathers and appropriate power supplies at no or low cost. Families identified as more at risk can be offered economic opportunities to generate additional income to self-finance measures for reducing SDS impacts. A significant element in defining and choosing appropriate socioeconomic measures is understanding risk and vulnerability, with education about SDS and risk reduction measures important in enabling a specific at-risk individual or group to select the best options for their needs.

3.3.9. Anthropogenic source mitigation

There are numerous technical measures for mitigating SDS at source (see **chapter 12**), including a wide array of techniques that are used for wind erosion control, most of which were developed to protect cultivated fields from soil loss (Skidmore, 1986; Nordstrom and Hotta, 2004).

At any particular location, a range of measures is typically employed. Riksen et al. (2003) distinguish between techniques designed to minimize actual risk (short-term: for example cultivation practices such as minimum tillage) and those that minimize potential risk (long-term: for example planting windbreaks).

Most of the technical measures are usually applied in places where wind erosion is predominantly an anthropogenic land-use issue. The main exceptions are in desert areas where naturally occurring mobile sand dunes and blowing sand present challenges to human activities.

Action taken to mitigate anthropogenic sources of SDS contributes towards the global aspiration to halt and reverse land degradation by 2030 (**Sustainable Development Goal target 15.3** https://sdgs.un.org/goals/goal15) and is in line with the concept of land degradation neutrality (LDN). Sustainable land use management (SLM), in particular, contributes towards resolving issues surrounding the need to achieve social, economic and environmental objectives in areas where productive land uses compete with environmental and biodiversity goals (Sayer et al., 2013).

3.4 Comprehensive approach to SDS risk management

Given the diverse spatial and temporal nature of SDS, impact and source management require a unified, coordinated cross-sectoral approach. As summarized in **Figure 14**, this approach involves three main groups:

1. **The agencies, institutions and authorities responsible for setting SDS risk management policies and implementing plans covering risk reduction, preparedness, warning and response. Key members of this group include:**

   » **land and water management authorities, including land reclamation authorities**
   » **agriculture and livestock ministries**
   » **health authorities**
   » **finance authorities**
   » **meteorology and hydrology services**
   » **disaster management authorities**
   » **transport authorities**
   » **public safety authorities**
   » **gender/women's ministries/committees**

Jared Verdi, ©Unsplash, October 21st, 2017

2. The scientific research and academic communities responsible for:

   » understanding the social and physical nature of SDS, including risk and vulnerability and the physical mechanics behind the origins of and causes of SDS impacts
   » identifying the ways in which source and impact mitigation policy and practice can be effective and
   » monitoring SDS-related policies and practices to assess effectiveness and define improvements to reduce risk

3. The at-risk communities impacted by SDS and who should be directly empowered to reduce SDS risk through:

   » comprehensive risk management plans covering risk reduction, preparedness, warning and response
   » a solid understanding of the origins and impacts of SDS and measures to mitigate SDS
   » involvement in impact-based warning systems that reflect specific threats and in the means to mitigate these threats
   » involvement in land and water use plans and programmes that can reduce the generation of SDS

In general, at-risk communities include the private sector as well as non-governmental organizations (NGOs) that are involved in risk reduction, preparedness and response. NGOs can vary widely in their nature and focus, from women-led mutual credit groups to international organizations involved in the environment and development. Efforts should be made to involve as many NGOs as possible in addressing the impacts of SDS on at-risk populations.

The process, as indicated in **Figure 14**, is iterative, with a constant exchange between the three groups in an attempt to find better policies and activities to reduce SDS impacts.

This process is also gender-responsive, recognizing that women, boys, girls and men are affected differently by SDS and are presented with different ways of reducing SDS impacts based on their social or cultural roles and expectations. Similar attention is given to young children and older persons as well as those individuals with compromised health, all of whom may be impacted more severely by an SDS event than the general population.

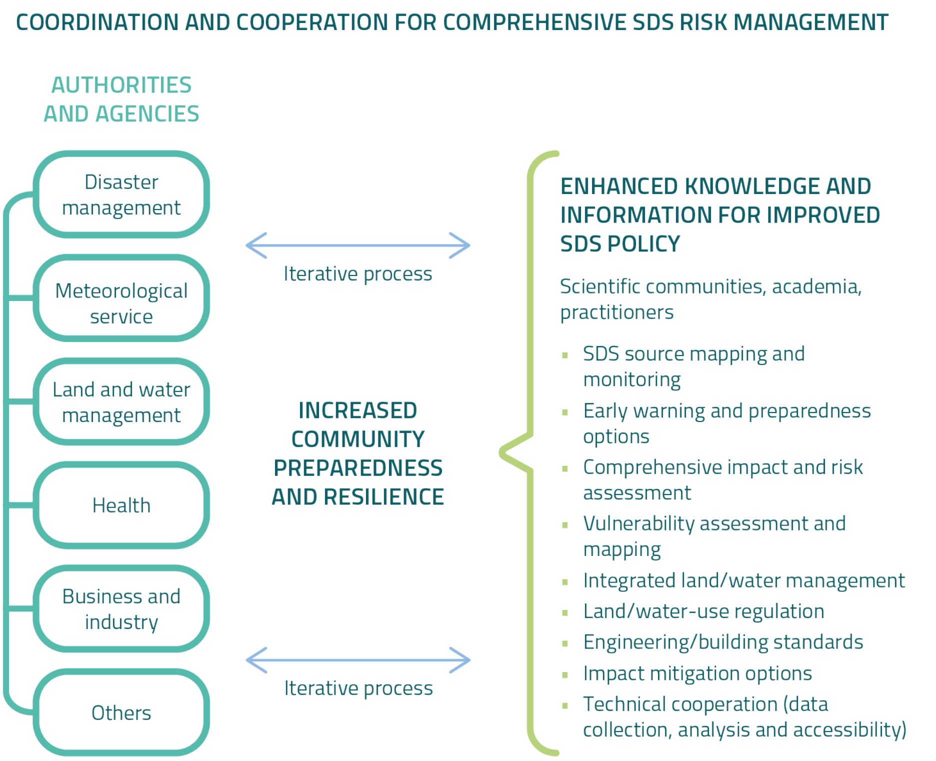


Figure 14. Framework for sand and dust storm risk management coordination and cooperation

Box 4. SDS and a changing climate

SDS are clearly affected by climate conditions, both in terms of climate variability and climate change. **Chapter 3** on climate change and desertification in **Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems** (Mirzabaev et al., in press) reports:

- The loss of vegetation or drying of soil "due to intense land use and/or climate change can be expected to cause an increase in sand and dust storms (high confidence)".
- There is "high confidence that there is a negative relationship between vegetation green-up and the occurrence of dust storms".
- "By decreasing the amount of green cover and hence increasing the occurrence of sand and dust storms, desertification will increase the amount of shortwave cooling associated with the direct effect (high confidence)".
- "There is medium confidence that the semi-direct and indirect effects of this dust would tend to decrease precipitation and hence provide a positive feedback to desertification". However, the "overall combined effect of dust aerosols on desertification remains uncertain".

(All quoted text from p. 268, Mirzabaev et al., in press).

Note that these conclusions relate more directly to desertification than to SDS. Changes to the climate may also affect other factors linked to SDS generation. These include longer periods where seasonal lakes are dry, thus contributing to longer periods of SDS generation, and changes to river flooding duration, where longer low-water periods can provide more source sediment for SDS entrainment.

One of the challenges around understanding the impact of a changing climate on SDS is the lack of extensive weather data collection and observations systems, which limits the understanding of climatic conditions. This same situation also impacts the understanding of SDS, as well as the implementation of warning systems and evaluation of the effectiveness of risk reduction.

Specific approaches to addressing the impact of a changing climate are not included in the Compendium. However, SDS source mitigation approaches incorporating land degradation neutrality, sustainable land management, integrated land management and integrated water use management described in **chapter 12** are all core to addressing the impact of climate on SDS generation and management. Improving the collection and understanding of weather data, at global to local levels, will also contribute to better understanding the links between a changing climate and SDS.

Source: Mirzabaev, A., and others (2019). Desertification. In Climate change and land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems, Priyadarshi R. Shukla, Jim Skea, Eduardo Calvo Buendía, Valérie Masson-Delmotte, Hans-Otto Pörtner, Debra C. Roberts, Panmao Zhai, Raphael Slade, Sarah Connors, Renée van Diemen, Marion Ferrat, Eamon Haughey, Sigourney Luz, Suvadip Neogi, Minal Pathak, Jan Petzold, Joana Portugal Pereira, Purvi Vyas, Elizabeth Huntley, Katie Kissick, Malek Belkacemi and Juliette Malley, eds. In press.

3.5 Conclusion

SDS are a significant natural process, but also a natural hazard that is receiving increasing attention. This increased attention is highlighting not only the human, social and economic impact of SDS, but also the ways in which the risks posed by SDS can be addressed.

The efforts to address the impacts of SDS focus on two areas:

- **impact mitigation**, to reduce the direct harm from SDS, and
- **source mitigation**, to reduce the potential for harm from sand and dust

These efforts involve authorities and agencies, scientific research and academic communities and, most importantly, the communities, households and individuals at risk from SDS. The combined effort is iterative and, to be effective and support all those at risk, must consider gender, age and health status.

The following chapters of the Compendium provide more details on how SDS impacts and sources can be managed, how risks and vulnerability can be assessed and how research and data collection can support preparedness, warning and the response to SDS. As indicated by **Figure 14**, this effort is collaborative insofar as it requires the cooperation of many sectors and actors working together in a way that builds on experience and continually improves work to reduce the impact of SDS.

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