MASTER OF SCIENCE IN ENGINEERING

Disaster resilient infrastructure projects in development and humanitarian aid context

Compendium on existing manuals

- Instruction note v.1 -

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Bern, 27 April 2016

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Abbreviations

BFH	Bern University of Applied Sciences
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
Helvetas	HELVETAS Swiss Intercooperation
MSE	Master Science and Engineering
(i)NGO	(international) non-governmental organisation
SDC	Swiss Agency for Development and Cooperation
SHA	Swiss Humanitarian Aid Unit
WASH	Water Sanitation and Hygiene

cf. annex with glossary of the main terms.

1. Introduction

Relevance of disaster risks in infrastructure projects

Investments and development gains can be lost in seconds of a natural disaster event, which tend to increase in frequency and intensity all over the world. Natural disaster risks are crucial to be considered when planning and constructing new infrastructure in order to ensure sustainable interventions and disaster resilient investments. Important sums are invested into infrastructure, though **technical practitioners -** particularly in development cooperation and humanitarian aid context- **lack practical guidance and technical tools** on how to consider natural disaster risks and according measures **in the design, planning and construction of their infrastructure projects**.

Information gap

Despite considerable efforts in the field of disaster risk reduction (DRR), the information gap related to practical guidance in infrastructure projects refers to the following aspects:

- Building codes and national norms often refer to a narrow range of natural hazard processes. There is a lack of a **multi-hazard approach.**
- Building codes and national norms tend to be highly **complex**, they are not adapted for practitioners implementing the projects (technicians, construction works) and small to medium scale projects.
- Technical manuals are often are addressed to engineers or architects with university degree or a broad technical background. These are often too **complex for local technicians** with a rather basic technical profile.
- Manuals on participatory methods involving the beneficiary communities and other local actors (e.g. for risk assessments) are often **too much vulgarized**. These lacking technical aspects as required for a project implementation.
- References on the design and implementation of mitigation/prevention measures of industrial countries are often too **complex and expensive** for a development country's context.
- Best practices and case studies tend to be **narrow;** i.e. very project and context specific.
- Manuals refer frequently to a **sub-sector or type of infrastructures** (e.g. buildings, roads etc.) **or explicitly to DRR/mitigation infrastructure** (e.g. bio-engineering, hydraulic engineering against floods), but only rarely linking both.
- There is **a lacking an overview** on the few existing documentations, particularly on practical manuals, which limits the potential for exchange and experience sharing amongst regions and infrastructure sub-sectors.

2. Frame of the compendium project

The compendium was elaborated as a semester project at Bern University of Applied Sciences (BFH) in the frame of the Master Science and Engineering (MSE). The whole project documentation (including a gap analysis) is documented in the main project document and can be shared upon request by the author. This note contains essentially a description of the content and the use of the compendium.

Objectives and methodology

This compendium aims to provide a **practical overview** of existing information, i.e. manuals, tool, instruction notes etc. - for practitioners of infrastructure projects in development cooperation and humanitarian aid.
The compendium entries - documents and web-sites were identified by an internet research.

Addressed public (compendium user)

The public of interest, defined as user of the compendium, refers to the following context:

- Institutions implementing infrastructure projects in **development cooperation and humanitarian aid**.
- Infrastructure projects related to the provision of basic services, namely **housing, education, transportation, water and sanitation** (including agriculture/ irrigation).
- Projects at **planning or implementation** stage, namely the design, planning and construction phase. Secondary, the compendium might be of interest at evaluation, operation and maintenance stage.
- **Practitioners, i.e. technical professionals** ranging from higher formal education (university degree) to informal instruction, namely architects/ engineers, technicians, construction workers of local institutions. These professionals might be linked to NGOs (local, national, international), government institutions (local to national), private sector (companies, consultants etc.). Secondary, the compendium also be of interest for the users and manager of infrastructure (e. g. private/public administration, private owners) and donor institutions financing infrastructure projects.

Focus of the compendium

- **Manuals;** including guidelines, tools, instruction notes for above described practitioners of infrastructure projects.
- Simple and **practical** methods including references, formula, illustrations etc. to plan, implement and/or adjust infrastructure projects.
- **Technical** measures, often referenced as “hard” or structural measures.

Unconsidered elements of the compendium

Manuals focusing on one of the following elements are not considered in the compendium:

- “Soft” measures referring to capacity building, management and organisation such as preparedness/rescue, awareness rising, policy dialogue etc.
- Measures outside the infrastructure area e.g. natural resource management, integrated watershed management etc.
- Anthropogenic risks e.g. technical accidents, environmental degradation, and climate change.

Some remarks

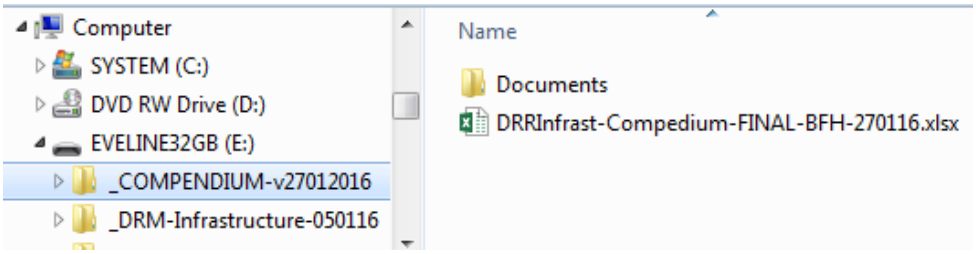
Building codes and other national norms are for any project an important reference to be known and respected by any implementing agency. However, due to the fact that they tend to be complex, voluminous and elaborated for big size infrastructure investments they are often of limited value for practitioners of simple small to medium size projects (cf. chapter 1: rational). The gathered guides of the compendium aims not to replace but to complement such building codes.

Despite the focus of this project related to technical measures, one should not forget that these should where ever be combined with “**soft measures**”, as stated above. Such a complex inventory would have been beyond the scope and time-frame of this project. It further has to be considered than in practice technical experts and practitioners have only very limited potential to intervene in management aspects which go (spatially) beyond the site of their infrastructure projects.

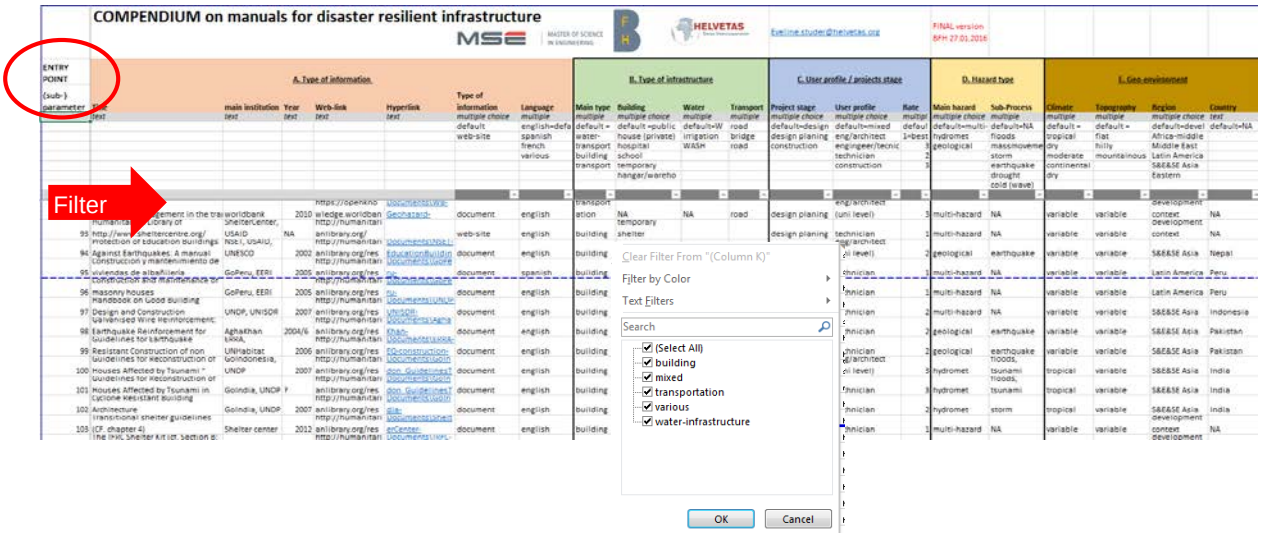
3. Compendium structure

Electronic structure of the compendium (cf. www.helvetas.org/drr-infras-compendium)

- The compendium (folder: “COMPENDIUM”) consists in
  - an excel-file (table with web-links and hyperlinks)
  - a subfolder “documents” with the linked documents.



- The compendium (folder: “COMPENDIUM”) requires a space of approx. 600 MB; alternatively only the excel table can be copied and relevant documents might be downloaded with the indicated web-link.
- The compendium can be completed and updated according to the user’s needs.
- A research can be done on any of the entry points A, B, C, D, E or its (sub-) parameters - as described hereafter - by making use of the according filters (in the grey bar) on the headers of the excel table:



Conceptual structure of the compendium

The compendium aims to serve as inventory for different contexts, projects and users. The compendium as presented in the mind map (fig. 1) is structured based on the following five entry points (A to E), which shall facilitate a specific research:

A. Type of information
B. Type of infrastructure
C. User profile / project stage
D. Hazard type
E. Geo-environment

The entry points (A to E) have various categories hereafter referred to as (sub-) parameters, which are described in the following paragraph. A research can be done on any of the entry points or its (sub-) parameters by making use of the according filters on the headers of the excel table.

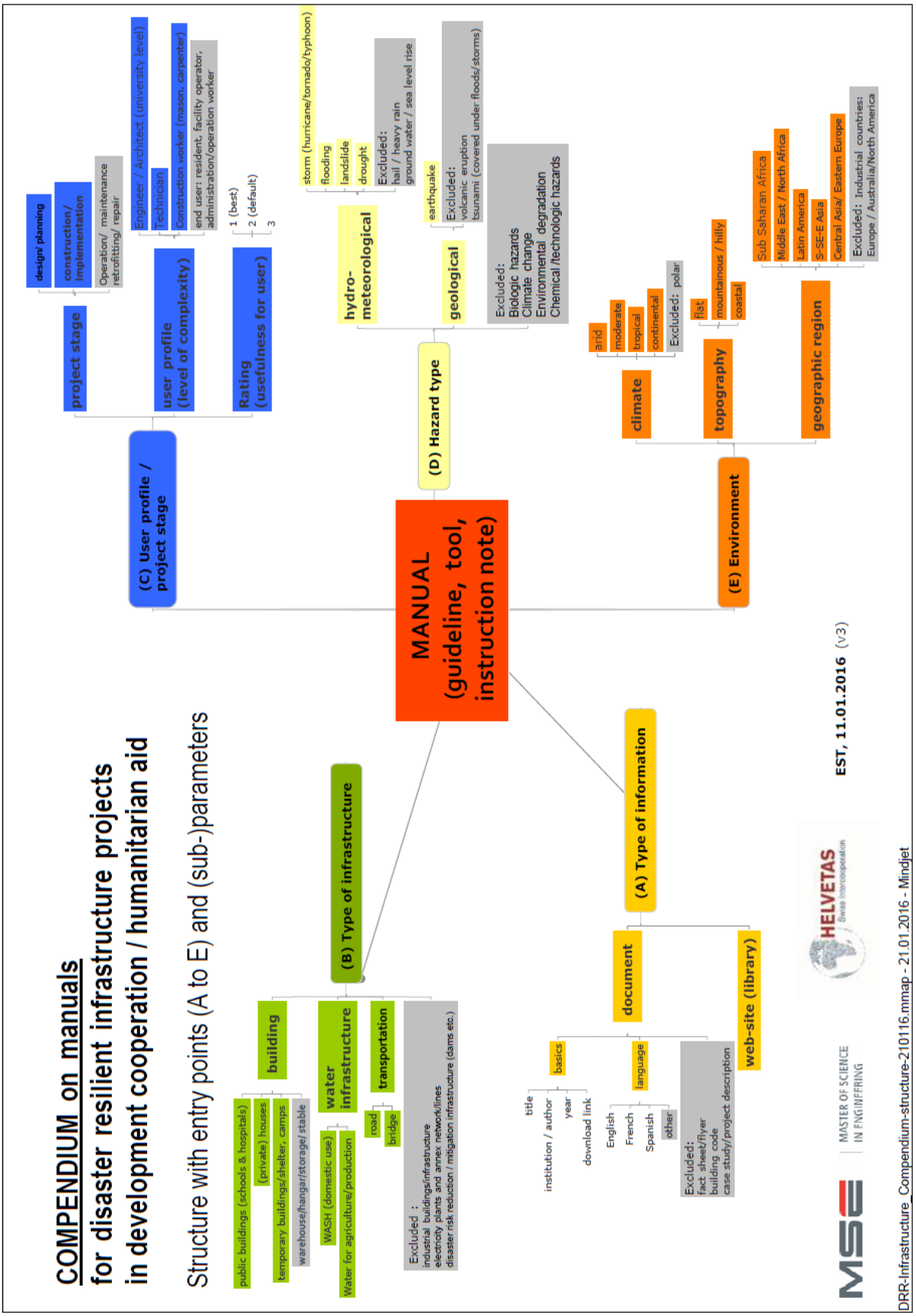


Fig. 1: Mind-map of the compendium structure with its entry points /A to E) and (sub-) parameters

Entry points and its (sub-) parameters

A. Type of information

This entry point refers to the basic characteristics of the cited information

Parameter	Sub-parameter	Description or comment
• Document	No sub-parameter, all entries are either a document OR a web-site	Cited document in pdf or word format
• Web-site		Web-link of an institution's library or resource hub with further information, which is published or indicated by the referenced institution. Only web-sites with a minimal interesting amount of relevant documents (approx. 10) are considered.
• Language	English, Spanish, French, various	Only documents in these three languages were considered. *Various* refers to web-sites, which gather publications in a mix of these languages
• Basic information and links	Title	Title of the document as they figure on the title page
	Year	Year of publication (last edition in case of reediting)
	Institution	Only main institution(s) as author(s) of the document. GoX refers to any governmental institution of country X.
	Web-link	Web-link for download (functionality checked by the time of research (Oct. 2015 to Jan. 2016)
	Hyperlink	Institution_ReferenceText_year.pdf with hyperlink Only functional if whole Compendium folder was correctly copied. No hyperlink for web-sites
Excluded elements	• Project specific documents: project descriptions, fact sheet, case studies, best practices, flyers. • (National) building codes. • Local languages other than English, Spanish, French.	

Tab. 1: (sub-)parameters for entry point A: type of information

B. Type of infrastructure

This entry point refers to the type of infrastructure to be planned, designed or implemented.

Parameter	Sub-parameter	Description or comment
• Building	Private building	From simple shelter (constructed by its own/ user) to durable building (designed by an engineer or architect) according to the geographic, socio-political context. Including buildings for storage of goods and stables.
	Schools	Includes any type of education facilities
	Hospitals	Includes any type of health facilities. Hospitals are frequently rather complex projects, beyond the scope of practitioners of the targeted public (compendium user). According

		documents were only considered if relevant and applicable in a development/humanitarian aid context.
	Temporary shelter	Refers to building which are not constructed for permanent housing. Namely refugee/displaced peoples' camps. According to the geographic context might these might be very simple (tents) to rather durable (temporary houses).
• Water infrastructure	WASH	Water, sanitation and hygiene (WASH) infrastructure, refers to domestic use of water. Includes capture, storage (reservoirs), adduction/distribution (pipes) and treatment (sanitation systems/latrines) of water for domestic use.
	Irrigation	Refers to use of water for agricultural / production (mainly irrigation). Includes adduction/distribution channels and annex infrastructure.
• Transportation	Roads	Any type from highway to rural road
	Bridges	Any type from multi-lane bridge to pedestrian trail bridge
Excluded elements	• Industrial buildings and annex infrastructure • Energy infrastructure: power plan, annex infrastructure, electricity lines etc. • Explicit mitigation infrastructure, e.g. river dam, check dam against flooding, erosion.	

Tab. 2: (sub-)parameters for entry point B: type of infrastructure

C. User profile / project phase

This entry point refers to the profile of the user to whom the manual is addressed, which is closely linked the stage of the project.

Parameter	Sub-parameter	Description or comment
• Project stage	Design planning	Refers to the planning of the construction (design, dimensioning etc.) before physical work at the construction site start.
	Construction	Refers to the concrete implementation of the project. Generally after the design / planning of the construction on paper, or in the case of very simple constructions without planning documents.
• User profile	Engineer/ architect	Refers to a professional with university degree in architecture or civil engineering, who is familiar with technical concepts and formula related to structures, load, resistance, properties of construction material for the design of a medium size infrastructure project considering according local building policies and planning procedures.
	Technician	Professional with a minimal technical education; Know how to implement and adjust plans/project designs.

	Construction worker	No formal education, knowledge by practical instruction and practice. According to the (country's) context, frequently infrastructure owner implement themselves the projects, especially in the case of houses.
• Rating	Rate 1,2,3.	Rating of the document's or web-site's usefulness in view of the according user profile: 1 = best (i.e. good illustrations/ examples, practical formula, graphs); 2 = default rate; 3 = mediocre (though might be of interest for a research on a specific country / infrastructure.)
Excluded elements	• Project stage: excluding rehabilitation, assessment, operation, maintenance. • User: excluding end user, consumer, inhabitant, operation/facility manager. • All user which mainly focus on "soft" aspects in DRR are excluded such as rescuer, manager, teacher/instructor (unless for infrastructure professionals)	

Tab. 3: (sub-)parameters for entry point C: User profile, project stage

D. Hazard type

This entry point refers to the type of natural hazard from which the infrastructure shall be protected.

Parameter	Sub-parameter	Description or comment
• Hydro-meteorological hazard	Floods	The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas that are not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods.[1]
	Mass movement	Mass movement in the context of mountainous phenomena refers to different types of mass transport processes including landslides, avalanches, rock fall, or debris flows. Landslide: A mass of material that has moved downhill by gravity, often assisted by water when the material is saturated. The movement of soil, rock, or debris down a slope can occur rapidly, or may involve slow, gradual failure. Debris flow: Geological phenomena in which water-laden masses of soil and fragmented rock rush down mountainsides, funnel into stream channels, entrain objects in their paths, and form thick, muddy deposits on valley floors.[2]
	Storm	Refers to all kind of storms: tropical storm (hurricane, extra tropical storm (tornado, strong wind). Cyclone: non-frontal storm that is characterized by a low pressure centre, spiral rain bands and strong winds. Usually it originates over tropical or subtropical waters and rotates clockwise in the southern hemisphere and counter-clockwise in the northern hemisphere. [8]

[1] Special report of the intergovernmental panel on climate change (SREX), IPCC, 2012
[2] Wikipedia, www.wikipedia.org, consulted 2016

		Tropical cyclone: The general term for a strong, cyclonic-scale disturbance that originates over tropical oceans. Extratropical cyclone: Any cyclonic-scale storm that is not a tropical cyclone. Usually refers to a middle- or high-latitude migratory storm system formed in regions of large horizontal temperature variations. Sometimes called extratropical storm or extratropical low. [4]
	Drought	A period of abnormally dry weather long enough to cause a serious hydrological imbalance. Drought is a relative term, therefore any discussion must refer to the related activity under discussion. For example, shortage of precipitation during the growing season impinges on crop production or ecosystem function in general (also agricultural drought), and during the runoff and percolation season primarily affects water supplies (hydrological drought). A period with an abnormal precipitation deficit is defined as a meteorological drought.[1]
	Cold wave/ frost	Marked cooling of the air over a large area. It is an extended period of above normal cold temperatures, a drop of atmospheric average temperature well above the averages of a region, with effects on human populations, crops, properties and services.[3]
• Geological hazard	Earthquake	Shaking, trembling or displacement of the earth surface due to seismic waves or other phenomena of volcanic or tectonic origin.[4] (also known as a quake, tremor or temblor)
Note	In reality it is often difficult to distinguish between different hazards (e.g. landslide, mud flow, flooding). Tsunamis are not treated separately, according documents are either covered under hazards type “flooding” or also partially under “storms”. Frequently one hazard can cause another one (e.g. landslides caused by earthquake, earthquake caused by volcanic eruption, floods caused by tsunami or storm). With the effects of climate change hazard events and its impacts will tend to increase in intensity and frequency.	
Excluded elements	• Biologic hazards: diseases, pests. • Technologic disasters, accidents. • Volcanic eruption • Heavy rain / monsoon, hail • El niño/ la niña, climate change • Environmental degradation.	

Tab. 4: (sub-)parameters for entry point D: Hazard type

[3] UNISDR, www.preventionweb.net/ consulted 2016
[4] Centre for Research on the Epidemiology of Disasters (CRED), http://www.emdat.be/ consulted 2016

E. Geo-environment

This entry point refers to the environmental context in terms of geographic region, climate and topography.

Parameter	Sub-parameter	Description or comment
• Climate	Tropical, moderate, continental, dry	Based on the generic world climate map (cf. fig. 3).
• Topography	Default = variable Flat, mountainous, hilly, coastal, variable	A rather general specification.
• Geographic region	Africa & Middle East Latin America South& East & SE Asia Central Asia& Central Eastern Europe	The geographic region refers to the context for which the document was elaborated.
• Country	Default = NA	If applicable, reference to a specific country for which context the information was elaborated
Note	Climate, geographic regions and topography are key factors which define the relevant hazard risks. Nevertheless at a local scale they might be very different from a general national or regional hazard profile. Especially with regards to the mitigation / prevention measures related to buildings, according construction material might be very different, depending on the climate, as well as other socio-cultural characteristics.	
Excluded elements	• Polar climate; since hardly relevant for ODA projects. • Industrial, first world regions/ countries, Antarctica, which are not relevant for development and humanitarian aid interventions.	

Tab. 5: (sub-)parameters for entry point E: (Geo-)environment

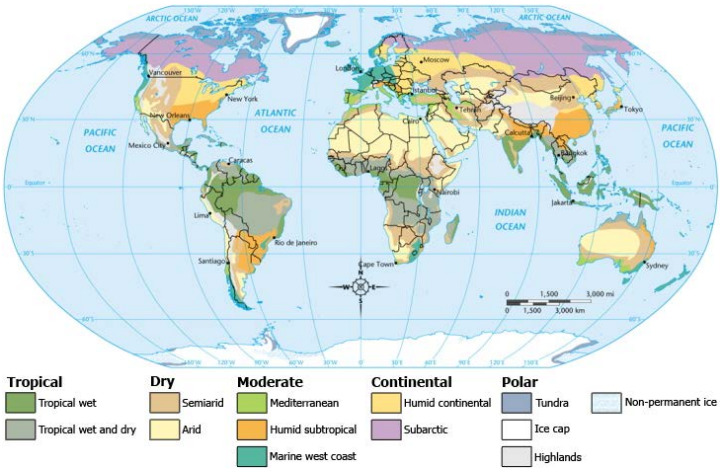


Fig. 2: World climate based on the Köppen classification.

4. Overview of the compendium content

The compendium gathers totally 124 relevant entries (status 27.01.2016), i.e. documents and websites of manuals, on disaster resilient infrastructure. Non-surprisingly there is an important heterogeneity per considered entry points (A to E), particularly with regards to the type if infra-structure, geographical context and languages. As illustrated in the mind map bellow.

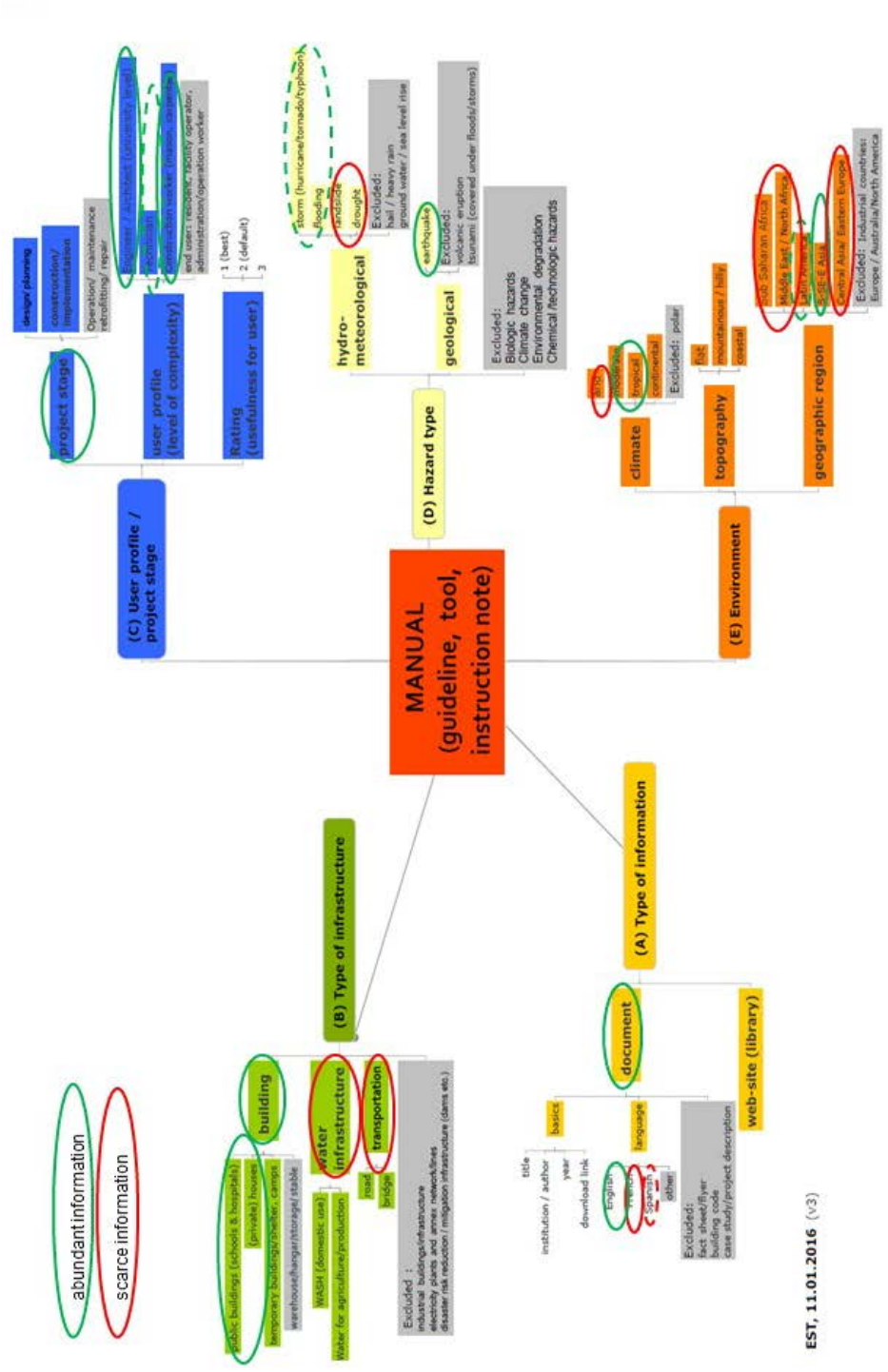


Fig. 3: Identified information: abundancy (green) and scarcity (red) per entry point

5. Annexes

A. References

[1] Construction Design, Building Standards and Site Selection, ProVention, 2007.

[2] The Built Environment Professions in Disaster Risk Reduction and Response – a guide for humanitarian agencies, MLC Press, University of Westminster, 2009.

[3] Guidebook for the capacity building in the engineering environment, World Federation of Engineering organization (WFEO), 2010.

[4] Proposed Updated Terminology on Disaster Risk Reduction: A Technical Review, UN Office for Disaster Risk Reduction (UNISDR), 2015.

B. Glossary

This glossary contains the most relevant terms in the sphere of DRR, as some of them are mentioned in the report or the titles of collected documentation of the compendium. Source: UNISDR, 2015 [4]

Basic services Services that are needed for all of society to function effectively.

Comment: Examples of basic services include water supply, sanitation, health care, education, housing, and food supply, including critical infrastructure such as electricity, telecommunications, transport, finance or waste management.

Build back better The guiding principle to utilize the reconstruction process to improve living and environmental conditions including through integrating disaster risk reduction into development measures, making nations and communities more resilient to disasters.

Building code A set of ordinances or regulations and associated standards intended to control aspects of the design, construction, materials, alteration and occupancy of structures which are necessary to ensure human safety and welfare, including resistance to collapse and damage.

Climate change "Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use".

Critical infrastructure The physical structures, facilities, networks and other assets that support services that are socially, economically or operationally essential to the functioning of a society or community.

Comment: Critical infrastructures support essential services in a society. They include electricity/power, water, transport systems, air and sea ports, communication systems, health and educational facilities (including hospitals, health centres, schools), as well as public administration services, financial services, centres for fire and police, etc.

Disaster A serious disruption of the functioning of a community or a society due to hazardous events interacting with conditions of vulnerability and exposure, leading to widespread human, material, economic and environmental losses and impacts.
Comments: Disaster results from the combination of: the exposure to a hazard; the conditions of vulnerability that are present; and insufficient capacity or measures to reduce or cope with the potential negative consequences. Consequences may include injuries, disease and other negative effects on human physical, mental and social well-being, together with damage to property, loss of services and environmental degradation.
Small-scale disaster: A type of disaster only affecting local communities which require assistance beyond the affected community.
Large-scale disaster: A type of disaster affecting a society, which requires national or international assistance.
Frequent and infrequent disasters: depend on the probability of occurrence and the return period of a given hazard and its impacts. The impact of frequent disasters could be cumulative, or become chronic for a community or a society.
A slow-onset disaster is defined as one that emerges gradually over time. Slow-onset disasters could be associated with e.g. drought, desertification, sea level rise, epidemic disease.
A sudden-onset disaster is one triggered by a hazardous event that emerges quickly or unexpectedly. Sudden-onset disasters could be associated with e.g. earthquake, volcanic eruption, flash flood, chemical explosion, critical infrastructure failure, transport accident.

Disaster management The organization, planning and application of measures preparing for, responding to and, initial recovery from disasters.

Disaster risk Disaster risk is considered to be a function of hazard, exposure and vulnerability. It is normally expressed as a probability of loss of life, injury or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time.

Disaster risk management (DRM) Disaster risk management is the application of disaster risk reduction policies, processes and actions to prevent new risk, reduce existing disaster risk and manage residual risk contributing to the strengthening of resilience.
Comment: DRM includes actions designed to avoid the creation of new risks, such as better land-use planning and disaster resistant water supply systems, actions designed to address pre-existing risks, such as reduction of health and social vulnerability, retrofitting of critical infrastructure.

Disaster risk reduction (DRR) Disaster risk reduction is the policy objective aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contributes to strengthening resilience.

Extensive risk The risk of low-severity, high-frequency disasters, mainly but not exclusively associated with highly localized hazards.

Geological hazard Geological process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.
Comment: including earthquakes, volcanic activity, and related geophysical processes such as mass movements, landslides, rockslides, surface collapses, and debris or mud flows. Tsunamis are difficult to categorize; triggered by geological events, they essentially become oceanic process that is manifested as a coastal water-related hazard.

Hazard A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation.

Hydro-meteorological hazard Process or phenomenon of atmospheric, hydrological or oceanographic nature that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.
Comment: including tropical cyclone (also known as typhoons and hurricanes), thunderstorms, hailstorms, tornados, blizzards, heavy snowfall, avalanches, coastal storm surges, floods including flash floods, drought, heatwaves and cold spells.

Man-made hazard Hazards induced entirely or predominantly by humans, including technological and socio-natural hazards.

Mitigation The lessening or limitation of the adverse impacts of a hazardous event.
Comment: The adverse impacts of hazards often cannot be prevented fully, but their scale or severity can be substantially lessened by various strategies and actions. Mitigation measures encompass engineering techniques and hazard-resistant construction as well as improved environmental policies and public awareness. Note: in climate change policy, "mitigation" is defined differently referring to the reduction of greenhouse gas emissions as source of climate change.

Natural hazard Natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Preparedness The knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current disasters.

Prevention Activities and measures to avoid existing and new disaster risks.

Reconstruction The medium and longer-term repair and sustainable restoration of critical infrastructures, services, housing, facilities and livelihoods required for full functioning of a community or a society affected by a disaster.

Rehabilitation The rapid and basic restoration of services and facilities for the functioning of a community or a society affected by a disaster.

Resilience The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.

Retrofitting Reinforcement or upgrading of existing structures to become more resistant and resilient to the damaging effects of hazards.

Comment: Retrofitting requires consideration of the design and function of the structure, the stresses that the structure may be subject to from particular hazards or hazard scenarios, and the practicality and costs of different retrofitting options. Examples of retrofitting include adding bracing to stiffen walls, reinforcing pillars, adding steel ties between walls and roofs, installing shutters on windows, and improving the protection of important facilities and equipment.

Risk The combination of the probability of a hazardous event and its consequences which result from interaction(s) between natural or man-made hazard(s), vulnerability, exposure and capacity.

Structural and non-structural measures Structural measures: Any physical construction to reduce or avoid possible impacts of hazards, or application of engineering techniques to achieve hazard resistance and resilience in structures or systems; Non-structural measures: Any measure not involving physical construction that uses knowledge, practice or agreement to reduce risks and impacts, in particular through policies and laws, public awareness raising, training and education.

Technological hazard A hazard originating from technological or industrial conditions, including accidents, dangerous procedures, infrastructure failures or specific human activities.

Vulnerability The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards.