TECHNICAL REPORT

ISO/TR 6030

First edition
2022-07

Smart community infrastructures – Disaster risk reduction – Survey results and gap analysis

Infrastructures urbaines intelligentes – Réduction des risques de catastrophes – Résultats d'enquête et analyse des écarts

Reference number
ISO/TR 6030:2022(E)

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Published in Switzerland

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 268, *Sustainable cities and communities*, Subcommittee SC 1, *Smart community infrastructures*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Over the last decade, global communities have made great progress towards reducing disaster risk through strengthening resilience against natural hazards. However, in addition to geological hazards, ongoing climate changes can exacerbate existing hydrometeorological hazard risks by increasing the frequency and intensity of these hazards, in either unprecedented combinations and/or unexpected locations. As a result, more communities and assets can be exposed to these hazards, leading to greater damage by disasters.

In order to protect communities against natural hazard risks, infrastructures can play a key role in strengthening resilience. Critical infrastructures that communities rely on, such as energy, information and communication technologies (ICT), transportation, waste and water, and other infrastructures affect vital community functions such as livelihoods, medical activities, financial services. This results in an increasing cost of disasters for all sectors of the community whether it is governments, businesses, and individuals. These costs include not only direct costs but also indirect ones such as costs from flow-on effects from disasters. Through the implementation of infrastructure that can strengthen resilience, communities can recover from the impacts of disasters quickly and effectively.

The demand for smart community infrastructures, as scalable and integrable products, will continue to grow in the decades ahead. However, it is imperative that such infrastructures can also be designed in a way that reduces disaster risk and strengthens disaster resilience. Through an analysis of existing documents on smart community infrastructure for disaster risk reduction and a survey of global examples, this document is intended to identify existing gaps in the implementation of smart community infrastructure for disaster risk reduction, and to identify topics for potential areas in the standardization of smart community infrastructures for disaster risk reduction. Through the accumulation of global best practices, this document identifies areas for potential standardization, which includes but is not limited to, the strengthening of disaster risk reduction technologies utilized in critical infrastructures such as energy, waste and water, transportation, ICT, and the built environment. This document seeks to provide the foundation for future standardization deliverables which promote the interoperability of disaster risk reduction technologies globally.

Smart community infrastructures – Disaster risk reduction – Survey results and gap analysis

1 Scope

This document identifies existing global smart community infrastructures that enhance disaster risk reduction, the key purposes served by these global examples, gaps in coverage, and the need for standardization activities, which establishes the basis for the next steps for standardization.

This document is intended to be a basis for the future standardization of smart community infrastructures for disaster risk reduction through the identification of areas for potential standardization. This includes, but is not limited to, infrastructures related to energy, waste and water, transportation, information and communication technologies (ICT), and the general built environment.

It does not address specifications or requirements already covered by other relevant international standards.

This document primarily addresses disasters caused by natural hazards, such as geological and hydrometeorological hazards, and does not focus on human-induced disasters such as terrorism or biological hazards such as pandemics.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
community
group of people with an arrangement of responsibilities, activities and relationships

Note 1 to entry: In many, but not all, contexts, a community has a defined geographical boundary.

Note 2 to entry: A city is a type of community.

[SOURCE: ISO 37120:2018, 3.3]

3.2
community infrastructure
systems of facilities, equipment and services that support the operations and activities of communities

Note 1 to entry: Such community infrastructures include, but are not limited to, energy, water, transportation, waste and information and communication technologies (ICT).

[SOURCE: ISO 37100:2016, 3.6.1]

3.3
critical infrastructure
physical structures, facilities, networks and other assets which provide services that are essential to the social and economic functioning of a *community* (3.1) or society

Note 1 to entry: Examples of critical infrastructure can include, but are not limited to, power generation, transmission and distribution, water treatment, distribution and drainage, wastewater and stormwater infrastructure, transportation, gas supply and distribution, telecommunications infrastructure, educational facilities, hospitals and other health facilities.

[SOURCE: ISO 37123: 2019, 3.1]

3.4
disaster
serious disruption to a city or *community* (3.1) due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to human, material, economic and/or environmental losses and impacts

Note 1 to entry: Disasters can be frequent or infrequent, depending on the probability of occurrence and the return period of the relevant *hazard* (3.5). A slow-onset disaster is one that emerges gradually over time, for example through drought, desertification, sea level rise, subsidence or epidemic disease. A sudden-onset disaster is one triggered by a hazardous event that emerges quickly or unexpectedly, often associated with earthquakes, volcanic eruptions, flash floods, chemical explosions, *critical infrastructure* (3.3) failures or transport accidents.

[SOURCE: ISO 37123:2019, 3.2]

3.5
hazard
phenomenon, human activity or process that can cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation

Note 1 to entry: Hazards include biological, environmental, geological, hydrometeorological and technological processes and phenomena. Biological hazards include pathogenic microorganisms, toxins and bioactive substances (e.g. bacteria, viruses, parasites, venomous wildlife and insects, poisonous plants, mosquitoes carrying disease-causing agents). Environmental hazards can be chemical, natural, radiological or biological, and are created by environmental degradation, physical or chemical pollution in the air, water and soil. However, many of the processes and phenomena that fall into this category can be "drivers" of hazard and risk rather than hazards themselves (e.g. soil degradation, deforestation, biodiversity loss, sea level rise). With respect to drinking water, 'hazard' can be understood as a microbiological, chemical, physical or radiological agent that causes harm to human health. Geological or geophysical hazards originate from internal earth processes (e.g. earthquakes, volcanic activity, landslides, rockslides, mud flows). Hydrometeorological hazards are of atmospheric, hydrological or oceanographic origin (e.g. cyclones, typhoons, hurricanes, floods, drought, heatwaves, cold spells, and coastal storm surges). Hydrometeorological conditions can also be a factor in other hazards such as landslides, wildland fires and epidemics. Technological hazards originate from industrial or technological conditions, dangerous procedures, infrastructure failures or specific human activities (e.g. industrial pollution, nuclear radiation, toxic waste, dam failures, transport accidents, factory explosions, fires, chemical spills).

[SOURCE: ISO 37123:2019, 3.3]

3.6
resilience
ability to absorb and adapt in a changing environment

Note 1 to entry: In the context of urban resilience the ability to absorb and adapt to a changing environment is determined by the collective capacity to anticipate, prepare and respond to threats and opportunities by each individual component of an urban system.

[SOURCE: ISO 22300:2021, 3.1.206]

3.7
smart community infrastructure
community infrastructure (3.2) with enhanced technological performance that is designed, operated and maintained to contribute to sustainable development and *resilience* (3.6) of the *community* (3.1)

[SOURCE: ISO 37156:2020, 3.1.4]

4 Basic concept and purposes of disaster risk reduction

4.1 General

Adopted at the UN World Conference on Disaster Risk Reduction in Sendai, Japan, in 2015, the Sendai Framework for Disaster Risk Reduction (SFDRR) is an agreement that provides communities with concrete actions to protect themselves from the risk of disasters. Four priorities for actions are identified in the SFDRR:

— understanding disaster risk,

— strengthening disaster risk governance to manage disaster risk,

— investing in disaster risk reduction for resilience,

— enhancing disaster preparedness for effective response, and to "Build Back Better" a term that emerged during the SFDRR which refers to the recovery, rehabilitation and reconstruction phase.

The SFDRR identifies the need to incorporate the use of technologies that can collect information and assist in disaster risk governance at various disaster phases. "In order to reduce disaster risk, there is a need to address existing challenges and prepare for future ones by focusing on monitoring, assessing and understanding disaster risk and sharing such information and on how it is created; strengthening disaster risk governance and coordination across relevant institutions and sectors and the full and meaningful participation of relevant stakeholders at appropriate levels; investing in the economic, social, health, cultural and educational resilience of persons, communities and countries and the environment, as well as through technology and research; and enhancing multi-hazard early warning systems, preparedness, response, recovery, rehabilitation and reconstruction. To complement national action and capacity, there is a need to enhance international cooperation between developed and developing countries and between States and international organizations" (SFDRR P.11).

By investing in these technologies, the SFDRR indicates that smart community infrastructure for disaster risk reduction can lead to the reduction of casualties and damages during a disaster event strengthen the resilience of the community's livelihoods. "Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment. These can be drivers of innovation, growth and job creation. Such measures are cost-effective and instrumental to save lives, prevent and reduce losses and ensure effective recovery and rehabilitation" (SFDRR P.18).

The importance of standardization is highlighted in the SFDRR. "Strengthening, as appropriate, disaster-resilient public and private investments, particularly through structural, non-structural and functional disaster risk prevention and reduction measures in critical facilities, in particular schools and hospitals and physical infrastructures; building better from the start to withstand hazards through proper design and construction, including the use of the principles of universal design and the standardization of building materials; retrofitting and rebuilding; nurturing a culture of maintenance; and taking into account economic, social, structural, technological and environmental impact assessments" (SFDRR P.19). "Promoting the further development and dissemination of instruments, such as standards, codes, operational guides and other guidance instruments, to support coordinated action in disaster preparedness and response and facilitate information sharing on lessons learned and best practices for policy practice and post-disaster reconstruction programmes" (SFDRR P.22).

Through the creation of standards, this document hopes to disseminate information on global best practices which can lead to the sharing and exchange of information between communities and countries. “Promoting the further development of and investment in effective, nationally compatible, regional multi-hazard early warning mechanisms, where relevant, in line with the Global Framework for Climate Services, and facilitate the sharing and exchange of information across all countries (SFDRR P.22). Promoting cooperation between academic, scientific and research entities and networks and the private sector to develop new products and services to help to reduce disaster risk, in particular those that would assist developing countries and their specific challenges (SFDRR P.20), and to disseminate and share good practices internationally" (SFDRR P.16).

In order to guide the survey to identify global best practices in regard to smart community infrastructure for disaster risk reduction, this document identifies key themes identified within the SFDRR.

4.2 Disaster risk reduction planning

Disasters have demonstrated that the recovery, rehabilitation and reconstruction phase, which needs to be prepared ahead of a disaster, is a critical opportunity to “Build Back Better”, including through integrating disaster risk reduction into development measures, making nations and communities resilient to disasters (SFDRR P.21). However, addressing underlying disaster risk factors through disaster risk-informed public and private investments is more cost-effective than primary reliance on post-disaster response and recovery, and contributes to sustainable development (SFDRR P.13). To encourage the establishment of necessary mechanisms and incentives to ensure high levels of compliance with the existing safety-enhancing provisions of sectoral laws and regulations, including those addressing land use and urban planning, building codes, environmental and resource management and health and safety standards, and update them, where needed, to ensure an adequate focus on disaster risk management (SFDRR P.17). To apply risk information in all its dimensions of vulnerability, capacity and exposure of persons, communities, countries and assets, as well as hazard characteristics, to develop and implement disaster risk reduction policies (SFDRR P.15).

4.3 Disaster research

Promoting investments in innovation and technology development in long-term, multi-hazard and solution-driven research in disaster risk management to address gaps, obstacles, interdependencies and social, economic, educational and environmental challenges and disaster risks (SFDRR P.15).

Enhancing the development and dissemination of science-based methodologies and tools to record and share disaster losses and relevant disaggregated data and statistics, as well as to strengthen disaster risk modelling, assessment, mapping, monitoring and multi-hazard early warning systems (SFDRR P.16).

4.4 Safer infrastructure

Strengthening, as appropriate, disaster-resilient public and private investments, particularly through structural, non-structural and functional disaster risk prevention and reduction measures in critical facilities, in particular schools and hospitals and physical infrastructures; building better from the start to withstand hazards through proper design and construction, including the use of the principles of universal design and the standardization of building materials; retrofitting and rebuilding; nurturing a culture of maintenance; and taking into account economic, social, structural, technological and environmental impact assessments (SFDRR P.19).

4.5 Human resource development

Building the knowledge of government officials at all levels, civil society, communities and volunteers, as well as the private sector, through sharing experiences, lessons learned, good practices and training and education on disaster risk reduction, including the use of existing training and education mechanisms and peer learning (SFDRR P.15).

Training the existing workforce and voluntary workers in disaster response and strengthen technical and logistical capacities to ensure better response in emergencies (SFDRR P.21).

4.6 Stockpiling

Establishing community centres for the promotion of public awareness and the stockpiling of necessary materials to implement rescue and relief activities (SFDRR P.21).

4.7 Securing evacuation support

Strengthening the capacity of local authorities to evacuate persons living in disaster-prone areas (SFDRR P.22).

4.8 Securing evacuation facilities

Promoting regular disaster preparedness, response and recovery exercises, including evacuation drills, training and the establishment of area-based support systems, with a view to ensuring rapid and effective response to disasters and related displacement, including access to safe shelter, essential food and non-food relief supplies, as appropriate to local needs (SFDRR P.21).

4.9 Procurement and supply of goods

Increasing business resilience and protection of livelihoods and productive assets throughout the supply chains, ensure continuity of services and integrate disaster risk management into business models and practices (SFDRR P.20).

4.10 Rescue, emergency and firefighting

Establishing community centres for the promotion of public awareness and the stockpiling of necessary materials to implement rescue and relief activities; To adopt public policies and actions that support the role of public service workers to establish or strengthen coordination and funding mechanisms and procedures for relief assistance and plan and prepare for post-disaster recovery and reconstruction; To train the existing workforce and voluntary workers in disaster response and strengthen technical and logistical capacities to ensure better response in emergencies (SFDRR P.21).

4.11 Medical activities

Enhancing the resilience of national health systems, including by integrating disaster risk management into primary, secondary and tertiary health care, especially at the local level; developing the capacity of health workers in understanding disaster risk and applying and implementing disaster risk reduction approaches in health work; promoting and enhancing the training capacities in the field of disaster medicine; and supporting and training community health groups in disaster risk reduction approaches in health programmes, in collaboration with other sectors, as well as in the implementation of the International Health Regulations (2005) of the World Health Organization (SFDRR P.19).

4.12 Health (physical and mental)

Enhancing cooperation between health authorities and other relevant stakeholders to strengthen country capacity for disaster risk management for health, the implementation of the International Health Regulations (2005) of the World Health Organization and the building of resilient health systems (SFDRR P.20).

Enhancing recovery schemes to provide psychosocial support and mental health services for all people in need (SFDRR P.22).

4.13 Voluntary support

Training the existing workforce and voluntary workers in disaster response and strengthen technical and logistical capacities to ensure better response in emergencies (SFDRR P.21).

4.14 Epidemic prevention

Establishing a mechanism of case registry and a database of mortality caused by disaster in order to improve the prevention of morbidity and mortality (SFDRR P.22). To promote transboundary cooperation to enable policy and planning for the implementation of ecosystem-based approaches with regard to shared resources, such as within river basins and along coastlines, to build resilience and reduce disaster risk, including epidemic and displacement risk (SFDRR P.18).

4.15 Securing transportation routes

Promoting the resilience of new and existing critical infrastructure, including water, transportation and telecommunications infrastructure, educational facilities, hospitals and other health facilities, to ensure that they remain safe, effective and operational during and after disasters in order to provide live-saving and essential services (SFDRR P.21).

4.16 Securing communication means and lifelines

Investing in, develop, maintain and strengthen people-centred multi-hazard, multisectoral forecasting and early warning systems, disaster risk and emergency communications mechanisms, social technologies and hazard-monitoring telecommunications systems; develop such systems through a participatory process; tailor them to the needs of users, including social and cultural requirements, in particular gender; promote the application of simple and low-cost early warning equipment and facilities; and broaden release channels for natural disaster early warning information (SFDRR P.21).

4.17 Livelihood recovery

Increasing business resilience and protection of livelihoods and productive assets throughout the supply chains, ensure continuity of services and integrate disaster risk management into business models and practices (SFDRR P.20).

4.18 Recovery planning

Promoting the incorporation of disaster risk management into post-disaster recovery and rehabilitation processes, facilitate the link between relief, rehabilitation and development, use opportunities during the recovery phase to develop capacities that reduce disaster risk in the short, medium and long term, including through the development of measures such as land-use planning, structural standards improvement and the sharing of expertise, knowledge, post-disaster reviews and lessons learned and integrate post-disaster reconstruction into the economic and social sustainable development of affected areas. It is advisable that this also applies to temporary settlements for persons displaced by disasters (SFDRR P.22).

4.19 Recovery action

Addressing underlying disaster risk factors through disaster risk-informed public and private investments is more cost-effective than primary reliance on post-disaster response and recovery, and contributes to sustainable development (SFDRR P.13).

Ensuring the continuity of operations and planning, including social and economic recovery, and the provision of basic services in the post-disaster phase (SFDRR P.21).

4.20 Collection and transmission of observation data

Promoting the collection, analysis, management and use of relevant data and practical information and ensure its dissemination, taking into account the needs of different categories of users, as appropriate (SFDRR P.14).

4.21 Collection and disseminating disaster information

Developing and periodically update and disseminate, as appropriate, location-based disaster risk information, including risk maps, to decision makers, the general public and communities at risk of exposure to disaster in an appropriate format by using, as applicable, geospatial information technology (SFDRR P.15).

Promoting real time access to reliable data, make use of space and in situ information, including geographic information systems (GIS), and use ICT innovations to enhance measurement tools and the collection, analysis and dissemination of data (SFDRR P.15).

5 Existing practices and documents relevant to disaster risk reduction

5.1 General

This clause gives an overview of existing concepts and initiatives relevant to disaster risk reduction. Due to common risks to natural hazards occurring globally, the standardization for disaster risk reduction in smart community infrastructure can help communities better anticipate and prepare for hazard events and reduce vulnerabilities. Subclause 5.2 examines what has been published thus far in international documents, on disaster risk reduction. As many international organizations such as the United Nations and World Economic Forum, have published documents in the English language, the document review is limited to publications produced in English. However, in some cases, national level documents that were published in English are also considered. Subclause 5.3 describes the survey design developed by this document which was used to acquire information on current and planned implementation of smart community infrastructure for disaster risk reduction. Subclause 5.4 analyses the survey results and compares it with the results of the document search as well as how these examples meet the key themes in disaster risk reduction as outlined in Clause 4. Subclause 5.5 is an issue landscape which categorizes the key themes identified in the Basic Concept in Disaster Risk Reduction in Clause 4 and aligns them with existing publications developed by the United Nations, national governments, and with other ISO deliverables. Finally, 5.6 provides a solution landscape, which utilizes the examples provided by the survey and categorizes them in terms of how they can be used by disaster phase and hazard type.

5.2 Literature review — Document search

431 documents in the English language were analysed. This included 230 documents published by the United Nations Office for Disaster Risk Reduction, 104 documents and presentations presented at the 2017 and 2019 World Bosai Forum, 49 documents published by the US National Institute of Standards and Technology, 18 documents published by the Global Facility for Disaster Reduction and Recovery, 15 documents published by United Nations Economic and Social Commission for Asia and the Pacific, 10 documents published by the International Recovery Platform, and 1 document each published by Elsevier, the Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT), the World Economic Forum, the International Federation of Red Cross and Red Crescent Societies, and the Association of Pacific Rim Universities and Tohoku University's APRU-IRIDeS Program. Out of the 431 documents researched, 243 relevant items were identified. Tables 1 and 2 summarize the results of this document search into key areas. First by region, based on the categorization by the UNDRR which includes the Asia and Pacific, Europe, Americas and the Caribbean, Arab States, Africa, and examples that were applied globally rather than by a specific region. Second, the results were categorized by infrastructure type concentrating on transportation, energy, waste and water, ICT, food security, and the built environment (e.g. hospitals, schools, homes, offices), food security, which refer to infrastructure that does not fall within the aforementioned categories. Disaster phases were categorized into three groups: the prevention and preparedness phases which occur prior to a disaster event, the response

phase which occurs immediately after the event, and Build Back Better, which the SFDRR refers to as the recovery and reconstruction phases that follows the response phase. Finally, the items are also broken down by hazard types that are caused either by hydrometeorological or geological events.

Table 1 — Region and infrastructure type from the document search

Region	Items	Percentage
Asia and Pacific	96	40 %
Europe	29	12 %
Americas and the Caribbean	56	23 %
Arab States	18	7 %
Africa	17	7 %
Global	27	11 %
Total	243	

Infrastructure type	Items	Percentage
Transportation	18	7 %
Energy	14	6 %
Waste and Water	30	12 %
ICT/ Communication	110	45 %
Built Environment	49	20 %
Food Security	6	2 %
Others	18	7 %
Total	245	

NOTE If an item spans multiple regions or infrastructure types, it is counted multiple times.

Table 2 — Hazard type and disaster phase from the document search

Hazard type	Items	Percentage
Flood	72	21 %
Earthquake	45	13 %
Tropical Cyclone	40	12 %
Heavy Rain	40	12 %
Drought	17	5 %
Tsunami	16	5 %
Wildfire	11	3 %
Volcanic Activity	11	3 %
Landslide	7	2 %
Tornado	6	1 %
Heatwave	4	1 %
General	72	22 %
Other (e.g. coastal erosion)	3	1 %
Total	344	

Disaster phase type	Items	Percentage
Prevention and Preparedness	151	57 %
Response	37	14 %
Build Back Better	30	11 %
General	49	18 %
Total	267	

NOTE If an item spans multiple hazard types or disaster phases types, it is counted multiple times.

An analysis of the document search revealed that nearly two-thirds of the literature focused on the Asia and Pacific Region and the Americas and Caribbean Region. This can be explained by the proximity of the western coast of the Americas, and the Asia and Pacific Region to the Ring of Fire, a region known for significant geological activity, such as earthquakes and volcanoes which can generate powerful tsunamis. Additionally, the Asia and Pacific Region and the eastern coastline of the Americas and the Caribbean experience significant hydrometeorological activity which leads to tropical cyclones and heavy rain. Europe is the third most commonly mentioned area behind the Asia and Pacific and Americas and Caribbean Regions. European communities are exposed to hazard risks caused by flooding due to the presence of multiple large rivers, while the communities around the Mediterranean and Caucasus are vulnerable to geological risks due to seismic activity in the region. The document search revealed that Arab States and Africa came in roughly equally with 7 % of the results. Although these two regions were not often cited in the document search, issues with droughts, heatwaves, flooding and earthquakes are frequent in these two regions. 11 % of the items discovered in the literature review focused on more general disaster-related infrastructure that can be referred to more globally.

In regard to the breakdown of infrastructure type, nearly half of the items focused on the role ICT plays in disaster risk reduction. This reflects the importance ICT infrastructure plays in the collection and dissemination of data to community stakeholders, which can be utilized at various disaster phases and strengthen resiliency. At 20 %, the next most common infrastructure focused on the built environment, which includes homes, buildings, and other facilities. Aspects of the built environment, such as their design and construction, location, and use cases can influence the survivability of the community and its economy. Waste and water were the next key infrastructure listed with 12 %, which includes sewer systems, ponds and other forms of water management, waste such as garbage, and wastewater infrastructure, which deals with water that has been contaminated by human activity, surface runoff, or stormwater. Transportation infrastructure was listed at 7 % of the review items, as maintaining accessibility serves a critical function in resiliency. Energy infrastructure was listed at 6 %, which focused on the resiliency of the facilities such as power plants, energy grids, and other energy-producing and managing facilities whose continued operation is vital for the community. Food security had the fewest comments at 2 %, despite the key role it plays during the recovery and Build Back Better process.

In terms of hazard types, general multi-hazard related literature comprised 22 % of the total documents, or nearly one-quarter of all literature research. However, in terms of specific hazards, floods were the most common, comprising 21 % of the results, followed by earthquakes at 13 % and tropical storms, which include typhoons, hurricanes, and cyclones, and heavy rain came at 12 %. Droughts and tsunamis came at 5 %, highlighting that although tsunamis are generated by seismic activities such as earthquakes, not all earthquakes necessarily lead to the creation of tsunamis. Wildfires and volcanic activities consisted of 3 % of the results, and landslides at 2 %. The remaining hazards such as tornadoes, heatwaves, and other hazards such as coastal erosion, came in at 1 %.

The distribution of responses by disaster phases resulted in more than half of the literature focused on the prevention and preparedness phase at 57 %. This reflects one of the SFDRR's guiding principles in which addressing underlying disaster risk factors are more cost-effective than primary reliance on post-disaster response and recovery. General phases (those that did not address a specific disaster phase or were broadly applied to all phases) were the next most common at 18 %, followed by the response phase at 14 % and Build Back Better at 11 %.

5.3 Survey design

The basis of the survey design is a document search which was conducted in order to provide background information on existing publications on smart community infrastructure for disaster risk reduction. The results of this document search identify past and current global initiatives and activities in disaster risk reduction that have been published in international literature. Based upon the themes identified in the SFDRR, this document then utilizes a survey to identify specific examples of current or planned smart community infrastructure for disaster risk reduction that exists globally.

The 16-question survey was designed to gather information on the current or planned implementation of smart community infrastructure that contributes to disaster resiliency globally. The questions can be divided into three areas: background information, functions based on the twenty themes identified in Clause 4, and detailed explanations.

The questions were broken down as follows:

— Questions one through three: ask respondents to provide background information that can identify the infrastructure and technology being examined, such as the name or title of the infrastructure and technology, its location, and the developer and operator of this infrastructure and technology.

— Questions four through nine: seek to examine the specific functions of the infrastructure and technology in question. These include identifying the hazard type being addressed, infrastructure type and disaster phase(s) that the infrastructure is oriented towards. These categories of infrastructure are based on those identified in existing International Standards used in ISO TC 268 as well as other ISO Technical Committees, such as ISO TC 224. Disaster phases are based on those identified by documents by the United Nations, in particular the post-disaster phase utilizes the term 'Build Back Better' which was adopted by the SFDRR, in reference towards the need to re-think

the reconstruction process in a way that improves upon the previous state that was vulnerable to disasters.

— Question seven and eight: ask respondents to provide a brief overview of the infrastructure and what issues are being addressed.

— Question nine: asks respondents to identify which target areas are being addressed by this infrastructure or technology. An extensive list of choices is provided based on a review of academic literature on some of the most common purposes found in disaster risk reduction and resilient infrastructures, however, a space called 'other' is provided in case the function of the particular infrastructure falls outside of the list. As infrastructure can address multiple hazards, phases, and targets, the selections are multiple-choice.

— Questions ten through fifteen: seek to inquire further background on how the technology and infrastructure is being utilized, what hazard and disaster risk are being addressed, its targets and achievements status thus far, the diffusion of its infrastructure, references about this infrastructure, and its relation to any existing policy or frameworks and laws such as a governmental disaster plan.

A free space is also provided at the end for respondents to add additional comments. In addition to this survey, a coversheet is also attached to the survey form via a tab on excel sheet, as well as a tab that provides a completed example for reference, and a supplementary tab where respondents can add additional figures, graphs, or any other relevant information. The survey was distributed to respondents globally with a total of 50 responses from respondents in seven countries: Australia, Japan, Greece, Turkey, Colombia, Chile, and Germany.

5.4 Specific examples of global initiatives

In this subclause, a summary and analysis of the 50 survey responses is discussed (a detailed list of each response is provided in Annex A).

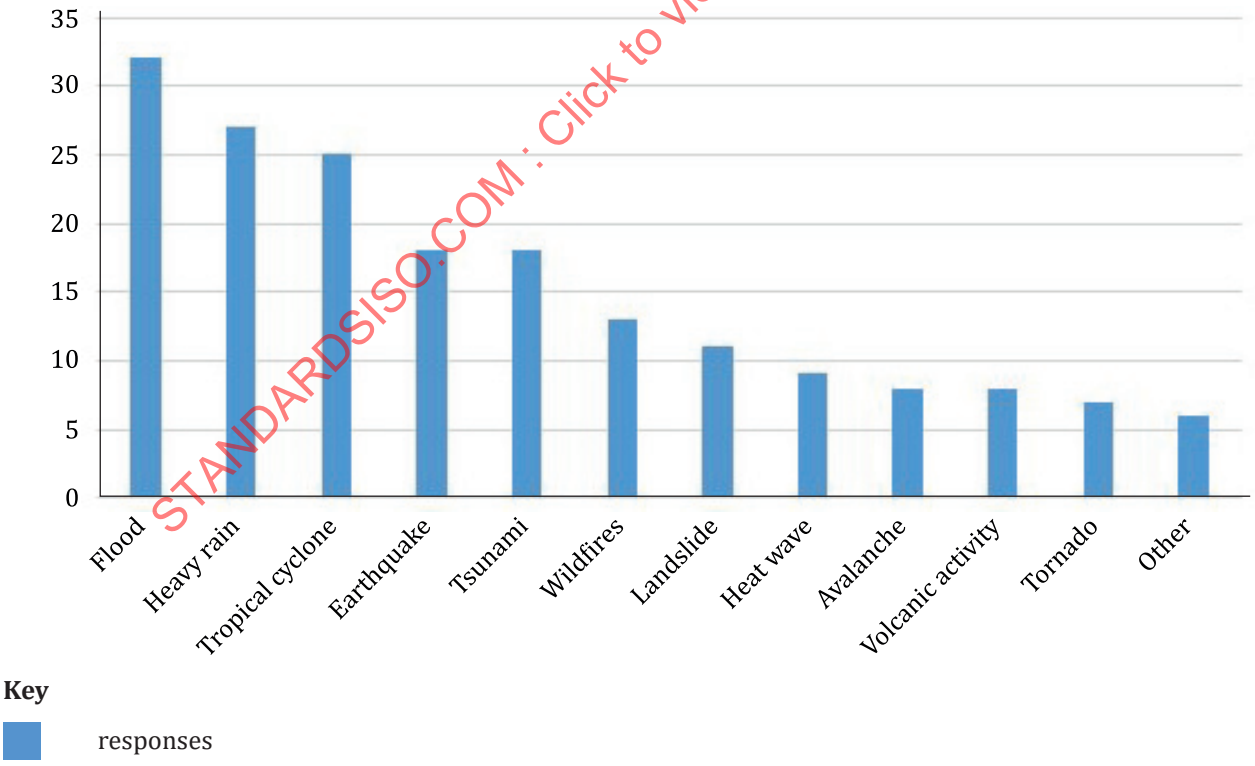

Figure 1 — Hazard types from the 50 survey responses

As shown in Figure 1, of the 50 responses received from respondents, flooding, heavy rain, and tropical cyclone-related hazards were the top three hazards listed with 32 (64 %), 27 (54 %), 25 (50 %) of the

responses respectively. Other hydrometeorological risks, such as heatwaves, which also lead to wild fires, constituted 9 (18 %) and 13 (26 %) of the responses, whereas tornadoes received 7 (14 %) of the total replies. Geological hazards, such as earthquakes and tsunamis, formed the second-largest focus area, with 18 responses each or 36 %. In addition, another geological hazard, volcanoes, received 8 (16 %) responses of the total replies.

Landslides and avalanches, which can be caused by either geological or hydrometeorological activity, recorded 11 (22 %) and 8 (16 %) responses. 6 (12 %) of the responses listed other, which includes storm surges (which can be included in the hydrometeorological category), and sediment runoff, which can be considered a type of landslide.

With flood, heavy rain and tropical cyclone dominating the top three hazards identified by the survey responses, survey respondents are focusing on hydrometeorological disasters. Following this are geological hazards such as earthquakes and tsunamis. Survey responses addressing these two hazards often combined them as part of the same system, as tsunamis are often generated by earthquakes, explaining the similar response rates for both hazards. Wildfires, landslides and heatwaves followed in frequency. As with the document review, avalanches, volcanoes and tornadoes were the least frequently focused on, and often included as a part of a broader multi-hazard system.

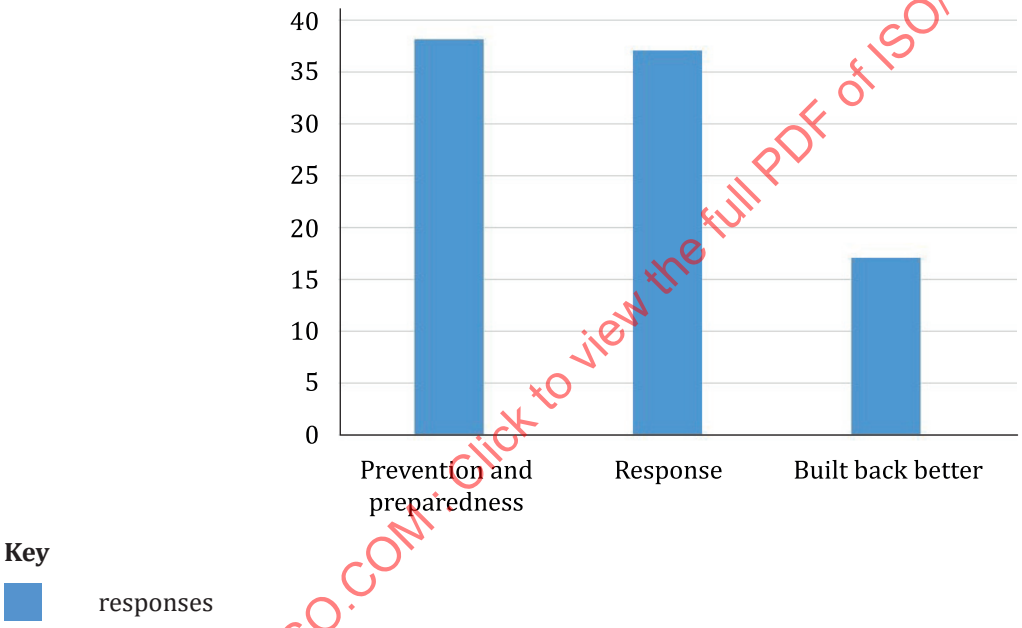

Figure 2 — Hazard phases from the 50 survey responses

As shown in Figure 2, in terms of disaster phases, a majority of the survey replies focused on the prevention and preparedness phases with 38 (76 %) replies, followed closely by the response phase with 37 (74 %) replies, highlighting strong interest in the pre-disaster phase and the disaster event phase. The post-disaster phase, or Build Back Better, recorded 17 (34 %) responses.

As with the document search, the prevention and preparedness phases were the areas most prioritized by the infrastructures identified in the survey. However, unlike the document search, responses focusing on the response phase were closely behind prevention and preparedness. A key component of smart community infrastructure is the ability to collect, transmit, and analyse data during a disaster event, highlighting the focus of the response phase by respondents. Among the 50 responses collected, Build Back Better collected the least number of responses with only 17 examples. Despite this, the gap between Build Back Better and the other phases is not as large as those identified in the document search.

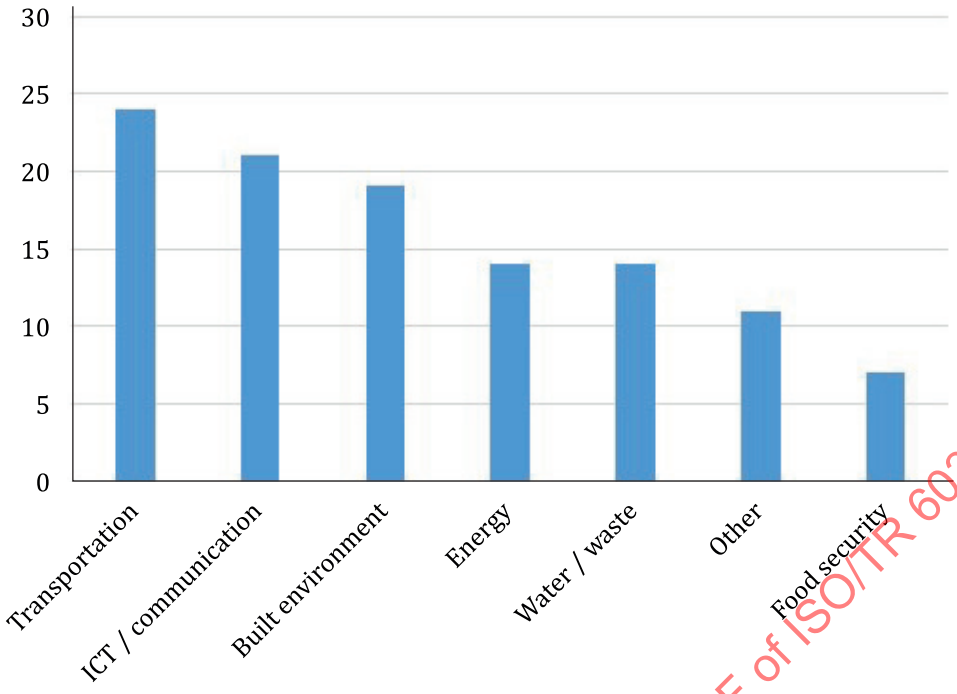

Figure 3 — Infrastructure types from the 50 survey responses

As shown in Figure 3, in terms of infrastructure type, the top three responses focused on transportation, ICT, and the built environment with 24 (48 %), 21 (42 %) and 19 (38 %) responses respectively. Energy and water and waste-related infrastructure gathered 14 (28 %) responses, and food security infrastructure with 7 (14 %) responses or 14 %. Other infrastructure, gathered 11 (22 %) responses, consisting of structures such as disaster specific infrastructure such as seawalls, other coastal structures, dams, and drainage systems.

Survey responses differed significantly from the document search results in regard to the type of infrastructure being targeted for disaster risk reduction technologies. Utilizing the 20 themes identified in the SFDRR in Clause 4, respondents were asked to identify which of these themes their infrastructure example addressed, in order to highlight its primary function in disaster risk reduction. Although ICT plays a leading role in smart community infrastructure for disaster risk reduction, it was second to transportation infrastructure based on the survey results. Examples of transportation infrastructure for disaster risk reduction include seismic detection systems on high-speed rail, flood alert systems for traffic, early warning systems for rail, and the detection of shaded areas for bicyclists. ICT infrastructure often focused on sensor technologies which could collect hazard information, e.g. seismometers, hydrometers, accelerometers, tsunameters, water level sensors, tide gauges, gauge boards, CCTV imaging, and drones. In addition, the need to transmit this data was also highlighted in the response phase, e.g. portable communication systems, satellite systems. The built environment was the third most common target. This often focused on structures that were the recipient of new designs or the retrofit of existing designs that can better withstand hazards. Several technologies emphasized the ability to monitor building conditions which can inform stakeholders on the health of these structures and when to take appropriate actions. The energy was the fourth most common infrastructure. Examples of smart energy infrastructure include smart grids which can provide stable electricity supply during and after a disaster event, and sustainable energy. Water and waste technologies tied with energy with fourteen responses. Examples focused on sensors that can detect flooding entering the community, automated operations of key water management structures such as sluices and dams, detection of stormwater entering sewers, and flood parks. Eleven of the responses consisted of “Other” infrastructure, with examples including coastal infrastructure, infrastructure dedicated to disasters, or agricultural infrastructure. Food security was the least common, however

seven responses were recorded, with areas addressing the safety and certification of emergency food which can reduce a potential cascading disaster related to health.

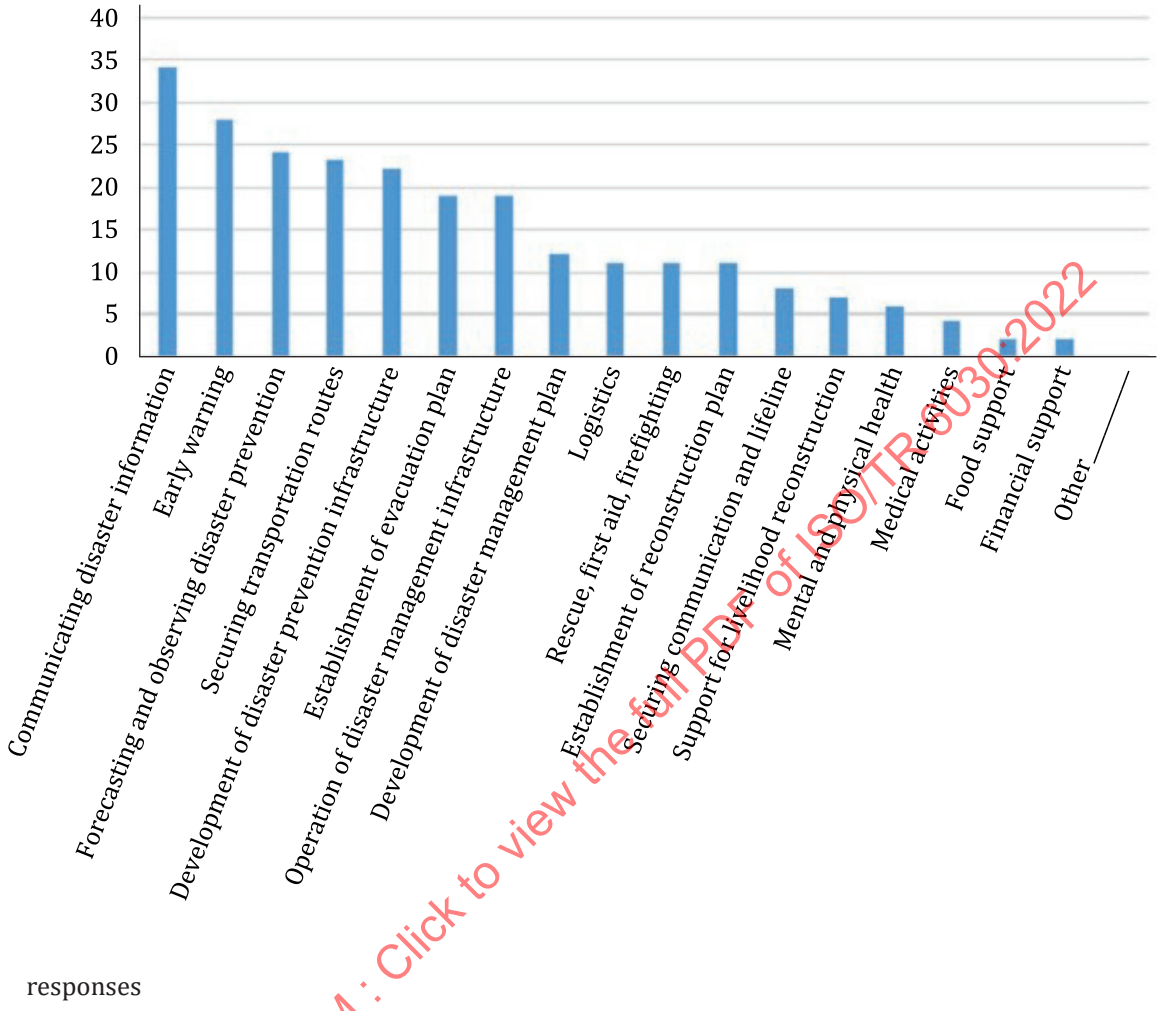

Figure 4 — Target areas from the 50 survey responses

As shown in Figure 4, target areas survey responses focused on were led by functions that focused on the transmission of hazard information, with communicating disaster information with 34 (68 %) responses, early warning at 28 (56 %) responses, and forecasting and observing disaster prevention with 24 (48 %) responses. Securing transportation routes that can strengthen accessibility, was the fourth most common response with 23 (46 %) responses.

Following this, the next four common target areas among the survey responses focused on disaster management planning, with development of disaster prevention infrastructure, establishment of an evacuation plan, operation of disaster management infrastructure, and development of a disaster management plan with 22 (44 %), 19 (38 %) and 19 (38 %), and 12 (24 %) responses respectively. Target areas that focused on logistics, rescue/first aid/fire-fighting, and the establishment of a reconstruction plan gathered 11 (22 %) responses. The remaining target areas, such as support for livelihood reconstruction, mental and physical health, medical activities, food support and financial support gathered less than 10 responses.

As a key function of smart infrastructure, the need to communicate disaster information, early warning systems, and forecasting and observing disaster prevention match the key processes of collecting data, transmitting said data, analysing and producing useful information for community stakeholders. It is worth noting that the functions of the top three responses allow for the following fourteen target areas,

as transportation routes, operation and development of disaster related infrastructure, and other activities rely on the information being gathered and produced by the first three infrastructure.

5.5 Issues landscape

The issues landscape is defined by the key themes identified in the SFDRR, as mentioned in Clause 4. These themes subscribe a list of actions that community stakeholders can take towards reducing disaster risk and has been identified as "purposes". In this subclause, this document correlates these functions by their implementation by disaster phase, and their relationship with other relevant documents.

Table 3 identifies key disaster risk reduction themes identified in Clause 4, and correlates them with the relevant SFDRR priority and which UN Sustainable Development Goal[25] (SDG) it contributes towards. For example, the theme "Securing Communication Means and Lifelines" falls in line with the SFDRR's Priority 4, specifically action 33B, which calls for the investment in, developing, maintaining, and strengthening people-centred multi-hazard, multisectoral forecasting and early warning systems, disaster risk and emergency communications mechanisms, social technologies, and hazard-monitoring telecommunications systems. This function also contributes to SDG 9.C which calls for the significant increase in access to ICT.

Table 4 similarly, provides indicators for each function, provided by ISO 37123. Indicators can be referenced by smart community infrastructure stakeholders. For example, utilizing the same function on "Securing Communication Means and Lifelines", relevant indicators can be found in ISO 37123:2019, 18.1, which provides a formula on the percentage of emergency responders in a city to be equipped with specialized communication technologies. In addition, indicators for auxiliary services used by communication infrastructure, such as backup power, are also listed.

Table 5 provides other relevant International Standards related to each key function. For example, as "Securing Communication Means and Lifelines" also deals with other key infrastructure communities use, such as water, documents such as ISO 24527 and ISO 24518, which are standards relating to drinking water, are listed.

Table 6 broadly provides guidance documents in the form of international and national level disaster management plans which contain similar information on how to plan for each disaster phase.

Table 3 — Key purposes of smart community infrastructure for disaster risk reduction and their correlation with relevant SFDRR actions and how they correspond with the United Nations Sustainable Development Goals (SDGs)

4 Phases of DRR	Purpose	SFDRR actions	Related UN SDG
Prevention	Disaster risk reduction planning	13J, 24N, 27D, 32	1.5, 2.4, 3.8, 3.D, 6.4, 6.5, 6.A, 6.B, 7.1, 7.2, 7.A, 7.B, 9.1, 9.4, 11.2, 11.3, 11.4, 11.6, 11.C, 13.1, 13.2, 13.3, 14.2, 14.5, 15.9
	Disaster research	24K, 25A	1.5, 2.4, 3.D, 6.4, 6.5, 6.A, 6.B, 7.1, 7.2, 7.A, 7.B, 8.10, 9.1, 9.4, 9.5, 11.3, 13.1, 13.2, 13.3, 15.9, 17.9, 17.16
	Safer infrastructure	30C	1.5, 3.D, 6.3, 6.4, 6.5, 6.A, 6.B, 7.A, 7.B, 9.1, 9.4, 9.A, 9.B, 9.C, 11.2, 11.C, 13.1, 14.2, 14.5
Preparedness	Human resource development	24G, 33F	4.7, 8.10, 9.5, 9.B, 10.B, 12.A, 13.1, 13.3, 16.6, 17.9, 17.18, 17.19
	Stockpiling	33D	2.4, 13.1
Response	Securing evacuation support	33M	1.5, 11.2, 13.1
	Securing evacuation facilities	33H	1.5, 9.1, 9.4, 13.1
	Procurement and supply of goods	33O	2.4, 13.1
	Rescue, emergency, firefighting	33D, 33E, 33F	13.1
	Medical activities	30I	3.8, 3.D, 13.1
	Health (physical, mental)	31E, 33O	3.8, 3.D, 5.6, 11.2, 13.1
	Voluntary support	33F	11.3, 13.1
	Epidemic prevention	28D, 33N	3.D, 11.6, 13.1
	Securing transportation routes	33C	11.2, 13.1
	Securing communication means and lifelines	33B	9.C, 13.1
Build Back Better	Livelihood recovery	30O	1.5, 8.10, 12.B, 13.1, 15.9
	Recovery planning	33J	1.5, 8.10, 11.3, 12.B, 13.1, 13.3, 15.9
	Recovery actions	19J, 33G	8.10, 13.1, 15.9
All phases	Collection and transmission of observation data	24A	9.C, 13.1, 17.8
	Collection and disseminating disaster information	24F	9.C, 13.1, 17.8

Table 4 — Key purposes of smart community infrastructure for disaster risk reduction and their correlation to relevant indicators identified in ISO 37123

4 phases of DRR	Purpose	SFDRR actions	ISO 37123:2019 indicators (subclause numbers listed)
Prevention	Disaster risk reduction planning	26A, 24N, 26B	5.2, 5.3, 7.1, 7.2, 7.3, 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 9.1, 9.2, 9.3, 9.4, 9.6, 9.7, 10.1, 10.2, 10.3, 11.1, 12.1, 12.2, 12.3, 12.4, 12.5, 12.6, 13.1, 13.3, 13.5, 15.1, 15.3, 16.1, 18.1, 19.1, 20.1, 21.1, 21.2, 21.3, 21.5, 23.1, 23.2
	Disaster research	24K, 24N	5.2, 5.3, 5.4, 6.4, 7.1, 7.2, 7.3, 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 9.1, 9.2, 9.3, 9.4, 9.6, 9.7, 10.1, 10.2, 10.3, 11.1, 12.1, 12.2, 12.3, 12.4, 12.5, 12.6, 13.1, 13.3, 13.5, 15.1, 15.3, 16.1, 18.1, 19.1, 20.1, 21.1, 21.2, 21.3, 21.5, 23.1, 23.2
	Safer infrastructure	30C, 33C, 33K	7.3, 8.9, 9.1, 9.2, 9.4, 12.1, 12.2, 12.3, 12.4, 21.2, 21.3, 21.4, 21.5
Preparedness	Human resource development	24G, 24L, 33M	6.1, 6.2, 6.3, 9.6, 15.1
	Stockpiling	33D, 33H	20.1
Response	Securing evacuation support	33H	9.5, 12.1, 15.2, 15.3, 15.4
	Securing evacuation facilities	33D, 33H	9.5, 12.1, 15.4
	Procurement and supply of goods	33H	20.1, 20.2, 23.2
	Rescue, emergency, firefighting	33D	9.5, 15.2, 15.3, 15.4, 18.1
	Medical activities	33C	11.1, 11.2, 11.3, 15.2, 15.3, 15.4
	Health (physical, mental)	30I, 30J, 33O	9.6, 11.1, 11.2, 13.3, 11.4, 15.2, 15.3, 15.4
	Voluntary support	33F	9.6
	Epidemic prevention	33N	11.4
	Securing transportation routes	33C	8.1, 19.1, 21.2, 21.4, 21.5
	Securing communication means and lifelines	33B	7.1, 7.2, 7.3, 9.1, 9.2.2, 10.3, 18.1, 21.4, 21.5
Build Back Better	Livelihood recovery	30J, 31G, 36A	5.1, 5.3, 5.4, 5.5, 5.6, 5.7, 6.4, 9.7, 10.6, 13.2
	Recovery planning	33J	5.1, 5.3, 5.4, 5.5, 9.7, 10.1, 10.2, 10.4, 10.6, 12.4, 13.5, 16.1,23.2
	Recovery actions	33E, 33J	5.1, 5.3, 5.4, 5.5, 9.7, 10.1, 10.2, 10.4, 10.6, 12.4, 13.5, 16.1,23.2
All phases	Collection and transmission of observation data	14, 24A	8.1, 8.4, 8.5, 8.6, 8.7, 10.3, 12.4, 15.1, 15.3, 18.1
	Collection and disseminating disaster information	24C, 25E	8.1, 8.4, 8.5, 8.6, 8.7, 10.3, 12.4, 15.1, 15.3, 18.1

Table 5 — Key purposes of smart community infrastructure for disaster risk reduction and their correlation to relevant ISO Technical Committees and documents for the purposes of future collaboration and research

4 phases of DRR	Purpose	Related ISO technical committees	Related ISO documents
Prevention	Disaster risk reduction planning	TC 262, TC 292, TC 224, TC 46/SC 10, TC 207/SC 7, TC 268	ISO 31000, IEC 31010, ISO 22301, ISO 22316, ISO 24518, ISO 24527, ISO 14090, ISO/TS 14092, ISO 21110, ISO 14080, ISO 37123
	Disaster research	TC 262, TC 224, TC 207, TC 68 SC2, TC 207/SC 7, TC 46/SC 10	ISO 31000, IEC 31010, ISO 22301, ISO 22316, ISO 24518, ISO 24527, ISO 14090, ISO/TS 14092, ISO 21188, ISO 14080, ISO 37123, ISO 21110
	Safer infrastructure	TC 224, TC 59, TC 268	ISO 24518, ISO 24527, IEC 63152, ISO 37123
Preparedness	Human resource development	TC 46/SC 10, TC 268	ISO 21110, ISO 37123
	Stockpiling	TC 34/SC 17, TC 268, TC 46/SC 10	ISO 22000, ISO 37123, ISO 21110
Response	Securing evacuation support	TC 292, TC 268	ISO 22315, ISO 37123
	Securing evacuation facilities	TC 292, TC 46/SC 10	ISO22315, ISO 37123, ISO 21110
	Procurement and supply of goods	TC 224, TC 268	ISO 24518, ISO 24527, ISO 37123
	Rescue, emergency, firefighting	TC 21/SC 3, TC 92/SC 4, TC 204, TC 268	ISO 7240, ISO 12239, ISO/TR 19803-1, ISO 37123
	Medical activities	TC 215, TC 268	ISO 37123
	Health (physical, mental)	TC 215, TC 268	ISO 37123
	Voluntary support	TC 292, TC 268	ISO 22319, ISO 37123
	Epidemic prevention	TC 190/SC 7, TC 268	ISO 28901, ISO 37123
	Securing transportation routes	TC 204, TC 268	ISO/TR 19803-1, ISO 37123
	Securing communication means and lifelines	TC 224, TC 268	ISO 24518, ISO 24527, ISO 37123
Build Back Better	Livelihood recovery	TC 292, TC 268	ISO 22313, IEC 27031, ISO 37123
	Recovery planning	TC 204, TC 268, TC 46/SC 10	ISO/TR 19803-1, ISO 37123, ISO 21110
	Recovery actions	TC 204, TC 268, TC 46/SC 10	ISO/TR 19803-1, ISO 37123, ISO 21110
All phases	Collection and transmission of observation data	TC 20 SC 16, TC 268	IEC 63152, ISO/IEC TR 20547 series, ISO 37123
	Collection and disseminating disaster information	TC 268, TC 46 SC 10	IEC 63152, ISO/IEC TR 20547 series, ISO 37123, ISO 21110

Table 6 — Key purposes of smart community infrastructure for disaster risk reduction and relevant guidance documents from international and national sources

4 Phases of DRR	Purpose	Related guidance documents
Prevention	Disaster risk reduction planning	— Sendai Framework for Disaster Risk Reduction (SFDRR) — Technical guidance for monitoring and reporting on progress in achieving the global targets of the Sendai Framework for Disaster Risk Reduction (UNDRR) — Disaster and crisis communication: Trend analysis of technologies and approaches (UNDRR) — Assessing seismic hazard and risk globally for an earthquake resilient world (UNDRR) — Disaster preparedness and complex adaptive systems: a government continuity plan for a self-organizing community (UNDRR) — Urban risk reduction and resilience (UNDRR) — The road to resilience: Financing resilient energy infrastructure (WEC) — Protecting New Health Facilities from Natural Disasters: Guidelines for the Promotion of Disaster Mitigation (WHO/PAHO) — National Infrastructure Protection Plan 2013 (US Department of Homeland Security) — German Recovery and Resilience Plan (German Federal Ministry of Finance) — Emergency Management Strategy for Canada Toward a Resilient 2030 (Public Safety Canada)
	Disaster research	
	Safer infrastructure	
Preparedness	Human resource development	— Sendai Framework for Disaster Risk Reduction (SFDRR) — Resilience of SMEs (UNDRR) — Disaster prevention for schools: guidance for education sector decision makers (UNDRR) — A Strategic Framework for Emergency Preparedness (WHO) — Implementation guide for local disaster risk reduction and resilience strategies (UNDRR) — Broadcasting for public warning, disaster mitigation and relief (ITU)
	Stockpiling	

Table 6 *(continued)*

4 Phases of DRR	Purpose	Related guidance documents
Response	Securing evacuation support	— Words into Action guidelines Disaster Displacement (UNDRR) — Disaster Preparedness for Effective Response — Guidance notes on recovery: health - Supplementary edition (IFR) — Management of Dead Bodies after Disasters (WHO/PAHO, ICRC) — Sendai Framework for Disaster Risk Reduction (SFDRR) — Transport sector recovery: opportunities to build resilience (World Bank) — Disaster risk reduction: Why do we need accurate disaster mortality data to strengthen policy and practice? (UNDRR) — Disaster Preparedness Guides for Persons with Disabilities (UNDRR) — Guidance note on recovery: shelter (UNDP) — Private sector activities in disaster risk reduction: good practices and lessons learned (UNISDR) — Resilient livelihoods: Disaster risk reduction for food and nutrition security (FAO) — Management of Dead Bodies in Disaster Situations (WHO) — Infection prevention and control for the safe management of a dead body in the context of COVID-19 (WHO) — Broadcasting for public warning, disaster mitigation and relief (ITU)
	Securing evacuation facilities	
	Procurement and supply of goods	
	Rescue, emergency, firefighting	
	Medical activities	
	Health (physical, mental)	
	Voluntary support	
	Epidemic prevention	
	Securing transportation routes	
	Securing communication means and lifelines	
Build Back Better	Livelihood recovery	— Sendai Framework for Disaster Risk Reduction (SFDRR) — Post-Disaster Needs Assessments (UNDP) Words into Action guidelines: Build Back Better in recovery, rehabilitation and reconstruction (UNDRR) — Build Back Better in recovery, rehabilitation and reconstruction (UNISDR) — Guidance note on recovery: livelihood (UNDP) — Guidance on Livelihood (ADPC) — Resilient livelihoods: Disaster risk reduction for food and nutrition security (FAO)
	Recovery planning	
	Recovery actions	

Table 6 *(continued)*

4 Phases of DRR	Purpose	Related guidance documents
All Phases	Collection and transmission of observation data	— Sendai Framework for Disaster Risk Reduction (SFDRR) — Technical guidance for monitoring and reporting on progress in achieving the global targets of the Sendai Framework for Disaster Risk Reduction (UNDRR) — Disaster and crisis communication: Trend analysis of technologies and approaches (UNDRR) — Advanced cyber technologies to improve resilience to emergencies (UNDRR) — Extensible data schemas for multiple hazards, exposure and vulnerability data (UNDRR) — Disaster risk reduction: Why do we need accurate disaster mortality data to strengthen policy and practice? (UNDRR) — The role of data interoperability in disaster risk reduction: Barriers, challenges and regional initiatives (UNDRR) — Basic Disaster Management Plan (Cabinet Office, Government of Japan) — The Booklet of Best Practices of resilient ICT systems in JAPAN (Japan Ministry of Internal Affairs and Communications) — National Disaster Risk Reduction Framework (Commonwealth of Australia) — Microgrids for disaster preparedness and recovery (IEC) — Introducing Infrastructure Resilience (UK Department for International Development) — Making Critical Infrastructure Resilient: Ensuring Continuity of Service (UNDRR) — Disaster and emergency management strategic plan 2013-2017 (Prime Ministry of Turkey)
	Collection and disseminating disaster information	

5.6 Solution landscape

The survey responses, as shown in Table 7, provide examples of smart community infrastructure for disaster risk reduction that have been implemented or planned to be implemented across the world. These examples consist of solutions that matches the SFDRR's priority to "promote investments in innovation and technology development in long-term, multi-hazard and solution-driven research in disaster risk management to address gaps, obstacles, interdependencies and social, economic, educational and environmental challenges and disaster risks" (SFDRR P.15).

The survey provides examples of global solutions to smart community infrastructure purposes identified in the issues landscape. Information on each example was compiled by academics, local governments, and the private sector, in line with the SFDRR's priority 25D "To promote common efforts in partnership with the scientific and technological community, academia and the private sector to establish, disseminate and share good practices internationally" (SFDRR P.15).

The examples of global solutions are categorized by hazard types as identified by the survey, cross-referenced with the four disaster phases. As many infrastructure examples are designed for multiple hazards and to operate during multiple phases, they can be listed multiple times. Examples of infrastructure intended for all phases, and/or all hazard types are also listed in separate categories. Each global solution is listed by number, which can be referenced in Annex A for specific details.

Table 7 — Solutions landscape — 50 global examples of global smart community infrastructure for disaster risk reduction by hazard type and disaster phase

Type	Prevention	Preparedness	Response	Build Back Better	All phases
Cyclones Typhoons Hurricanes	6, 7, 12, 32, 35, 36, 37, 38, 39, 40, 41, 42, 45	6, 7, 12, 32, 35, 36, 37, 38, 39, 40, 41, 42, 45	7, 12, 14, 29, 32, 38, 50	14, 29	3, 11, 30, 31, 44
Earthquakes	1, 43, 46, 47, 48	1, 43, 46, 47, 48	1, 14, 22, 29, 46, 47, 48, 49	14, 29, 43	24, 28, 30, 31
Tsunami	1, 6, 17, 27, 32, 41, 43	1, 6, 17, 27, 32, 41, 43	1, 14, 23, 27, 29, 32, 49	14, 21, 29, 43	30, 44
Flood	1, 6, 7, 12, 17, 19, 26, 32, 38, 39, 40, 42, 43, 45	1, 6, 7, 12, 17, 19, 26, 32, 38, 39, 40, 42, 43, 45	1, 4, 7, 12, 14, 15, 16, 19, 26, 29, 32, 38, 50	14, 20, 29, 43	11, 18, 24, 31, 44
Heavy Rain	6, 7, 12, 19, 26, 32, 38, 39, 40, 42	6, 7, 12, 19, 26, 32, 38, 39, 40, 42	7, 12, 16, 19, 26, 29, 32, 38	29	3, 11, 18, 24, 25, 30, 31, 44
Heatwaves	9, 13, 26	9, 13, 26	9, 13, 26		11
Landslides	32	32	14, 29, 32	14, 29	24, 44
Avalanche			14, 29	14, 29	24
Tornadoes			29, 50	29	
Wildfires	8, 10, 13	8, 10, 13	10, 13, 14, 15, 24	14, 29	3, 11, 18
Volcanoes			14, 29	14, 29	24
Other hazards	17 (sea level rise), 37 (high waves)	17 (sea level rise), 37 (high waves)			18, 44 (sediment)
All hazards	5	5	5, 33, 34	34	2
NOTE Annex A provides a summary of each global solutions which are listed by number.					

5.7 Common areas of function

Of the fifty survey results collected, general themes were identified by the type of common functionality being provided by these infrastructures.

Hazard Identification: Incorporating disaster risk reduction planning and disaster research from the prevention phase, examples of infrastructure in under hazard identification assists community

stakeholders in identifying hazards. Hazard identification includes the creation of maps and local government disaster plans. Survey examples include 15. 3rd Party Road Mapping Apps is an example of hazard identification, where community stakeholders can utilize map applications that identify potential emergency situations.

Hazard Monitoring and Detection: Infrastructure which monitors areas or other structures over time that can assist in the detection of initial signs of disasters. Survey examples of monitoring systems include 49. Seismometer Sensors Deployed for Seismic Monitoring, which is used to monitor all seismic activities including powerful earthquakes include 24. SISMAN LISA and SIMAC which are integrated hazard detection systems that monitor hydrometeorological activities that can lead to disasters, and thus allow for stakeholders to respond in time.

Preparedness Systems: Infrastructure which contributes to community preparedness to disasters. Survey example 29 on Sustainable Emergency Food Supply Chain, which was developed to strengthen the ability of communities to certify emergency foods and promote stockpiling.

Response Systems: Examples of infrastructure that are primarily utilized during the response phase, this includes purposes identified in Table 6, e.g. such as evacuation support, medical activities. Survey examples include 33. SIP4D Shared Information Platform for Disaster Management and SIP4D-ZIP Commonality Data Framework which is a multi-hazard technology that facilitates information sharing between organizations for quick disaster response, and the new 5. Traffic Management System Rail Networks which allow for quick responses to service disruptions.

Governance Systems: Examples that can strengthen aspects of governance, such as multi-stakeholder collaboration, command systems, etc. related to infrastructure for disasters. Survey examples include 30. Framework for multi-stakeholder dialogue at the subnational level for effective economic recovery from disasters, which strengthens guideline development for various stakeholders on information collection for disaster related recovery, and example 26. Blue-Green Infrastructure in the Ruhr Metropolis, which promotes interaction between communities and local governments to address solutions to stormwater problems among others.

6 Gap analysis

6.1 General

This clause introduces a gap analysis to identify the possible needs for standardization based on the survey result provided in Clause 5. This clause also introduces some key discussions on the possible needs for standardization held in the process of the development of this document. These key discussions are provided for the reference of further discussion on this topic in relevant standardization bodies and does not intend to suggest or justify possible individual standardization items.

6.2 Gap analysis types

6.2.1 Gap analysis by community infrastructure functions

Table 8 shows a gap analysis by community infrastructure functions. The vertical axis is identical with that of issue landscape introduced in Clause 5. The horizontal axis introduces a layered model of community infrastructure ranging from city management to supporting functions. In Table 8, existing ISO Technical Committees (TCs), Subcommittees (SCs) and Working Groups (WGs) are mapped in each cell.

Table 8 — Key purposes of smart community infrastructure for disaster risk reduction and their correlation to ISO Technical Committees addressing relevant layers of community infrastructure functions

4 phases of DRR	Purpose	City management — ISO Technical Committees (TCs)	Infrastructure	Technical enabler	Supporting functions
Prevention	Disaster risk reduction planning	— TC 292, Security and resilience (e.g. ISO 22397) — TC 292/WG 2, Continuity and organizational resilience — TC 292/WG 7, Guideline for events (e.g. ISO 22396) — TC 292/WG 9, Crisis management — TC 268/WG 2, City indicators (e.g. ISO 37123) — TC 46 SC10, Requirements for document storage and conditions for preservation (e.g. ISO 21110). — TC 207 SC 7, Greenhouse gas and related activities (e.g. ISO 14091, ISO/TS 14092) — TC 92 SC 4, Fire safety engineering (e.g. ISO 16732 series)	— IEC SyC Smart Cities (e.g. IEC 63152)	— IEC SyC Smart Cities (e.g. IEC 63152)	
	Disaster research	— TC 207 SC 7, Greenhouse gas and related activities (ISO 14091)			

Table 8 *(continued)*

4 phases of DRR	Purpose	City management — ISO Technical Committees (TCs)	Infrastructure	Technical enabler	Supporting functions
	Safer infrastructure	— TC 292/WG 3, Emergency management (e.g. ISO 22326) — TC 224 (e.g. ISO 24518, ISO 24511)	— TC 224 (e.g. ISO 24536, ISO 24527, ISO 24510) — TC 92 SC 4, Fire safety engineering (e.g. ISO 16733 series), — TC 21 SC 3, Fire detection and alarm systems (e.g. ISO 7240) — IEC SC 8A, Grid integration of renewable energy generation (e.g. IEC TR 63043) — IEC TC 75 (e.g. IEC 62599 series) — IEC TC 81 Lightning protection (e.g. IEC 62305 series) — IEC TC 88, Wind energy systems (e.g. IEC 61400 series) — IEC TC 103, Transmitting and receiving equipment for radiocommunication (e.g. IEC 60215)	— IEC TC 89, Fire hazard testing (e.g. IEC 60695 series) — ISO/IEC JTC 1/SC 41, Internet of things and digital twin (e.g. ISO/IEC 19637)	
Preparedness	Human resource development	— TC 292/WG 9 Crisis management — TC 292 /WG 3 Emergency management (e.g. ISO 22320)			
	Stockpiling	— TC34/WG 25 Food security in emergency or crisis situation	*s*		
Response	Securing evacuation support	— TC 292/WG 5 Community resilience (e.g. ISO 22395, ISO 22315)	— TC 292/WG3, Emergency management (ISO 22327) — TC 21 SC 3, Fire detection and alarm systems (e.g. ISO 7240)		

Table 8 *(continued)*

4 phases of DRR	Purpose	City management — ISO Technical Committees (TCs)	Infrastructure	Technical enabler	Supporting functions
	Securing evacuation facilities	— TC 92 SC 4, Fire safety engineering (e.g. ISO 20414)	— TC 92 SC 4, Fire safety engineering (e.g. ISO 20414)		
	Procurement and supply of goods	— TC 292/WG 8, Supply chain security (e.g. ISO 22396) — TC 224 WG 7, Crisis management of water utilities (e.g. ISO 24527) — TC 34 WG 25, Food security in emergency or crisis situation (i.e. NP 3409)	— WG 7, Crisis management of water utilities (e.g. ISO 24527),		
	Rescue, emergency, fire-fighting		— TC 21 SC 3, Fire detection and alarm systems (e.g. ISO 7240)		
	Medical activities				
	Health (physical, mental)				
	Voluntary support	— TC 292/WG 5, Community resilience (e.g. ISO 22391 series)			
	Epidemic prevention				
	Securing transportation routes	— TC 204 WG 8, Public transport/emergency (i.e. ISO/TR 19803-1)	— TC 204 WG 8, Public transport/emergency (i.e. ISO/TR 19803-1) — IEC TC 81, Lightning protection (e.g. IEC 62305 series)	— ISO/IEC JTC 1/SC 41, Internet of things and digital twin (i.e. ISO/IEC 19637)	

Table 8 *(continued)*

4 phases of DRR	Purpose	City management — ISO Technical Committees (TCs)	Infrastructure	Technical enabler	Supporting functions
	Securing communication means and lifelines	— ISO/IEC JTC 1 SC 6, Telecommunications and information exchange between systems (e.g. ISO/IEC TR 16167)	— IEC SyC Smart Cities (e.g. IEC 63152)	— IEC TC 82, Solar photovoltaic energy systems (i.e. IEC 60904 series) — IEC TC 103, Transmitting and receiving equipment for radiocommunication (e.g. IEC 60215) — IEC 104, Environmental conditions, classification and methods of test (e.g. IEC 60068 series) — ISO/IEC JTC 1/SC 41, Internet of things and digital twin (i.e. ISO/IEC 19637)	
Build Back Better	Livelihood recovery	— TC 34 WG 25, Food security in emergency or crisis situation (i.e. NP 3409)			
	Recovery planning	— TC 46 SC10, Requirements for document storage and conditions for preservation (e.g. ISO 21110) — TC 92 SC 4, Fire safety engineering (e.g. ISO 16732 series)	— TC 190 SC 7, Impact assessment (e.g. ISO 28901)		
	Recovery actions		— TC 190 SC 7, Impact assessment (e.g. ISO 18504)		
Cross cutting all phases	Collection and transmission of observation data	— TC 292/WG 3, Emergency management (e.g. ISO 22326) — TC 207 SC 7, Greenhouse gas and related activities (ISO 14091) — IEC TC 57 (e.g. IEC 31010)	— TC 21 SC 3, Fire detection and alarm systems (e.g. ISO 7240) — IEC TC 57, Power systems management and associated information exchange (e.g. 60870) — IEC TC 79, Alarm and electronic security systems (e.g. IEC 60839 series)	— IEC 104, Environmental conditions, classification and methods of test (e.g. IEC 60068 series). — ISO/IEC JTC 1/SC 41, Internet of things and digital twin (i.e. ISO/IEC 19637)	

6.2.1.1 Prevention and preparedness

For prevention and preparedness phases, various guidelines for city management level are provided by ISO TC 292 and other technical committees. However, the guidelines or common frameworks for DRR focused on infrastructure are currently limited. IEC SyC Smart Cities covers this, however, the coverage is limited to the core areas of IEC which is relevant to electric and electronic technologies. Also, supporting functions such as financing schemes to implement the DRR planning focused on infrastructure are not as well covered by existing TCs and SCs.

6.2.1.2 Response

For response phase, issues with regard to evacuation are well covered by ISO TC 292. Some issues to secure so called lifelines are covered by several TCs which cover individual type of infrastructure such as transportation or telecommunication. On the other hand, the holistic framework for response phase for multiple infrastructure is not as well covered by existing TCs.

6.2.1.3 Build Back Better

For Build Back Better phase, not many standards are provided considering the importance of this phase in the SFDRR.

6.2.1.4 Cross-cutting in all phases

There are some possible standardization areas relevant to all four phases of DRR. One salient example of this area would be information exchange.

6.2.2 Gap analysis by hazard types and infrastructure types

Based on the general themes identified in 5.6 which categorized the 50 survey results into common groups, Table 9 maps which existing ISO and IEC standards can be utilized within each of these five themes, and for which hazards. In addition to existing standards, Table 9 also maps areas for which standards are not yet developed, but for which the survey results provide an example, which is marked with an X. Finally, areas which do not contain any known standards at time of writing and are not covered by the survey examples are marked with O.

Table 9 — ISO technical committees, standards, and the survey results, relevant to hazard type and each of the five categories of common DRR functions provided by smart community infrastructure

	Hazard identification	Hazard monitoring and detection	Preparedness systems ISO technical committee (TC)	Governance systems	Response systems
Typhoon	X	X	X (IEC 61400 series)	X	X
Earthquake	X	X	X, TC 224	X	X
Tsunami	X	X	X, TC 224	X	
Flood	X	X	X, TC 224 (ISO 24536)	X	X
Heavy Rain	X	X	X check	X	X
Heatwave	X	X	X	X	X
Landslide	X		X, TC 292 (ISO 22327)	X	X, TC 292 (ISO 22327)
Avalanche	O	O	O	O	O
Tornado	O	X	O	O	O

Table 9 *(continued)*

	Hazard identification	Hazard monitoring and detection	Preparedness systems ISO technical committee (TC)	Governance systems	Response systems
Wildfires	X, TC 92 SC 4 (ISO 16732 series, ISO 16733 series), TC 21 (ISO 7240), IEC TC 89 (IEC 60695 series)	X, TC 21 (ISO 7240),	X, TC 92 (ISO 20414)	X	X
Volcanoes	O	O	O	O	O
Other	X, TC 207 SC 7 (ISO 14091, ISO 14902)	X	IEC TC 81 (IEC 62305 series)	O	O
All hazards	X	X, TC 292 (ISO 22326)	TC 268 SC 1 (ISO 37123), TC 292 (ISO 22320), ISO 22315	X, TC 292 (ISO 22395, ISO 22396, ISO 22397, ISO 22320)	X, (IEC 63152)
X: Standards are not yet developed, but an example is provided. O: Areas which do not contain any known standards at time of writing and not covered by the survey examples.					

Based on this analysis, many of the current ISO and IEC International Standards focus on preparedness systems. Although there are few standards that specialize in specific hazard identification, examples of standards for landslides and wildfires have been developed in ISO TC 292, TC 92, TC 21, and IEC TC 75 and 89. However, in terms of all or multi hazard situations, TC 268 SC1 provides indices that cities can use to prepare for various disasters, whereas TC 292 has developed standards relating to governance, such as multi-stakeholder collaboration, business continuity plans, and management considerations. In terms of response systems, IEC 63152 provides guidance on the continuity of electrical supply after an emergency event, this however only focuses on electric related infrastructure.

As a result, Table 10 also categorizes the five categories by infrastructure orientation, in order to provide a clearer picture of which area is being targeted by existing ISO and IEC International Standards, examples from the survey report, and areas not being covered by either. This allows examination of how different standards can focus on different functions of an infrastructure. For example, ISO 22320 covers multiple infrastructure use cases, but focuses primarily on the governance aspects, and less so on the functions of hazard identification, and monitoring and detection.

Table 10 — ISO technical committees, standards, and the survey results, relevant to infrastructure type and each of the five categories of common DRR functions provided by smart community infrastructures

	Hazard identification	Hazard monitoring and detection	Preparedness systems	Governance systems	Response systems
Transportation	X	X	X	X	X
Energy	X	X, TC 224 (ISO 24536)	X, (IEC 63152, IEC 61400 series)	X	X, (IEC 63152, IEC 61400 series)
Water/ Waste	X	X	X, TC 224 (ISO 24536, ISO 24527)	X	X, TC 224 (ISO 24527)
ICT/ Communications	X	X, ISO/IEC JTC 1/ SC 41	X		X

Table 10 *(continued)*

	Hazard identification	Hazard monitoring and detection	Preparedness systems	Governance systems	Response systems
Built environment	X, TC 21 (ISO 7240), IEC TC 75 (IEC 62599 series), IEC TC 89 (IEC 60695 series)	X, TC 292 (ISO 22326), TC 21 (ISO 7240),	X, IEC TC 81 (IEC 62305 series), TC 92 (ISO 20414)	X	X, TC 21 (ISO 7240)
Food security	X	X	X	X	X
Other	X, TC 92 SC 4 (ISO 16732 series), TC 46 (ISO 21110	X	TC 268 SC 1 (ISO 37123) ISO 22315, TC 46 (ISO 21110), TC 292 (ISO 22320)	TC 292 (ISO 22320, ISO 22396)	X, TC 46 SC 10 (ISO 21110),
X: Standards are not yet developed, but an example is provided.					

6.3 Possible areas for action by standardization bodies

Based on the results of the surveys and gap analyses the following possible areas for standardization are identified for priority.

a) **Common framework for the implementation of disaster risk reduction in smart community infrastructure**: An overarching framework that harmonizes the various examples of smart community infrastructure for disaster risk reduction is needed. This allows stakeholders, such as municipal planners, to understand how the various infrastructures function together as part of a broader system. This framework is intended to be a guideline for a system of systems related to disaster risk reduction. Survey Examples #2, #18, #24, and #33 demonstrate how cities in Oceania, South America, and Asia utilize and manage their network of smart community technologies, to create and provide integrated and comprehensive disaster information to multiple stakeholders in the community.

b) **Governance systems**: Based on Example #30, this includes frameworks or systems regarding how multiple stakeholders collaborate regarding disaster risk reduction infrastructure.

   1) **Local multi-stakeholder dialogue framework**: Based on Example #30, this focuses on multi-stakeholder collaboration at the sub-national level

   2) **Community engagement and participation framework**: This is to identify how members of the community can interact with other stakeholders regarding the use of disaster risk reduction infrastructure

   3) **Risk financing systems**: As hazard investments may be modest or limited for many cities, this sub-category seeks to identify how communities can identify means to invest in smart community infrastructure for disaster risk reduction.

   4) **Disaster information sharing systems**: Based on Example s #11 and #33, this focuses on how multiple-stakeholders can coordinate together utilizing information for immediate response during an emergency event, such as the response phase of a disaster. Digital twins such as those found in Example #2, can create virtual replicas of a city, providing multiple stakeholders visualized data of disaster information across the community.

   5) **Intergovernmental data sharing framework**: This focuses on how governments can collaborate with each other on common hazard vulnerabilities, such as sharing hazard information or coordinating disaster response. Example #27 incorporates elements of data sharing for tsunamis in countries within the region.

6) **Risk assessment systems**: A framework is needed to identify vulnerabilities and evaluate potential damage or loss of infrastructure, utilizing hazard and risk models.

c) **Prevention systems**: This category focuses on smart community infrastructure that is utilized primarily during the prevention or mitigation phase of a disaster event:

1) **Hazard identification systems**: This includes systems that lead to the development of hazard identification tools, such as the creation of maps.

2) **Hazard monitoring, detect, and prediction systems**: Multiple examples discovered in the survey have focused on the use of infrastructure to monitor, detect, and predict hazards that can be used to prevent or mitigate damages and losses. Specific categories have been identified, which include:

i. **Transportation monitoring systems**: Infrastructure which monitors hazard risk to transportation infrastructure, such as Examples #4, #5, #15, #16, and #47. This can be used to monitor hazard risk in the pre-disaster phases.

ii. **Rain and flooding prediction, monitoring, and detection systems**: As heavy rain and tropical cyclones often leads to flooding, examples found in our survey often focus on the prediction, monitoring and detection of both hazards. Examples #7, #12, #19, #32, #38, #39, #40, #41, #42, #45, and #50 are some examples of such infrastructure which can predict rainfall and support discharge operations for dams, floodgate monitoring and operations, long-term flood prediction systems, among others.

iii. **Hail prediction, monitoring and detection systems**: This includes systems that can predict, monitor and detect on hail hazards.

iv. **Wildfire prediction, monitoring, and detection systems**: Infrastructure such as Examples #10 and #13, utilizes technologies that can predict, monitor and detect wildfire hazards and related hazards such as smoke and other air quality related hazards.

v. **Coastal prediction, monitoring, and detection systems**: Examples such as #7, #17, #35, #36, and #37 utilizes infrastructure that can predict, monitor, and detect tide and wave related hazards. This includes uses such as tide, waves and inundation analysis systems, as well as flow rates of overtopping wave detection and prediction systems. This differs from tsunami hazards which are generated by seismic activity.

vi. **Waste water systems**: Examples such as #25 utilize infrastructure that monitors and detect the impact of hazards on sewer infrastructure. This includes waste water treatment, detection of flood waters into sewers, among others.

vii. **Ground water identification systems**: Examples such as #43 utilizes infrastructure which can identify ground water that can be used during emergency situations.

viii. **Tsunami prediction, monitoring, and detection systems**: Examples such as #1, #23, and #27 include infrastructure which can predict, monitor, and detect tsunami waves caused by seismic activity.

ix. **Seismic prediction, monitoring, and detection systems**: Examples such as #22, #24, #28, #46, #48 and #49 include infrastructure that detects seismic activities relating to earthquakes and volcanoes. Some systems may also include tsunamis due to the connection between these two hazards.

x. **Urban heat island systems**: This includes infrastructure that monitors the effects of heat generated in urban areas, which may pose risks to local communities. Example #9 is an

example of how technology could be used to map urban hot spots to help pedestrians and cyclists.

3) **Disaster mitigation systems**: This is a category that focuses more on modifications in the design of the actual physical structure that can contribute to disaster risk reduction rather, in contrast to the utilization of identification and monitoring systems. These include:

i. **Elevated houses**: Example #21 describe how elevated houses can be used to mitigate the impact of tsunami waves and flooding.

ii. **Flood parks**: Examples #20 and "26 describe how public areas can be developed that provides both scenic experiences and disaster reduction applications.

iii. **Rainwater harvesting systems**: Rain harvesting systems are used within cities in order to harvest rain for multiple uses while contributing to flood control.

d) **Preparedness systems**: This category focuses on smart community infrastructure that is utilized primarily during the preparedness phase of a disaster event.

1) **Food security systems**: This sub-category focuses on technologies that can strengthen the accumulation and supply of food and drink related items that can be utilized during and after a disaster event. This includes:

i. **Stockpiling systems**: Identified in Example #29. This includes the ability to certify emergency food systems and promote logistics that strengthen the ability of stakeholders to stockpile food supplies for use during a disaster event.

ii. **Drinking water systems**: Identified in example #43, this focuses on systems that can identify and utilize the use of ground water for emergency drinking water usage.

2) **Energy security systems**: Identified in Examples #3, #8 and #31, this focuses on how communities can strengthen energy security during a disaster event. This includes the usage of smart and microgrids, redundant energy infrastructure systems, and energy infrastructure that is resilient to hazard risk.

di) **Response systems**: This category focuses on smart community infrastructure that is utilized primarily during the response phase of a disaster event.

1) **Evacuation systems**: As identified in Example #44, evacuation systems such as the integrated support system for municipal disaster response, can strengthen evacuation decisions by community stakeholders.

2) **Drones for rescue, emergency, and firefighting use**: Identified in Example #14, this explores the multiple use of drones for disaster response, such as locating people, assessing damage, and boosting mobile networks.

3) **Emergency communication systems**: Identified in Example #34, this includes technology that can quickly be utilized during situations where communications are limited, such as during black outs after a disaster event.

dii) **Build Back Better systems**: This category focuses on smart community infrastructure that is utilized primarily during the Build Back Better phase of a disaster event.

1) **Food distribution systems**: This sub-category explores how food supplies can be strengthened to distribute food after a disaster event.

2) **Smart and resilient buildings**: This sub-category explores how buildings can be rebuilt to be more resilient to future hazards.

3) **Public spaces**: This sub-category explores how public areas can be utilized for the use of all community members in a manner that contributes to disaster resiliency

4) **Evaluation and auditing systems**: This sub-category identifies the need to evaluate and audit post-disaster impacts.

NOTE The listed items do not necessarily fit into the current scope of TC 268/SC 1 or even that of TC 268.

Annex A
(informative)

Examples of global smart community infrastructures for disaster risk reduction

The following are the survey responses of smart community infrastructure for disaster risk reduction globally.

1. **Australian Tsunami Warning System (Australia):** provides a comprehensive tsunami warning system delivering timely and effective tsunami warnings to the Australian population. It is also a key element of the Indian Ocean Tsunami Warning and Mitigation System and contributes to the facilitation of tsunami warnings for the South West Pacific.

2. **Digital Twins of Infrastructure (Australia):** creates virtual replicas of small- and large-scale physical objects, buildings, cities, regions and systems (above and below ground). It is a platform/tool allowing for data visualisation, simulation and collaboration. It includes: 3D visualisation, wireless technology, structural engineering and Internet of Things. The output: a digital model of the built environment, including the physical infrastructure, which can be seen on a PC, tablet or mobile phone. Digital twins allow engineers to observe: deformations, deflections, cracks, or stresses due to various loads (such as traffic or wind). The intelligent digital twin model can also suggest appropriate maintenance decisions.

3. **Power Grid Stand Alone Power Systems (SAP) (Australia):** an electricity generation and supply system comprising solar panels, a large battery and a backup diesel generator; these can operate independently of the electricity grid. Two energy companies in Western Australia are supplying selected remote customers with SAPS and disconnecting them from the grid. Also involved in this work is the elimination of the risk of old poles and wires starting fires. SAPS reduce the amount of infrastructure exposed to a natural hazard and therefore the chance of damage or powerlines starting fires. Also, these systems decrease the recovery time for a community.

4. **Flooded Roads Smart Warning System (FRSWS) (Australia):** uses smart technology to provide both proactive and reactive mechanisms to enhance road safety during flood episodes. The FRSWS minimises the risk of drivers inadvertently driving into flooded roads by using advance warning signs that only activate in flood conditions. The innovative design and programming of these signs allows real time mapping and information for each road location with a FRSWS to be provided to disaster management entities and the community through a range of communication methods.; The FRSWS signs are powered by recycled laptop batteries and solar panels and flash a “Road Flooded” warning for motorists when activated by rising waters.

5. **New Traffic Management System Rail Network (Australia):** Traditionally, the train service planning system has been based on a timetable planned in advance and if any changes were to occur on the day, it would be managed manually by controllers. But the TMS now enables the timetable to be managed in real-time, allowing controllers to respond quickly to any disruptions. The new TMS will be used to monitor train services and will work alongside the advanced train running indication and control system that is currently used by Sydney Trains to manage network operations.

6. **Coastal Estuary Drainage Network (Australia):** Expanding the knowledge of the coastal - terrestrial interface by surveying accurate water levels and time patterns for peak tides at the estimated Highest Astronomical Tide (HAT) limits within key coastal estuaries on the Capricorn Coast, Central Queensland. Actual survey measurement of tide level and time pattern has revealed significant time delay and some material water level differences which would influence flood computer model predictions. Gauge boards have been installed and survey reference levelled using RMT. Traffic type video records of the tide level and time are later downloaded and analysed.

7. **State-wide Flood Early Warning System (Australia):** The aim of this project is to design and deploy a road flood forecasting system covering State-controlled roads within Queensland. The road flood forecasting system would be an automated system and utilise existing BoM rainfall forecasts, running the results through their AWRA-L model producing a forecast map of surface runoff for Queensland. Results would be assessed at key flood hotspots across the road network to predict the probability and severity of flooding within the next five days. This provides TMR with a highly reliable spatial prediction of the future state of the road network, allowing proactive planning and deployment of resources, and communication with key road users (e.g. major freight users who supply using just-in-time modes). Such an approach will minimise the impact of flood-related road closures.

8. **Rapid Earth Fault Current Limiters (REFCLs) (Australia):** reduce the threat of arcing and igniting bushfires; this is done by "lowering the energy release in certain types of powerline faults (multi-wire and wire-to-earth faults) within milliseconds. Power is restored immediately if the fault clears.

9. **Shadeways (Australia):** This project's aim is to develop a platform that integrates maps of satellite-derived land surface temperatures to inform users of the location of urban hot spots. The Shadeways Project involved key three areas of activity: 1) The development of an urban heat/thermal comfort mapping program; 2) Support for an enhanced network of localized temperature sensors; and, 3) A process of testing and research on issues of shade and active transport with community members. In turn, pedestrians and cyclists, for example, can understand how their route will differentially expose them to extreme temperatures and map a low temperature route, if warranted. https://www.infrastructure.gov.au/cities/smart-cities/collaboration-platform/Smart-Active-Transport-Urban-Heat-Maps-for-Bendigo.aspx

10. **Active Bushfire Hotspot Detection (Australia):** In 2018, RMIT developed a geostationary fire-hotspot algorithm that required no separate cloud mask and no additional numerical weather prediction information. The algorithm was applied to Himawari-8 data and involved calculating statistics over bio-geophysical-regions, sub-seasons and times-of-day to detect rises in mid-infrared sky (MIR) brightness temperature that were unlikely to be due to cloud.

11. **Local Council Area Disaster Management Dashboard (Australia):** This infrastructure is a website which locals can log onto at any time and get up-to-date information on critical events which could have yet to occur, currently occurring, or have occurred and are in recovery stages.

12. **CCTV to monitor rivers and stream levels (Australia):** By installing strategically located CCTV cameras on bridges to provide a real-time video stream to emergency services and an Emergency Operation Centre. Assists with early warning disaster management which can prompt evacuation.

13. **Air Rater App (Australia):** Free to download app that monitor's the user's environment to obtain information on up-to-date air quality information Key features include: Keeping track of hay fever and asthma symptoms in one place; Checking the air quality at any location; Setting up 'saved' locations so the user can quickly view what's happening in areas they visit frequently; Seeing the location of bushfires; Seeing how their symptoms correlate with environmental conditions". In addition, the app keeps track of temperature and alerts people on particularly cold or hot weather days.

14. **Communications Drone Swarm (Australia):** The Telestra team labs executed a drone swarm and a mobile 'cell on wings' demonstration using 4GX on the Telstra mobile network. It can be used for multiple purposes: 1) the drone swarm is a group of drones controlled by a single pilot flying in formation and using vision capture to quickly and efficiently map an area impacted by fire or flood. Computer vision capability enables the cameras on the drones to identify specific objects, such as people and vehicles. This can help emergency services operators to locate people who require rescue, and also in assessing the overall scale of damage over a large area; 2) the 'cell on wings' is a mobile small cell mounted on a drone in order to temporarily boost mobile network coverage in a local area, which is particularly useful in emergency situations.