EUROPEAN LEVEES AND FLOOD DEFENCES

Inventory of characteristics, risks and governance

PRE-DRAFT (YET INCOMPLETE) for EURCOLD LFD-WG Meeting October 2016

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NOTICE - DISCLAIMER:

This document has been drafted with care but we cannot guarantee that it covers all aspects of the discussed topics.
One must pay attention to the fact that the report gives only a summary of levee-related information in each Country. It is impossible to explain all the details and the intricacies of the laws, standards, etc.

This document also refers to some legislation. Especially on this topic, the information, analyses and conclusions in this document have no legal force and must not be considered as substituting for legally-enforceable official regulations. They are intended for the use of experienced professionals who are responsible to judge their pertinence and applicability.

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EUROPEAN LEVEES AND FLOOD DEFENCES REPORT
Inventory of characteristics, risks and governance

2016 Report and updating process

- This is the first product of the ICOLD European Club Working Group on Levees and Flood Defences
- This is the first edition of this report, which yet has to be completed by some countries.
- Further updates are expected in later years

Working Group on Levees and Flood Defences

Bottema, Marcel (WVL) 5/2/16 09:32
Commentaire: I checked the spelling, and according to The Guardian, this is the correct UK spelling (so perhaps we should correct our name!)

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CURRENT UPDATING

Country	Updating Date
Czech Republic	2016
England	(2016)
Finland	(2016)
France	2016
Germany	2016
Hungary	..
Italy	..
Netherlands	2016
Poland	..
Romania	..
Russia	..
Slovenia	..
Spain	2016
Other countries…	
..	
..	
..	

UPDATING PROCESS – Notes

2016 – October: some new members added as well as chapter for Spain

Contents

Summary of report (to be done by NL/F)

Bottema, Marcel (WVL) 11/2/16 17:47
Commentaire: Some texts may be transferred and/or copied to other sections (introduction, conclusions, ..), this is just to give an impression of the report and its contents

Throughout Europe, at least 50 million people are at risk from flooding, and at least 2000 billion Euro's of economic value. In the period 1950-2005, over 45 major flood events involving either over 70 casualties or over 0,005% of the European GDP in damage (http://link.springer.com/article/10.1007/s11069-006-9065-2#/page-1). No wonder, the 2015 EURCOLD Manifesto on Dams and Reservoirs points at the relevance of floods and the role dams could play in flood protection and flood peak reduction (see also Report of the European ICOLD Club Working Group "Dams and Floods": Dams and floods in Europe. Role of dams in flood mitigation, 2010)

Bottema, Marcel (WVL) 25/4/16 10:07
Commentaire: check numbers later

Levees (also called dikes, dykes or flood embankments) and other flood protection structures including urban flood walls (upstream) regulating and flood protection dams have a key role in reducing this risk. Numerous recent floods have demonstrated that this is not just an academic risk, but a risk that even today regularly results in major damage and even life risk across Europe. Even in recent years (1989-2008), floods caused about 150 casualties per year across Europe, as well as 40% of all natural disaster damage (2015 EURCOLD Manifesto on Dams and Reservoirs)

This report is the first report of the EURCOLD (ICOLD European Club) Working Group on Levees and Flood Defences. It serves as a global and yet highly approximate inventory of the levees and protection structures themselves, of the value they protect, of the residual risk including recent flood events, and of maintenance, governance and legislation issues.
Besides demonstrating the relevance of the levee issue, this report also aims to give a first indication of levee-related issues, so as to facilitate future comparisons with issues related to dams, especially embankment dams and small dams. The latter get increasing attention within ICOLD, because their vast number and (in many cases) unknown state may imply a significant safety and flooding risk.

The main outcomes of this report are [expected to be]:

- *Levees indeed seem to be a relevant issue in many countries, or at least for many regions across European Countries. Countries like England, France, Germany, The Netherlands, Poland Spain and [….+ Hungary + …] each have several thousand kilometres of levee, and many more still have a significant amount of levees.*
- *The majority of levees and protection structures can be found along rivers, but especially in Western Europe, a significant fraction of levees and structures can be found along the coasts and estuaries*
- *For the whole of Europe, both annual flood damage and Flood Risk Management investments run into the billions of Euros (per year).*
- *Governance and legislation strongly differ per country. This also implies that some countries had a relatively easy job in contributing to this inventory, and others a very tough job. Anyway, there seems to be no such thing as a central levee database.*

Résumé (to be done by F)

Rémy, if the final version is ready, could you please provide an extensive 1-4 page French summary here (since the remainder of the report is in English)

1 Introduction (to be done by NL/F)

Throughout Europe, at least 10 million people are at risk from flooding, and at least 2000 billion Euro's of economic value. In the period 1950-2005, over 45 major flood events involving either over 70 casualties or over 0,005% of the European GDP in damage (http://link.springer.com/article/10.1007/s11069-006-9065-2#/page-1). No wonder, the 2015 EURCOLD Manifesto on Dams and Reservoirs points at the relevance of floods and the role dams could play in flood protection and flood peak reduction (see also Report of the European ICOLD Club Working Group "Dams and Floods": Dams and floods in Europe. Role of dams in flood mitigation, 2010)

Levees (also called dikes, dykes or flood embankments) and other flood protection structures including (upstream) regulating and flood protection dams have a key role in reducing this risk. Numerous recent floods have demonstrated that this is not just an academic risk, but a risk that even today regularly results in major damage and even life risk across Europe. Even in recent years (1989-2008), floods caused about 150 casualties per year across Europe, as well as 40% of all natural disaster damage (2015 EURCOLD Manifesto on Dams and Reservoirs)

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In this first pre-draft version for the ICOLD Annual Meeting 2016 in Johannesburg, 5 countries have provided a draft text for their chapter, more countries will soon join in.

Every country chapter has the same format where the following issues are discussed.

1. Facts and figures on levees and flood defences
2. Protected value, safety standards and flood risk
3. Recent major floods and (near-)failures of levees
4. Legislation and governance
   a. Legislation and governance – implementation EU Regulations
   b. Legislation and governance – National legislation
   c. Legislation and governance – Governance
5. Guidelines and good practices
6. Common practices during Levee Life Cycle
7. Critical knowledge and data gaps; critical research needs
8. Summary of key facts
9. References (per country)

After the country chapters, the main results and conclusions will be reported.
The Questionnaire that we used to gather initial information and prepare a report template is included in Appendix A; the report template format itself (including the requested information) is reported in Appendix B.

1.1 Section 1.1 (if needed)

In .....

1.2 Section 1.2 (if needed)

In .....

1.3 Section 1.3 (if needed)

In .....

2 Czech Republic

PLEASE NOTE:

YELLOW MARKED text gives a description of the contents that are requested for this report
GREEN MARKED text gives information that may be of help when you are writing your country chapter.

Bottema, Marcel (WVL) 15/4/16 15:21
Commentaire: Chapter re-edited to fit into template, text preserved but in slightly different order

TO BE FILLED AS MUCH AS POSSIBLE BY EACH COUNTRY. You do not need to provide lengthy texts; brief fact-sheet like texts are sufficient, at least for now.

You may find your chapter already filled in with some first suggestions; please feel free to use them or replace them with your own text, as you wish. In the end, the text is about your country, and therefore we prefer the final text is primarily your text and not the text of the main editors.

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INFORMATION THAT MAY BE OF HELP WHEN COMPILING YOUR CHAPTER

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2.1 Facts and figures on levees and flood defences

This section is meant to answer questions like:

- *how many levees and other flood defences do you have (km's / nr's)*
  - *other flood defences may be moveable flood walls, storm-surge-barriers and also ordinary gates and sluices (the latter may be so numerous it may be too difficult to quantify them)*
- *what are typical dimensions and other properties (materials, layering, revetment, ..) for (different types of) levee in your country*
- *what is the geographical context: what are typical environments / flood types (% urban/rural levees, % river, estuary or coastal levees)*
- ***Could you give also an indication of yearly spendings on levee management and levee reinforcement (or on overall flood risk management if only that is available)? We think it has added value to present these numbers, and especially make clear what Business Case is hidden in the levee issue.***

You may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

Answers from Questionnaire

What types of flood defences do you have in your country:
How many levees (Levees are raised, predominantly earth, structures that are not reshaped under normal conditions by the action of waves and currents, whose primary objective is to provide protection against fluvial and coastal flood events along coasts, rivers and artificial waterways (from the definition in the ILH)) do you have (in km)

- Mostly flood levees - about 4000 km, dominantly earth structures, they assure protection along the rivers

How many flood walls (flood walls are hard structures which, like levees, protect against flooding, the difference being the type of material) do you have (in km)

- Flood walls are located in urban areas, there are about single hundreds km, in case of higher floodwalls (in Prague about 4 m) they rae provided by slurry walls

How many hydraulic structures (like gates, pumping stations, closure structures, …) do you have (in numbers)

- The number is not known (estimate is several hundreds), they are located at tributaries and for pumping inner waters. Pumping stations are frequently designed as mobile to be able to serve for severeal localities.

How many flood defences of other type do you have (in km, or in numbers according to the type)

- Other flood defences - dry reservoirs (hundreds), polders (less than 50)

What % of your flood defences (of each type) is linked to the following physical environment / flood threat: (The numbers need to add up to 100)

- River 95
- Torrent 5

What would be a typical flood defence height in your country (please give min, max, medium if possible). The height is defined as difference top of the levee and ground level.

- Min 0,5
- Max 4,5
- Medium 2

General facts:

History of building flood protection measures stretches back to middle ages. The principle structures were

- reservoirs – multipurpose ponds serving for fish production and also for the protection against flood. One of the largest ponds in Europe – the Rožmberk (built in 1590) 14 m high with normal volume 6.2 mil m3 retained during the flood in 2002 about 70 mil m3 of flood volume and contributed to the flood protection of Prague.
- Farmer levees built from local material (soil, stones, gravel) to protect agricultural land. In some cases these levees were rebuilt (beginning of 20th century) to standard levees, unfortunately inappropriate material remained in the embankment body and significant seepage was identified at these section during past floods (1997, 2002, 2006, 2010, 2013).
- The systematic protection of extensive areas comprising urban and also outdoor areas started in twenties of the 20th century. Hundreds kilometres were built along the principal Czech rivers, mostly at the wide floodplains of lower reaches of the Morava, Elbe, Oder and other rivers. There is only poor knowledge about the material of the levees and their sub-base which in many cases consists of highly permeable quaternary gravel sands covered by the topsoil of various thickness (0 - 5 m).

The financing of flood protection measures differs. Since 2003 so called “Programme financing” has been under progress. It is guaranteed by the Ministry of Agriculture (MA), the financial sources are provided by European Investment Bank as a loan to the CR. The process is as follows:

- The subjects who want to be protected submit the application to the Ministry of Agriculture. The applicant appends the preliminary project of the flood protection and also basic information for the assessment of its efficiency.
- Independent “Strategic expert” elaborates the quantitative risk assessment and evaluates quantitative parameters like relative efficiency, absolute efficiency and return period (recovery of investment).
- The future owner will prove feasibility of the project in terms of the accessibility of the plots for the construction. This may take several years to negotiate the project with land owners.
- For efficient projects MA provides the loan.
- The corresponding River Agency will run the project.
- After finishing the project it is forwarded to the future owner (municipality, private bodies).

In the Czech Republic (CR) until now there is no central database of existing flood protection measures. This is probably because of numerous bodies which built and “possess” structural flood protection measures in the form of investment. Mostly the technical level and maintenance of flood protection structures correspond to the owner. In general the owners of flood protection measures can be:

- River Agencies, state enterprises are responsible for overall river basin management, conceptual planning of flood protection measures, etc. There are 5 River Agencies in CR corresponding to five major river basins – The Elbe, Vltava (Moldau), Oder, Morava and Ohře rivers. These companies have

enough professional staff to manage flood protection issues, they are probably the major owner of flood levees and similar structures.

- Municipalities may be owners of local flood protection arrangements like levees, floodwalls, flood attenuation reservoirs including dams, etc. An example may be flood protection in Prague consisting of more than 20 km of levees, floodwalls, mobile walls including several pumping stations and appurtenant structures (gates, sewer closures, …). Smaller municipalities usually do not possess enough technical staff and operation and maintenance of flood protection measures may be a problem.
- Forests of the Czech Republic, state enterprise are the owners of smaller streams and thus also owners of relevant flood protection arrangements related to these streams. They have their own Departments for Water Management, even if these are only minor and "less important" part of the enterprise and thus underfinanced.
- Private bodies are owners of arrangements protecting private property against floods. These may be private companies, factories, individual inhabitants, etc.

This state makes the development of central summary about levees extremely difficult. The more reliable database is now under construction with the help of major owners – River Agencies. Therefore the data mentioned below are rough estimates only.

Number and type of flood protection measures

In CR it is estimated to be about 4000 km of earthen levees complemented by floodwalls in constraint urban areas. It is estimated that there are surely more than 100 km floodwalls (single hundreds of km) in CR. Floodwalls may reach significant height, e.g. about 4 m in Prague. They are usually provided with slurry walls to assure seepage stability of the sub-base.

Due to aesthetical reasons in urban areas where the river is important environmental element the flood walls are designed as combined – with fixed (concrete, masonry) part and movable part made of mobile elements like jambs and stop-logs (nowadays made of aluminium).

Practically at each separate closed locality the arrangement (stable or mobile) for pumping of inner waters (rainfall, sewage, seepage) during the flood is installed. Pumping stations are frequently designed as mobile to be able to serve for several localities. At the same time gated sluices or culverts are installed in levees to empty the areas behind the levees after the flood. These arrangements are installed also in case of crossing levees with local tributaries.

During last two decades more than one hundred "dry reservoirs" for trapping local (mostly flash) floods were constructed in CR. These are mostly so called "small reservoirs", i.e. dam up to 9 m height, volume up to 2 mill. m^3.

There are several polders (less than 50) located at the floodplains adjacent to the streams with significant flood attenuation volume.

Technical arrangement

In the Czech Republic the construction principles related to the flood protection arrangements have developed continuously in accordance with increasing demands for the protection against floods. Recently, regulations have become fragmented into a great number of laws, amendments, national technical standards and guidelines. In this text the current system of flood protection legislation in the Czech Republic is briefly described, and some comments are mentioned about the present system.

The levees are constructed as earthen, usually homogeneous, exceptionally as zonal with clayey core and shoulders. Traditionally they have no sealing of the sub-base (slurry wall) and toe drain. Dominantly they are built in relatively unique geological conditions where the fluvial sands (or sandy gravels) are covered by relatively impervious topsoil layers making the protection against the seepage. The problems may occur in cases of engineered rivers where levees cut former meanders and where original geological conditions are disturbed.

In the Czech Republic following principles are used at the design of levees:

- the width of levee crest should not be less than 3 m and is governed by the utilisation of the levee crest (footpath, service road, public road, etc.),
- the use of soils according the type and structure of the levee is in Tab. 2.1,
- recommended upstream and downstream slopes according the type of levee and soil used is summarized in Tab. 2.2.

Tab. 2.1 Applicability of soils for the types of levees (ČSN 75 2310 – Czech national standard)

Soil symbol	Soil type	Homogen.	Sealing	Shoulders
GW	well graded gravel	not suitable	not suitable	excellent
GP	poorly graded gravel	not suitable	not suitable	excellent
GM	silty sandy gravel	excellent	quite suitable	less suitable
GC	clayey sand gravel	excellent	excellent**)	less suitable
SW	well graded sand	not suitable	not suitable	suitable*)
SP	poorly graded sand	not suitable	not suitable	suitable*)
SM	silty sand	suitable	suitable	not suitable
SC	clayey sand	quite suitable	excellent	not suitable
ML	inorganic sandy silt, very fine sand	less suitable	less suitable +)	not suitable
CL	inorganic clay with low to medium plasticity	suitable	quite suitable	not suitable
OL	organic sandy loam	less suitable	less suitable+)	not suitable
MH	inorganic loam	less suitable	less suitable+)	not suitable
CH	inorganic high plasticity clay, fat clay	less suitable	less suitable+)	not suitable
OH	organic clay with medium to high plasticity	not suitable	not suitable	not suitable
*) for gravel soils , **) special care on weathered particles , +) not suitable for upstream sealing				

Tab. 2.2 Slopes of individual types of levees (ČSN 75 2410– Czech national standard)

Type of soil sealing	Soil classification		Slopes	
	Sealing	Shoulders	upstream	downstream
Thin	GM, GC, SM	rockfill	1 : 1,75	1 : 1,5
	SC, CG, MG	GW, SW	1 : 2,8	1 : 1,75
	ML-MI, CL-CI	GP, SP	1 : 3	1 : 1,75
Wide	GM, SM	rockfill	1 : 3	1 : 2
	GC, SC, MG, CG, MS, CS	rockfill GW, GP	1 : 3 1 : 3,2	1 : 2
	ML-MI, CL-CI	SW, SP	1 : 3,4	1 : 2,2
Homogeneous levee *)	GM, SM		1 : 3	1 : 2
	GC, SC		1 : 3,4	1 : 2
	MG, CG, MS, CS		1 : 3,3	1 : 2
	ML-MI, CL-CI		1 : 3,7	1 : 2,2
*) For levees smaller than 4 m the slope can be increased to 1 : (*x* - 0,5)				

Hydrology

The last experience comes from following floods in CR:

Time	Type of the flood	Fatalities	Material loss (USD)
1997 - July	Regional - summer	49	1.91E+09
1998 - July	Local – flash flood	10	6.18E+07
2000 - March	Sub-regional, snow melting	2	1.03E+08
2002 - August	Regional - summer	17	2.32E+09
2006 - spring	Regional – snow melting	11	2.74E+08
2009 - June	Local – flash flood	18	3.21E+08
2010 - May, June	Regional	8	2.45E+08
2013 - August	Regional	15	1.00E+09

Most of these floods locally exceeded return period 100 years, in 1997, 2002, 2009, 2013 even 500 years. The design return period for levees is from 20 years (smaller towns) to 100 years (larger cities usually with population exceeding 100 ths. inhabitants), exceptionally 500 years (Prague with historical monuments and subway).
Corresponding height of levees (floodwalls) is from 0.ř to 4.5 m according to local conditions. Usual freeboard is from 0.3é to 0.70 m. Sometimes uncertainty of the design discharge is used instead of the fixed freeboard (e.g. increase of design discharge by 30%).

Performance and maintenance of levees
The regular maintenance of levees consists mostly in grass cutting. Other spendings are not regular and are usually linked to the flood situation and the damage of the levee.
Extensive damages were also identified due to the activities of burrowing animals - European beaver. The reparation of the levees at the Dyje river cost about 2 mill EUR/km. The vegetation on the levees damaged by beavers was refurbished with the cost approximately 10 ths EUR/km.
Flood damages of levees are not expressed separately. The flood damages and financial means necessary for the reparation works are funded by the government after each extreme flood and include sources for the reparation of river bed, levees and structures at the rivers (bed drops, revetment, weirs, conduits, ...). For example the 2013 flood losses related to the water courses (including levees) - corresponding with reparation works - were about 90 million EUR.

Water Act 254/2001 Sb. excludes planting wooden species on the levees. Also levee owner has to clear away all self-seeded wooden plants except historical trees or protected plants and herbs.
For the treatment, maintenance and protection of vegetation it is possible to apply the Guideline on maintenance of vegetation on small embankments (Section 2.4). It is necessary to systematically remove bushes, self-seeded plants, young trees and evidently perished and ill or uprooted trees. Inacceptable are trees endangering dike safety, damaging levee lining or structures in levees (sluices, spillways) and restricting access to levee crest and slopes. Trees should be also removed if they decrease capacity of channel, berms or floodplain upstream of levees. Vegetation also should not constrain technical surveying and geodetical measurements.

2.2 Protected value, safety standards and flood risk

This section is meant to give an indication of the following:

- *What is (by and large) the protected value that could flood without levees and flood defences. Both in terms of life and economic value (preferably the assets, otherwise a fraction of the Gross Domectic Product)*
- *Do your levees and structures have a safety standard, and if so what does it refer to and what value has it got*
- *What is the actual protection level of your levees etc. (or what % does or does not satisfy the safety standards)*
- *Coming to the first issue: what is the residual risk (related to flooding despite the levees etc.), and how large is it compared to protected value (the ratio is in fact a measure of the actual protection level)*

Answers from Questionnaire

If they break what % of your flood defences represent: no hazard, material hazard, some life hazard and large scale life have hazard. (The numbers need to add up to 100)

- No hazard 10
- Material hazard only 40
- Some life hazard 20
- Large scale life hazard/economic hazard (say > 100 people/over 100 million) 30

Levee-related costs:
What would be a typical construction and/or rehabilitation cost for 1 km of levee in your country

- 700 ths - 1 mill EUR

What would be the typical maintenance and management cost for 1 km of levee in your country (including inspections and minor repairs)?

- about 100 - 500 EUR / year

Other information you wish to add (for example on other flood defence types?)

- about 500 EUR / year for dry reservoir

Explanatory remarks (if you had to adapt the hazard categories to what is commonly used in your country)

- categories of hydraulic structures (dams, weirs levees,...) according the consequences

In our report we wish to give an impression of the importance of levees in terms of protected value. Could you give a rough indication of the (levee-)protected population size and economic value in your country?

- thousands of inhabitants, about 10 billion EUR

Design flood

There are no strict requirements on the design flood (return period) for individual land use categories. However, historically some guidance is anchored in older and also in presently valid (but not obligatory) national standards. In tables 2.3 and 2.4 recommended design flood return periods are linked to particular land uses according the older Czech national technical standards.

Tab. 2.3 Design flood discharges for river treatment purposes according to ČSN 73 6820 (1973)

Land use	Design discharge for channel capacity
Continuous urbanisation, industry area, important roads, infrastructure	> Q_{50}
Valuable arable land, vineyards, hop gardens, etc.	> Q_{20}
Arable land	Q_5 to Q_{20}
Meadows, pastures, forests	Q_2 to Q_5
For stability and resistance of levees	Q_{100}

Tab. 2.4 Design flood discharges for river treatment purposes according to ODN 75 2103 (1993)

Land use	Design discharge
Historical town centres, historical monuments	≥ Q_{100}
Continuous urbanisation, industry area, important roads, infrastructure	≥ Q_{50}
Dispersed built up area (residential and industrial), continuous recreational areas (cottages, etc.)	≥ Q_{20}
High value land like orchards, hop gardens, etc.	≥ Q_{20}
Arable land (according its bonification)	Q_5 to Q_{20}
Pastures and forests	Q_2 to Q_5

In the year 2000 the **Strategy for the Flood Protection** for the Territory of the Czech Republic was issued, further on the Documentation of the programme 129 120 „Support of the prevention against floods II“ was published by the Ministry of Agriculture of the Czech Republic. According these documents the following factors should be taken into account when deciding about the design flood return period *N*:

- the necessity of flood protection with respect to the lowering of damage and loss on human lives and material property,
- appropriate flood protection level should be determined using the risk based methods with respect to the following criteria:
  - population at risk ,
  - the value of property and potential material losses,
  - occurrence of important structures and strategic facilities in endangered area (principal highway, railway, gas duct, power plants, etc.),
  - the celerity of the flood and warning time available (especially at flash flood prone areas),
  - data about sediment transport,

- water sources and water supply infrastructure,
- water pollution sources like waste water treatment plants, industry handling with dangerous toxic substances,
- general feasibility of flood protection arrangements (agreement of land owners, other conflicts),
- impact on nature, landscape and cultural heritage,
- economic effectiveness of the arrangements.

Resulting recommendations according the Strategy for the Flood Protection for the Territory of the Czech Republic are shown in table 2.5.

Tab. 2.5 Design flood discharges according to the Strategy for the Flood Protection for the Territory of the Czech Republic

Land use	Design discharge
Historical monuments	≥ Q_{100}
Public roads	according importance Q_{20} to Q_{100}
Continuous urbanisation, important industry area,	Q_{100}
Larger built up areas or manufacturing, services	Q_{50} to Q_{100}
Smaller urban areas	Q_{20} to Q_{50}
On-purpose roads	Q_{10} to Q_{50}
Orchards, gardens, hop gardens	Q_{10}
Arable land	Q_5
Meadows, forests, pastures	Q_{30d} to Q_1

At the design of river channel and flood protection measures (levees, floodwalls) , hydrologic uncertainties should be taken into account. In the Czech Republic these are quantified according the "accuracy class" at the standard ČSN 75 1400 via standard error (Tab. 2.6). Uncertainties can be considered e.g. by corresponding increase of design discharge or taken into account when designing levee freeboard.

Tab. 2.6 Characteristic error in provided hydrologic data

Hydrological data	Accuracy class			
	I	II	III	IV
	Standard error [%]			
Average annual discharge (Q_a)	8	12	20	30
M – day´s discharges (Q_{30d} to Q_{300d})	10	15	25	40
M – day´s discharges (Q_{330d} to Q_{364d})	20	30	45	60
N – year´s discharges (Q_1 to Q_{10})	10	20	30	40
N – year´s discharges (Q_{20} to Q_{100})	15	30	40	60

Check Flood

According the article I, §5, sect. (6) of the Decree 367/2005 Sb. it is required to assure water structures (dam, levee, dry reservoir) during the flood towards passing so called "check flood" according Tab. 2.7. Levees, polders and dry reservoirs and are considered to be structures damming water during the floods and have to satisfy these requirements similarly to the dams with permanent storage.

Tab. 2.7 Required return period of check flood for water structures

Loss	Description of consequences	Annual probability	Return period
		$P \approx 1/N$	N
Extremely high	Considerable loss of human lives	0.0001	10 000
	Fatalities improbable	0.0005	2 000
High	Expected single fatalities	0.001	1 000
	Fatalities improbable	0.005	200
Low	Losses downstream of water structure, no fatalities	0.01	100
	Losses only for the owner, other losses minor	0.02–0.05	50–20

Freeboard and levee spillways

Uncertainties related to hydrologic data, inaccuracy of geodetic data, hydraulic model and also importance of the flood protection measure are governing the height of freeboard. According the Decree 590/2002 Sb. and 367/2005 Sb. it is required to assume the freeboard height 0.3 to 1.0 m at the protection against Q_{100}, in lower flood protection level the freeboard should be up to 0.5 m. As mentioned above, consequences in case of levee breaching should be taken into account together with other factors mentioned. Generally the freeboard height should not compensate uncertainties taken into account e.g. by increasing design discharge according the table 6. Another important factor is expected settlement of the dike which from experience could reach 0.4 % to extremely 1 % of levee height.
In case of the protection lower than Q_{100}, the protection against levee breaching due to overtopping should be assured according the Decree 590/2002 Sb. At the same time the levee should satisfy requirements related to check flood (tab. 7).
In case of international or boundary streams the freeboard height has to be co-ordinated based on transboundary negotiations and agreement.
At the undermined areas the statements of the standard ČSN 73 0039 should be taken into account. The levee crest has to be designed including overelevation related to the expected land subsidence due to undermining or with the possibility of rapid increase of its crest level. It is recommended to propose levees with wider crest with the corresponding stock of appropriate earth. The subsidence forecast should be verified periodically by visual inspections and geodetical surveying.

2.3 Recent major floods and (near-)failures of levees

This section is meant to give a brief description of (near-)failures of levees/structures, and their causes and failure modes. Detailed information is not required, but we wish this section to serve as a portal to this detailed information.
Again, you may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

NOTE – Episodes with major storm surges or major high-river-discharge episodes without damage are also be relevant to mention as they give a measure of proven strength of the levees and flood defences.

The more detailed analysis was carried out at the Morava river Basin where about 1300 km of levees were analysed. The summary of levee failures was done for the period 1965 - 2004, i.e. about 40 years. The percentage of identified primary reasons of failures are shown in Fig. 2.1. The analysis showed that there were 153 levee failures during the studied period. The relative frequency of failures per 1 km was 0,118, the annual frequency per km was 0,00295 failures/km/year.
Number of failures fit well to the return period of individual floods (Fig. 2.2). This also reflects the design level of the flood protection. It can be seen that the most of the failures occurred during the flood in 1997 when the return period exceeded locally 500 years. Episodes at which only minimum of levees failed are also visible in Fig. 2.2.
It is obvious that the statistics cannot be applied generally at the flood risk analysis.

Fig. 2.1 The percentage of reasons of levee failures in the Morava river basin

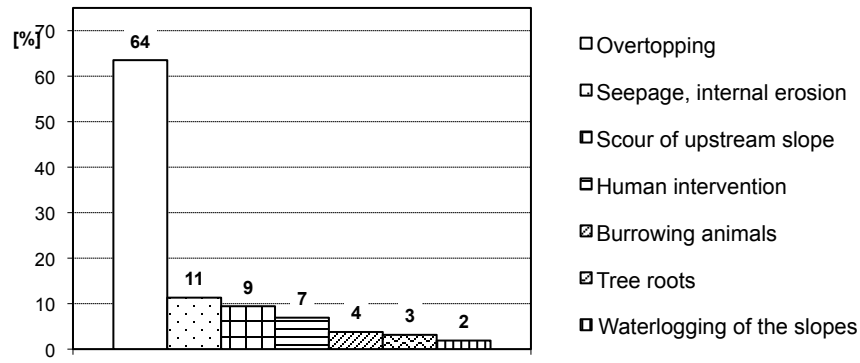
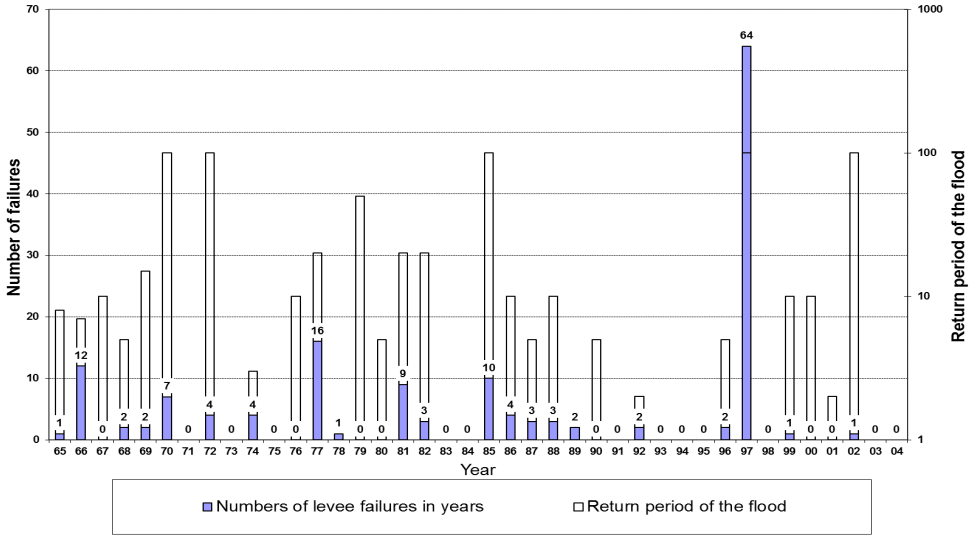


Fig. 2.2 The percentage of reasons of levee failures in the Morava river basin



2.4 Legislation and governance

Please give a short description about the main legislation related to levees and flood defences.

Please also indicate whether (i) this legislation is similar or even identical to the legislation used for dams (please check the Dam Legislation Report from the ICOLD European Club; levees are mentioned at least for ES, FI, FR and NL) and whether (ii) this legislation is a translation of the EU Floods Directive. The latter is interesting, because it allows to get an indication to what extent the Floods Directive has resulted in a common legal framework throughout Europe.
Besides this, it is also important to describe the key players with respect to Levees and Flood Risk Management and how they interact, i.e. the governance with respect to all life cycle phases of Levees and

Flood Defences. Not only to describe the governance, but also to make clear how easy/difficult it is to get relevant information.

In the Czech Republic the construction principles and legislation related to the flood protection arrangements has developed continuously in accordance with increasing demands for the protection against floods. Recently, regulations have become fragmented into a great number of laws, amendments, national technical standards and guidelines.

In the Czech Republic the construction of flood protection measures of modern conception began at the end of the 19th century and practically is not finished until now. The legislation has developed gradually with increasing demands for the safety and reliability of flood protection systems. The legal basis for the monitoring and supervision of related structures was established in seventies of the last century and in some aspects took ICOLD recommendations into account in some areas.

Today, design standards and safety regulations for water structures (including dams and flood protection works) are fragmented into a relatively great number of laws, announcements, technical standards and guidelines. Due to gradual elaboration and abundant changes during this period some minor inconsistency occurs in individual statements and requirements.

In fact in the legislation there is no **formal difference between dams and levees**. The legislation (Water Act) distinguishes so called "specified water structures" which may cause major financial losses and fatalities when failed. They are obligatorily subject to categorization (4 categories = consequence classes) which is governing the particulars of technical surveillance (extent, measured variables, frequency, ...). Experience shows that levees are classified as category 4, exceptionally category 3 while dams fall into categories 1 or 2.

EU Floods Directive projects namely to the conceptual issues like level of flood protection, efficiency assessment, flood risk analysis etc. There is no guidance to the structural issues of levees, surveillance, etc.

In CR the key player in levee design is still the state (Ministry of Agriculture and Ministry of Environment), further on River Agencies which play the role of "river basin planner" and which always give their official statement to the conception when planning any new flood protection measure in the catchment. When purchasing the assets from land owner for the building new levees, ... the key role is played by the local authorities, municipalities which will be protected. This is mostly the key issue in flood protection development and sometimes this is a limiting factor. The maintenance and operation belongs to the owner of the installation. This may be private body, municipality, Forests of the Czech Republic, river agency.

2.4.1 Legislation and governance – implementation EU Regulations

Please briefly describe how key EU legislation (mainly/especially the Floods Directive) is translated into national policy and legislation.

Procedures of flood risk analysis have been developed in the Czech Republic since the catastrophic floods of 1997 in line with European and worldwide trends and have been tested and applied in hundreds of case studies to date. In the past decade the Flood Risk Directive Guideline based on past experience with flood risk analysis applications was processed. The more detailed information may be taken from (Dráb, Říha 2010).

The Flood Risk Directive requires three stages of flood risk management (see details in Sect. 2):
1. Preliminary flood risk assessment.
2. Creation of flood hazard and risk maps for various scenarios.
3. Development of flood risk management plans.

During the implementation of the Flood Risk Directive (ES, 2007), currently used flood risk assessment methods are being employed. At present a detailed description of these methods is part of the Guidelines (MA CR, 2009) which have been elaborated.

2.4.2 Legislation and governance – National legislation

Please give a short description about the main national legislation related to levees and flood defences, and whether/how it differs from Dam Legislation.

The legislation does not differ for dams and levees, the difference is anchored in the categorization of hydraulic structures. The overview of classified hydraulic schemes into categories is shown in tab. 2.8. It can be seen that only two levees are classified as category II, 58 levees as category III, The others belong to category IV.

Tab. 2.8 The summary of hydraulic structures and categories (issued 2014)

Category	Type of the hydraulic structure						Total
	Dam	Weir + hydropow.	Tailing dam	Levee	Penstock	Hydropower	
I.	27	-	-	-	-	-	27
II.	52	3	7	2	2	1	67
III.	212	44	18	58	4	5	341
Totall hydraulic structures in category I. – III.							435
Comment:	There are about 20 000 hydraulic structures in Category IV (levees, small dams, weirs, etc.)						

Laws

The two principal legal documents concerning construction, administration and control in water management in the Czech Republic are the Civil Engineering Act and the Water Act.

The Civil Engineering Act (Building Code) defines general rules in landscape and urban planning, development, construction and maintenance of civil structures, including water structures and flood protection measures. The Act regulates preparation procedures and building permits, and defines restrictions, liability and ownership demands in the development of civil structures in general. Since 2007 an amendment of the Civil Engineering Act substituted the original law (1976).

The Water Act deals with the administration, ownership, control, and use of water as a resource. Of great importance is the part dealing with water courses and water structures, the responsibility of their owners and the obligation to carry out the supervision and inspection of hydrotechnical structures. Improved extensive part including numerous paragraphs deals with various aspects of the flood protection. The last amendment of the new Water Act (from 2001) was issued on late summer in 2010 into which the implementation of European directives were done.

Decrees and technical standards in flood protection

Decrees have lower force in the Czech legislation hierarchy than laws; however, their statements are obligatory. The following are closely related to the flood protection:

- Decree concerning technical-safety supervision of water structures.
- Decree concerning particulars of the handling rules and operational rules for water structures

- Decree concerning technical requirements for water structures.
- Decree concerning the delimitation of flood zones.
- The set of laws and decrees concerning emergency activities during floods.

Technical standardisation was organised in Czechoslovakia from the beginning of the 20th century. In 1951 the responsibility for technical standardisation was taken over by the state administration through the Institute for Standardisation. The previously voluntary standards became obligatory under the law. New legislation defined technical standards as non-obligatory from 1995 again. The exceptions are the statements of laws and decrees referring to technical standards or the decrees of bodies entrusted by law to order standards to be obligatory.

Technical standards in flood protection structures (namely levees) have been elaborated since the nineteen-sixties. The set of standards dealing with flood protection included topics like river engineering, weirs, calculation of wave effect, construction of embankments, design of outlets and intakes, stability computations for embankments, measurements and observations for water structures, the set of standards for dam engineering, etc.
Over time, most of the standards were improved and transformed into the Czech National Standards, which were periodically updated. Extensive improvement and updating of standards has been carried out approximately since the year 1987. Some standards have also been issued as "Technical standards for water management". In accordance with requirements for new types of structures (e.g. dry reservoirs, etc.) some new standards have been issued as well.

Dam standardisation in the Czech Republic has a long tradition with its roots in water management and construction advances from the end of the 19th century. On the other hand, from the list shown above, which is not complete (it does not include standards for soil mechanics, hydrology, etc.), it is clear that knowledge and experience are dispersed across a great number of documents.

Problems with some aspects of flood related legislation, standardisation and technical surveillance
The general framework for flood protection structures design, construction, maintenance, and safety assessment is defined by the obligatory statements of corresponding laws and decrees. More detailed requirements are anchored in the statements of technical standards and guidelines. Unfortunately for the user it is quite difficult to implement the complex system of standards and follow up its development and all cross-references between individual standards and legislative documents. Moreover, due to the time factor over the course of the elaboration and publication of laws, decrees and standards some inconsistency occurs in terminology and sometimes also in individual statements.

Differences can also be found in the safety supervision of flood protection structures when compared with European and worldwide practices. The safety supervision is executed as follows:
- Periodical and "after the flood" inspections are carried out as a part of normal operation by the owner´s staff.
- The second inspection level in the case of important flood protection schemes is carried out by a single private agency with the highest level of authorisation by MA and qualified staff. The advantage of such a system is that it allows long-term systematic inspection. The result of this periodical supervision and monitoring is a report assessing the safety of each structure, and proposals for its improvement. For the monitoring of levees of lower importance the owner is obliged to appoint a certified body for dam safety supervision. In the Czech Republic 11 companies and agencies are holders of such certification.
- The third level of safety inspection is assumed to be an independent check mechanism. In the Czech Republic the responsibility belongs to the state administration officers. Due to the wide range of problems concerning state control in water management, the qualifications and specialisations of state regional and governmental officers are sometimes not adequate to the task required of them. There is no existing system of qualification requirements and periodical certification of expertise in flood protection and construction in water management.

The specific problem consists in the method of elaboration of decrees and standards. In most cases the wider professional community is engaged in the discussion only as a formality. The active standard-negotiation

process is time consuming and sometimes also necessitates expenses for which the participating external professional bodies are not compensated. Therefore, as a rule only a few professional subjects respond regularly to interim proposals for standards and take part in the negotiations involved.

2.4.3 *Legislation and governance – Governance*

Please give a short description about the governance of levees and flood defences, i.e. the main parties / key players involved and their roles and duties.

Water authorities are located in cities of greater importance, where environmental departments are responsible for activities in the field of water management. In the case of larger flood protection schemes this position is held by regional authorities.

The central water authority is the Ministry of Agriculture (MA). The responsibility of the MA extends to water management activities and care for water management infrastructure. According to the Water Act, the Ministry of Environment has a wide range of competence, which covers flood protection or hydrometeorological forecasts.

The principal owners of flood protection facilities are usually the River Board state agencies. Only a minority of flood protection infrastructure belongs to municipalities. Water courses of lower importance and small dams are managed by Forests of the Czech Republic and exceptionally to local municipalities and other owners (water supply companies, etc.).

Decree No 241/2001 Coll. is the key mandatory document concerning technical-safety supervision of water structures. The governance and surveillance is carried out according the category of hydraulic scheme.

2.5 Guidelines and good practices

Please mention what guidelines and good practice documents you use for design, safety assessment and maintenance of levees/flood defences; please give references/weblinks to some key documents.
Please also mention what parts of ICOLD-Bulletins and/or the International Levee handbook ILH are used in your country for the above.

Answers from Questionnaire

What is your personal view on the applicability of ICOLD Bulletins/publications to levees and flood defences in your country?

- Some are applicable with adaptation

Is the previous answer just your personal point of view or do you represent a group of people

- Personal view

Apart form ICOLD bulletins and the International Levee Handbook, is there some other type of guidance available in your country?

- A few guidance documents from Cemagref / Irstea, and a general document (Referentiel TechniqueDigues)

What levee- and flood-defense related issues and knowledge gaps are critical (to guarantee safety, and the integrity of the structure)?

- Transitions, assessments related methods

In general no ICOLD bulletin is directly applied into Czech documents. Particular ICOLD experiences and recommendations are gradually and slowly projecting into technical standards when they are amended. For levee´s planning, design and operation following documents are used:

Obligatory:

- Decree 471/2001 Sb. concerning technical-safety supervision of water structures.
- Decree 195/2002 Sb. concerning particulars of the handling rules and operational rules for water structures.
- Decree 236/2002 concerning the delimitation of flood zones.
- Decree 367/2005 Sb. concerning technical requirements for water structures.

Recommended:

Technical Standards:

- ČSN 72 1006 Control of soil compaction (1998).
- ČSN 73 0039 Design of structures on the undermined areas. Basic requirements (1989).
- ČSN 73 1000 EN 1997 Eurocode 7. Geotechnical design (2006).
- ČSN 73 1001 Foundation of structures (1988).
- ČSN 73 1208 Design of concrete water structures.
- ČSN 73 6110 Design of local roads (2007).
- ČSN 73 6201 Design of bridges (1995).
- ON 73 6821 Lining of banks of water courses (1974).
- ON 73 6827 Vegetation at water courses (1974).
- ČSN 75 0250 The load on water structures (1990).
- ČSN 75 0255 The action of waves on water structures (1987).
- ČSN 75 1400 Hydrological data (1990).
- ČSN 75 2101 Ecologization of water courses (1993).
- TNV 75 2102 Treatment of streams (1995).
- TNV 75 2103 Treatment of rivers (1998).
- ČSN 75 2130 Crossing and passing of water courses with railways, roads and lines (2000).
- TNV 75 2131 - Outlets and intakes for water structures (1999).
- ČSN 75 2410 Small embankments (2011).
- TNV 75 2415 Dry reservoirs (2002, 2006).
- TNV 75 2910 Operational rules of water structures on water courses (1994).
- TNV 75 2931 Flood protection plans (2001).
- TNV 75 2935 Assessment of safety of water structures during floods (2014).

National guidelines, directives

- Guideline on assessment impacts of dam break floods and their implementation into flood protection plans. Ministry of Environment. 2000.
- Guideline on maintenance of vegetation on small embankments. Ministry of Agriculture. 2003.
- Guideline on technical-safety surveillance at small embankments. Ministry of Agriculture. 2003.
- Guideline on classification of water structures according the technical surveillance. Ministry of Agriculture. 2009.
- Strategy for the Flood Protection for the Territory of the Czech Republic approved by the resolution of the Government of the Czech Republic on 19 April No. 382. Guidance, Ministry of Agriculture 35/2000.
- Documentation of the programme 129 120 „Support of the prevention against floods II“. Ministry of Agriculture. Prague. 2006.
- MA CR, 2009 The implementation of the Directive 2007/60/EC of the European Parliament and of the Council on the assessment and management of flood risks into Czech conditions. 2009.
- Říha, J. River levees. The guideline certified by the Ministry of Agriculture, 2010, 223 p.

2.6 Common practices during Levee Life Cycle

This section is meant to briefly share some common practices related to various life cycle phases of Levees & structures:

- *Design practice and cost of reinforcement (per km or per object)*
- *Inspection of levees*

- *Maintenance and safety assessment*
- *Flood event management*
- ...

Design practice and cost of reinforcement (per km or per object)
It is always difficult to specify costs for levees as they differ in their height, foundation conditions, seepage regime, crossing with other linear structures (railway, motorway, conduits, ...).
As an approximate values for the Czech republic are:
- maintenance of plain surface of levees (cutting grass, small vegetation) - 1-2 ths EUR/km/year
- maintenance of more complicated reaches (crossing, dismantling of railway, ...) - several millions EUR/km/year

Inspection of levees
It is carried out according the Category. In category IV, only visual inspections are carried out annually, during and after each flood event. During last decade the geophysical measurements are gradually performed namely along critical reaches (crossing past meanders, crossing with conduits, etc.) to identify critical sections.

Maintenance and safety assessment
Safety assessment of existing levees is normally not performed. During the design the safety assessment is carried out to identify safety factor for structural failure (sliding surface), for seepage and internal erosion failures. When appropriate, the spillways in the levees are newly designed and built to protect them against uncontrolled overtopping and breaching.

Flood event management
In case of flood danger, during and after the flood the "flood committee" starts its work. The committees operate at several levels (state, district, municipality, river basin, ...) according to the extent of flood. The members of the committees are representatives of state authorities, rescue services - fire brigade, river agency, hydrological services, technical surveillance, etc.
The following situations are considered as situations posing flood danger:
- specified limit of the water level or flow in a watercourse is reached and the increase tends to continue,
- heavy rain falling for long period of time, forecasted occurrence of intensive precipitation or snow melting, dangerous movement of ice or occurrence of dangerous ice jams and blockages,
- emergency situation of a water management structure posing a danger that the structure may become damaged.

Flood Protection Measures:
1. Preventive measures and measures in situations posing flood danger are
   - determination of flood plain areas
   - specification of limits for flood protection activity degrees
   - flood protection plans
   - flood protection inspections
   - organisation of flood forecasting and reporting services,
   - organisational and technical preparation
   - creation of flood reserve stock
   - clearing of flood plain areas
   - training of persons participating in flood protection activities,
   - activities of the flood forecasting service,
   - activities of the flood reporting service
   - warning in cases of danger of floods,
   - establishment and activities of the watching service,
   - flood recording and documentation.
2. Measures taken during flood are
   - regulation of flow regime,
   - flood protection activities (sandbags, provisional construction activities, antiseepage measures),

- flood rescue activities,
- activities aimed at ensuring substitute functions and services in territories affected by floods.

3. Flood documentation and assessment including the assessment of damage caused by flood, causal factors adversely affecting the flood, efficiency of adopted measures and proposals for amendment to flood protection measures constitute an integral part of flood protection measures.
4. Construction, maintenance and repairs of structures and other installations serving for flood protection, as well as investments evoked by floods are not flood protection measures according the Water Act.

2.7 Critical knowledge and data gaps; critical research needs

This section is meant to summarise critical data and knowledge gaps, as well as critical research needs. Please not this is really about the critical knowledge gaps and research needs for proper (risk-based) management of levees, not about nice-to-know knowledge.
We need this information to be able decide on further topics to be explored with our working group

In the Czech Republic there exists no systematic central information about the extent of flood protection measures, its behaviour during the floods, levee failures and failure modes, flood losses due to the levee collapse, etc.

2.8 Summary of key facts

This section is meant to summarise some key facts and figures in just a few words, for easy comparison amongst countries, and to facilitate writing the summary and conclusions:

- *Km of levees, no. of structures*
- *% along river, estuary, sea, lake*
- *Protected value, safety standard, actual protection level or flood risk*
- *Recent (near-)failures*
- *Key facts governance (which key players) and legislation*
- *Types of guidelines used*

- About 4000 km of levees including floodwalls, no. of structures not identified, estimate - several hundreds,
- 90 % along rivers, 10% along streams and/or torrents
- Protected value will be identified,
- Safety standard not unique, according to the property in floodplain, determined by the cost benefit analysis using risk approaches,
- Failures mostly due to overtopping and internal erosion, many a times close to the conduits in the levee.
- Key facts governance - levee owners, state interventions, key role of river agencies.
- Guidelines - mostly technical standards and national guidelines.

2.9 References (per country)

Please support the Country-specific facts of the previous sections by references and weblinks as much as possible, so that information remains traceable and easy to update.

Laws
Water Act. 138/1973 Sb. (until 2001).
Environmental Law 17/1992 Sb.
Law about nature and landscape preservation 114/1992 Sb.
Environmental Impact Assessment Law 100/2001 Sb.
Water Act. 254/2001 Sb. (since 2001), latest amendment 273/2010 Sb.
Building Code 183/2006 Sb.
Law about the emergency management 240/2000 Sb.

Decrees

Decree 471/2001 Sb. concerning technical-safety supervision of water structures.
Decree 195/2002 Sb. concerning particulars of the handling rules and operational rules for water structures.
Decree 236/2002 concerning the delimitation of flood zones.
Decree 367/2005 Sb. concerning technical requirements for water structures.

Technical Standards
ČSN 72 1006 Control of soil compaction (1998).
ČSN 73 0039 Design of structures on the undermined areas. Basic requirements (1989).
ČSN 73 1000 EN 1997 Eurocode 7. Geotechnical design (2006).
ČSN 73 1001 Foundation of structures (1988).
ČSN 73 1208 Design of concrete water structures.
ČSN 73 6110 Design of local roads (2007).
ČSN 73 6201 Design of bridges (1995).
ČSN 73 6500 - Calculation of wave effects (1971).
ON 73 6504 Hydraulical calculations of water structures (1963).
ČSN 73 6505 - Loads on water structures (1979).
ČSN 73 6512 Terminology in river engineering (1964).
ČSN 73 6512 Terminology in river engineering (1983).
ČSN 73 6532 Terminology in hydrogeology (1983).
ČSN 73 6814 - Design of dams. Basic parameters and equipment (1972).
ČSN 73 6820 River engineering (1973).
ON 73 6821 Lining of banks of water courses (1974).
ON 73 6822 River engineering. Flood levees (1964).
ČSN 73 6824 Small earth dams (1964, 1966, 1978).
ON 73 6827 Vegetation at water courses (1974).
ČSN 73 6850 - Earth dams. Design and construction (1968, 1978).
ČSN 75 0121 Terminology in river engineering (1997).
ČSN 75 0250 The load on water structures (1990).
ČSN 75 0255 The action of waves on water structures (1987).
ČSN P 75 0290 - Design of earth structures of hydrotechnical works (1993).
ČSN 75 0271 - Statics computations for concrete dams (1990).
ČSN 75 1400 Hydrological data (1990).
ČSN 75 2101 River engineering (1992).
ČSN 75 2101 Ecologization of water courses (1993).
TNV 75 2102 Treatment of stream (1995).
ODN 75 2103 Treatment of rivers (1993).
TNV 75 2103 Treatment of rivers (1998).
ČSN 75 2130 Crossing and passing of water courses with railways, roads and lines (2000).
TNV 75 2131 - Outlets and intakes for water structures (1999).
ČSN 75 2310 Embankment dams (2005).
ČSN 75 2410 Small embankments (1997).
TNV 75 2415 Dry reservoirs (2002, 2006).
TNV 75 2910 Operational rules of water structures on water courses (1994).
TNV 75 2931 Flood protection plans (2001).
TNV 75 2935 Assessment of water structures during floods (1994, 2003).

National guidelines, directives
Guideline on assessment impacts of dam break floods and their implementation into flood protection plans. Ministry of Environment. 2000.
Guideline on maintenance of vegetation on small embankments. Ministry of Agriculture. 2003.

Guideline on technical-safety surveillance at small embankments. Ministry of Agriculture. 2003.
Guideline on classification of water structures according the technical surveillance. Ministry of Agriculture. 2009.
Strategy for the Flood Protection for the Territory of the Czech Republic approved by the resolution of the Government of the Czech Republic on 19 April No. 382. Guidance, Ministry of Agriculture 35/2000.
Documentation of the programme 129 120 „Support of the prevention against floods II". Ministry of Agriculture. Prague. 2006.
MA CR, 2009 The implementation of the Directive 2007/60/EC of the European Parliament and of the Council on the assessment and management of flood risks into Czech conditions. 2009.
Říha, J. River levees. The guideline certified by the Ministry of Agriculture, 2010, 223 p.

Selected reports about extreme floods in CR

EVALUATION OF THE 1997 FLOOD EVENT. 1998. Ministry of the Environment (In Czech).
EVALUATION 1998. The evaluation of the flood event in July 1997. (In Czech). CHMI, ME Prague, 8 pieces of CD.
EVALUATION 2000. The report on the floods in the Ohře River basin in March 2000 (In Czech), Ohře River Basin Agency.
EVALUATION 2001. The report on the floods in the Ohře River basin, 31 August - 7 September 2001 (In Czech), Ohře River Basin Agency.
EVALUATION 2002. The report on the floods in the Ohře River basin, 18 January - 8 February 2002 (In Czech), Ohře River Basin Agency.
EVALUATION OF THE 2002 FLOOD EVENT. 2002. Ministry of the Environment, CD ROM (In Czech).
EVALUATION 2002. The evaluation of the catastrophic flood in August 2002. (In Czech). VUV, ME Prague.
EVALUATION 2005. The report on the floods in the Ohře River basin, March 2005 (In Czech), Ohře River Basin Agency.
EVALUATION 2006. The report on the catastrophic flood in the Morava River basin on 26 March - 20 April 2006, September 2006. (In Czech), Morava River Basin Agency.
EVALUATION 2006. The report on the catastrophic flood in the Ohře River basin on 26 March - 20 April 2006, (In Czech), Ohře River Basin Agency.
EVALUATION 2009. The report on the floods in the Ohře River basin in July 2009 (In Czech), Ohře River Basin Agency.
EVALUATION 2010. The report on the floods in the Ohře River basin in June 2010 (In Czech), Ohře River Basin Agency.
EVALUATION 2013. The evaluation of the catastrophic flood in May and June 2013. (In Czech). VUV, ME Prague.

3 England [IN PROGRESS – NOT YET COMPLETE]

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INFORMATION THAT MAY BE OF HELP WHEN COMPILING YOUR CHAPTER

- ***THE INFORMATION BELOW (MARKED IN GREEN) WILL BE REMOVED WHEN THE CHAPTER IS COMPLETE***
- ***Text which is not colour-marked nor in italic is recently added information***

The report http://www.crue-eranet.net/partner_area/documents/D5_Main_Report.pdf contains some useful facts and figures on levees and the governance of Flood Risk Management (FRM) of many European countries, even though the data are 10 years old and not always up to date. However, they may be very useful to supplement that data gathered by our Levee Working group members, when they have difficulty in getting the right data:

- Table 34: Total yearly FRM investment Europe: close to or over 3 billion Euro.
- In each country chapter: years with main recent flood events
- CH11 – UNITED KINGDOM – ENGLAND
  - About 4-5 mln people and 140000 businesses at risk, representing 400 billion Euro of assets
  - Average annual damage over 1,5 billion Euro per year
- CH12 – UNITED KINGDOM – SCOTLAND
  - ~80000 homes + businesses at risk from river flooding (commonly occurring), another 100000 for coastal flooding (rare)

The preliminary flood risks assessments (PRFA's) and flood risk management plans (FRMP's) of the EU Floods Directive (http://www.envir.ee/sites/default/files/flooddirective.pdf; http://ec.europa.eu/environment/water/flood_risk/) may also provide useful information; water authorities can be found on http://www.eea.europa.eu/themes/water/interactive/floods-directive-viewer .

Some country- or river specific information can be found on:

- www.climateadaptation.eu: Quite useful site for some general information on vulnerability to for instance river floods, but also coastal floods, flash floods & urban floods, etc. etc., see for example:
- Appendix A of http://www.starflood.eu/documents/2013/06/flood-risk-management-in-europe-similarities-and-differences-between-the-star-flood-consortium-countries.pdf (for UK: floods no major problem until end of 20th century, some interesting damage estimates for recent floods)
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3.1 Facts and figures on levees and flood defences

This section is meant to answer questions like:

- *how many levees and other flood defences do you have (km's / nr's)*
  - *other flood defences may be moveable flood walls, storm-surge-barriers and also ordinary gates and sluices (the latter may be so numerous it may be too difficult to quantify them)*
- *what are typical dimensions and other properties (materials, layering, revetment, ..) for (different types of) levee in your country*
- *what is the geographical context: what are typical environments / flood types (% urban/rural levees, % river, estuary or coastal levees)*
- ***Could you give also an indication of yearly spendings on levee management and levee reinforcement (or on overall flood risk management if only that is available)? We think it has added value to present these numbers, and especially make clear what Business Case is hidden in the levee issue.***

You may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

Answers from Questionnaire

What types of flood defences do you have in your country:
How many levees (Levees are raised, predominantly earth, structures that are not reshaped under normal conditions by the action of waves and currents, whose primary objective is to provide protection against fluvial and coastal flood events along coasts, rivers and artificial waterways (from the definition in the ILH)) do you have (in km)

- 8500 km

How many flood walls (flood walls are hard structures which, like levees, protect against flooding, the difference being the type of material) do you have (in km)

- included in above

How many hydraulic structures (like gates, pumping stations, closure structures, …) do you have (in numbers)

- 22000 structures (includes from flapped outfalls to

What % of your flood defences (of each type) is linked to the following physical environment / flood threat: (The numbers need to add up to 100)

- Sea 12
- Estuary 18
- River 70

What would be a typical flood defence height in your country (please give min, max, medium if possible). The height is defined as difference top of the levee and ground level.

- Min 1
- Max 6

3.2 Protected value, safety standards and flood risk

This section is meant to give an indication of the following:

- *What is (by and large) the protected value that could flood without levees and flood defences. Both in terms of life and economic value (preferably the assets, otherwise a fraction of the Gross Domectic Product)*
- *Do your levees and structures have a safety standard, and if so what does it refer to and what value has it got*
- *What is the actual protection level of your levees etc. (or what % does or does not satisfy the safety standards)*
- *Coming to the first issue: what is the residual risk (related to flooding despite the levees etc.), and how large is it compared to protected value (the ratio is in fact a measure of the actual protection level)*

Answers from Questionnaire

If they break what % of your flood defences represent: no hazard, material hazard, some life hazard and large scale life have hazard. (The numbers need to add up to 100)

- Material hazard only 23
- Large scale life hazard/economic hazard (say > 100 people/over 100 million) 77

Explanatory remarks (if you had to adapt the hazard categories to what is commonly used in your country)

- assets are classified as high, medium and low risk according to probability of failure and consequence of failure. Figures in q4 relate to this. 77% includes both 'some' and 'large' scale impacts
- The Thames Barrier and associated defences protects £200 billion of property and other assets. This is by far the largest of our systems of structures.
- There are other urban barriers each protecting multi-million pounds worth of property
-

In our report we wish to give an impression of the importance of levees in terms of protected value. Could you give a rough indication of the (levee-)protected population size and economic value in your country?

- The flood risk assets themselves have a total value of £30 billion. They protect property (homes, businesses, infrastructure). Over the period of 2016 to 20121 we plan to better protect 300,000 houses plus businesses, infrastructure and land at a cost of £2.3billion bringing benefits of £30.3billion
- Figures from LTIS 2014 There are 2.4 million properties at risk from flooding from rivers and the sea. 748,000 of these have at least a 1% annual likelihood of experiencing flooding. A further 3 million properties are at some risk from surface water flooding in England, around 772,000 of which are at or above the 1% annual likelihood level. About 600,000 properties are at risk from both sources of flooding.

Table 1 From National Flood Risk Assessment (NaFRA)

Risk	Rivers and sea	Rivers and sea	Surface water	Surface water	
	Residential	Non-residential	Residential	Non-residential	
High	153,000	91,000	209,000	73,000	
Medium	350,000	153,000	388,000	102,000	
Low	1,274,000	329,000	1,809,000	423,000	
Very Low	72,000	21,000	Not assessed	Not assessed	
Total	1,849,000	594,000	2,406,000	598,000	

- We estimate the average annual economic consequences of flooding, based on the likelihood of these properties flooding, to be about £960 million from river and coastal flooding and coastal erosion, and £290 million from surface water flooding.
- Over 7100 electricity substations in the floodplain (14% of total in England)
- 950 Sewage treatment works are at risk (over half total number in England)
- 28% of gas infrastructure sites are at flood risk

Explanatory remarks you wish to add (for example levee types that are not included in your answers because they are too small/numerous/cumbersome to elaborate upon).

- only community assets included not property level protection. Coastal erosion assets not included

What are typical (levels of) safety requirements for the hazard categories mentioned?

Material hazard only

- 1/5 agricultural to 1/100 property (varies)

Some life hazard

- 1/100 (fluvial) to 1/200 coastal (varies according to risk and scheme

Large scale life hazard/economic hazard (say > 100 people/over 100 million)

- 1/100 year to 1/1000 year depending on asset

Safety requirement definitions may differ across countries. Please explain how the above safety requirements are defined (for example maximum allowable values of risk level, flood probability, water level a levee can just withstand, …)

Material hazard only

- see below

Some life hazard

- see below

Large scale life hazard/economic hazard (definitions of this category may differ across countries; as rough indication, large scale may mean at least 100 victims or 100 million Euro damage)

- all tend to be on optimum benefit / cost of design options

To what type of Limit State do these requirements refer (if you are familiar with Box 5.11 of the International Levee Handbook, please use the terms Protection Level or Safety Level or Danger Level; if easier you can also use the 'Some Damage', 'Serious Damage', and 'Ultimate' Limit State).
Large scale life hazard/economic hazard (say > 100 people/over 100 million)
- all both ULS and SLS are checked

3.3 Recent major floods and (near-)failures of levees

This section is meant to give a brief description of (near-)failures of levees/structures, and their causes and failure modes. Detailed information is not required, but we wish this section to serve as a portal to this detailed information.
Again, you may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

NOTE – Episodes with major storm surges or major high-river-discharge episodes without damage are also be relevant to mention as they give a measure of proven strength of the levees and flood defences.

Answers from Questionnaire

Is there coordinated operation and/or crisis management of upstream dams and downstream levees in the case of immediate flood threat?
- Yes

Did you have any recent (near-)failures of levees or other flood defences in recent years/decades
- Yes – in 2013/14 there were some failures mostly after overtopping causing rear face erosion. Also in 2015/16 there were similar types of failures including at transitions. These are currently being investigated.
-

Did you have large scale life hazard (say > 100 people) (near-) failures
- No

Did you have some life hazard (near-) failures
- Yes, but no lives lost. Severe flood warnings issued leading to evacuation (St Michaels on Wyre)

How often do some life hazard (near-)failures roughly occur?
- 1/10 years

In which type of environment?
- Sea, Estuary, River

What are the most common failure mechanisms for these incidents?
- Overtopping, • Piping, • Geotechnical instability, Other (please specify) transition points

Do you have any well-described events that are suitable for case studies?
- Yes

Are there reports regarding lessons learnt from these (near-)failures, and have the conclusions from these report been followed in actual actions later?
- Preventative measures proposed and implemented.
- Current investigations ongoing in relation to 2015/16 floods
-

Please give a brief description of event suitable for a case study for some life hazard?
- breaches both before and after overtopping (various)

Did you have material hazard (near-)failures
- yes

How often do material hazard (near-)failures roughly occur?
- 1/10 years

In which type of environment?
- Sea, Estuary, River

Do you have any well-described events that are suitable for case studies?
- Yes

Are there reports regarding lessons learnt from these (near-)failures, and have the conclusions from these report been followed in actual actions later?
- Preventative measures proposed and implemented

Please give a brief description of an event suitable for a case study for material hazard?
- asset damage without structural failur

Did you have no hazard (near-)failures
- yes – small, low consequence assets

3.4 Legislation and governance

Please give a short description about the main legislation related to levees and flood defences.

Please also indicate whether (i) this legislation is similar or even identical to the legislation used for dams (please check the Dam Legislation Report from the ICOLD European Club; levees are mentioned at least for ES, FI, FR and NL) and whether (ii) this legislation is a translation of the EU Floods Directive. The latter is interesting, because it allows to get an indication to what extent the Floods Directive has resulted in a common legal framework throughout Europe.
Besides this, it is also important to describe the key players with respect to Levees and Flood Risk Management and how they interact, i.e. the governance with respect to all life cycle phases of Levees and Flood Defences. Not only to describe the governance, but also to make clear how easy/difficult it is to get relevant information.

Answers from Questionnaire

Indicate the organization(s) that manage the flood defences. If management is distributed over different organizations, indicate which organization manages a certain fraction of the levees.
- Environment Agency (approx 50%), third parties inc Local Authorities and Private (approx 50%)

From a management viewpoint, and from a viewpoint of roles and responsibilities (i.e. governance), are there any differences between (i) levees, (ii) flood control dams and (iii) other types of dams worth mentioning, including the way these roles and responsibilities are referred to in law.
- levees permissive powers to build and maintain flood control. Dams legislative duties on safety where they come under the terms of the Reservoirs Act 1975 (amended by the Flood & Water Management Act 2010)

What aspects of dams and levees are included in the products (Preliminary Risk Assessment, Risk Maps and Flood Risk Management Plans) required by the EU Floods Directive (EUFD)?
- Risk Maps and Management Plans

Are dams and levees similarly dealt with under your countries EUFD-implementation or differently (and in which respects).
- legal duty in respect of large raised reservoirs, other assets permissive powers

Remarks, lessons and or documents you want to share

- https://www.thomastelford.com/books/bookshop_main.asp?ISBN=9780727757692

3.4.1 Legislation and governance – implementation EU Regulations

Please briefly describe how key EU legislation (mainly/especially the Floods Directive) is translated into national policy and legislation.

Debated in Parliament and national Acts passed. Example Flood and Water Management Act 2010.

3.4.2 Legislation and governance – National legislation

Please give a short description about the main national legislation related to levees and flood defences, and whether/how it differs from Dam Legislation.

Levees and Flood Defences – Water Resources Act 1991 and Flood & Water Management Act 2010 for Main River (plus Land Drainage Act 1991 for ordinary watercourses) gives permissive powers. Byelaws in addition to these Acts allow serving of notices for infringements.

Reservoirs – Reservoir Act 1975 amended by Flood & Water Management Act 2010 gives duties on owners and operators of dams under strict criminal liability.

3.4.3 Legislation and governance – Governance

Please give a short description about the governance of levees and flood defences, i.e. the main parties / key players involved and their roles and duties.

Environment Agency control main river and sea flood defences. Local Authorities and Internal Drainage Boards control ordinary watercourses (not main river). Maritime Local Authorities control works relating to erosion from the sea.

Environment Agency regulate dams under the Reservoir Act.

3.5 Guidelines and good practices

Please mention what guidelines and good practice documents you use for design, safety assessment and maintenance of levees/flood defences; please give references/weblinks to some key documents.
Please also mention what parts of ICOLD-Bulletins and/or the International Levee handbook ILH are used in your country for the above.

Does your country have central dam and/or levee registers?

- Yes
  - For Dams the Reservoir Safety Register is held by the Environment Agency and is soon to be accessible to all dam owners (some information will remain restricted due to data protection act requirements)
  - For levees on Main River and the coast there is an Environment Agency database called AIMS:Inventory (Asset Management Information System) most of which is available publicly as open data.
  - For ordinary watercourse and coastal protection assets local authorities and IDBs have their own inventories

If so, what information is included?

- Physical and condition data plus for reservoirs Safety regulation information

Who has access to the data?

- State control authorities,
- Other (please specify) Currently only state (Environment Agency) have access to dam information but owners will soon have access to the database for their dams
- For levees AIMS:inventory data is now open data

What is your personal view on the applicability of ICOLD Bulletins/publications to levees and flood defences in your country?

- Some are directly applicable

Is the previous answer just your personal point of view or do you represent a group of people

- Organisational view

Apart form ICOLD bulletins and the International Levee Handbook, is there some other type of guidance available in your country?

- ICE guide to Reservoirs Act, Guide to application of Eurocode 7 for flood embankments in UK and Ireland

What levee- and flood-defense related issues and knowledge gaps are critical (to guarantee safety, and the integrity of the structure)?

- Predicting stage in useful life of a levee
- Predicting performance and failure modes especially around transitions in structures
- Impact of climate change on assets eg wetting / drying cycles, drought effects etc

3.6 Common practices during Levee Life Cycle

This section is meant to briefly share some common practices related to various life cycle phases of Levees & structures:

- *Design practice and cost of reinforcement (per km or per object)*
- *Inspection of levees*
- *Maintenance and safety assessment*
- *Flood event management*
- ...

The typical construction cost of an embankment will be dependent on volume of material, but making the following assumptions

Height 2m
Crest Width 3m
Side slope 1:3

Would give a volume of 18,000 m3 @ £28.48 /m3 giving a cost of **~£641 k /km** (including indirect Costs @ 25%).

- Inspection of levees
  - A risk based visual asset inspection programme is in place for all Environment Agency and integral third party assets. Inspections are 6 monthly for the highest risk assets, 12 – 18 months for medium risk assets and 24 – 60 months for low to very low risk assets. These visual inspections trigger more detailed assessments as necessary.
- Maintenance and safety assessment
  - An annual programme of maintenance is carried out based on risk.
- Flood event management
  - The Environment Agency and partner organisations work together on planning and preparing for flood events and in carrying out activities during events from flood forecasting, warning, operational response, working with communities and recovery.

3.7 Critical knowledge and data gaps; critical research needs

This section is meant to summarise critical data and knowledge gaps, as well as critical research needs.

Please not this is really about the critical knowledge gaps and research needs for proper (risk-based) management of levees, not about nice-to-know knowledge.
We need this information to be able decide on further topics to be explored with our working group

- Predicting stage in useful life of a levee
- Predicting performance and failure modes especially around transitions in structures
- Impact of climate change on assets eg wetting / drying cycles, drought effects etc
- Vegetation management on levees
- Adaptation and resilience in the future (climate change and other effects)

3.8 Summary of key facts

This section is meant to summarise some key facts and figures in just a few words, for easy comparison amongst countries, and to facilitate writing the summary and conclusions:

- *Km of levees, no. of structures*
- *% along river, estuary, sea, lake*
- *Protected value, safety standard, actual protection level or flood risk*
- *Recent (near-)failures*
- *Key facts governance (which key players) and legislation*
- *Types of guidelines used*
- *X*

TO BE CHECKED

- *2.4 million properties and a significant amount of critical infrastructure at risk from sea or river flooding (and 3 million more by surface runoff), representing an annual economic consequences of river/coastal flooding risk about 960 million pound (slightly over 1 billion Euro).*
- *About 8000 km of levees of 1-6 m height, and 22000 hydraulic / flood protection structures*
- *70% of them along rivers, another 18% along estuaries and 10 % along the coast*
- *Safety requirements up to 1/1000yr for large scale life hazard (depending on cost-benefit), typically 1/100yr or 1/200yr for some life hazard, and 1/5yr - 1/100yr for metrial hazard only.*
- *Some failures during the winters of 2013/2014 and 2015/2016, due to overtopping and inner slope erosion and along transitions. No lives lost, but some people evacuated. Improvements implemented or under investigation.*
- *Levees along sea and main rivers managed by state (Environment Agency), the remaining 50% by third (public or private) parties)*
- *Dam legislation appears to be more restrictive/specific than levee legislation.*
- *There are central registers for dams, and also for major levees.*
- *Common practices are annual risk-based maintenance programmes, risk-based inspections every 0,5-5 years (depending on risk) and flood event management.Rough estimate of reinforcement cost is 650 pound/km, somewhat less than 1 MEuro/km.*
- *Critical knowledge gaps relate to climate change/adaptation, levee performance and failure modes (especially near transitions), predicting life stage of levee and vegetation management.*
- *2.4 million properties at risk from sea or river flooding (and 3 million more by surface runoff)*

3.9 References (per country)

Please support the Country-specific facts of the previous sections by references and weblinks as much as possible, so that information remains traceable and easy to update.

Long term investment strategy https://www.gov.uk/government/publications/flood-and-coastal-risk-management-in-england-long-term-investment

4 Finland [IN PROGRESS – up to section 5.4/5.5]

PLEASE NOTE:

YELLOW MARKED text gives a description of the contents that are requested for this report
GREEN MARKED text gives information that may be of help when you are writing your country chapter.

TO BE FILLED AS MUCH AS POSSIBLE BY EACH COUNTRY. You do not need to provide lengthy texts; brief fact-sheet like texts are sufficient, at least for now.

You may find your chapter already filled in with some first suggestions; please feel free to use them or replace them with your own text, as you wish. In the end, the text is about your country, and therefore we prefer the final text is primarily your text and not the text of the main editors.

++
INFORMATION THAT MAY BE OF HELP WHEN COMPILING YOUR CHAPTER

-

The report http://www.crue-eranet.net/partner_area/documents/D5_Main_Report.pdf contains some useful facts and figures on levees and the governance of Flood Risk Management (FRM) of many European countries, even though the data are 10 years old and not always up to date. However, they may be very useful to supplement that data gathered by our Levee Working group members, when they have difficulty in getting the right data:

- Table 34: Total yearly FRM investment Europe: close to or over 3 billion Euro.
- In each country chapter: years with main recent flood events
- CH3 – FINLAND
  - Estimated flood damage potential 500-600 mln Euros

inary flood risks assessments (PRFA's) and flood risk management plans (FRMP's) of the EU Floods Directive (http://www.envir.ee/sites/default/files/flooddirective.pdf; http://ec.europa.eu/environment/water/flood_risk/) may also provide useful information; water authorities can be found on http://www.eea.europa.eu/themes/water/interactive/floods-directive-viewer .

Some country- or river specific information can be found on:

- www.climateadaptation.eu: Quite useful site for some general information on vulnerability to for instance river floods, but also coastal floods, flash floods & urban floods, etc. etc., see for example:
  - Slovenia: http://www.climateadaptation.eu/slovenia/river-floods/
  - Italy: http://www.climateadaptation.eu/italy/river-floods/
  - Romania: http://www.climateadaptation.eu/romania/river-floods/
- Finland, flood maps and other information: http://www.environment.fi/en-US/Waters/Floods/Flood_risk_management/Flood_risk_management_planning

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4.1 Facts and figures on levees and flood defences

This section is meant to answer questions like:

- *how many levees and other flood defences do you have (km's / nr's)*
  - *other flood defences may be moveable flood walls, storm-surge-barriers and also ordinary gates and sluices (the latter may be so numerous it may be too difficult to quantify them)*
- *what are typical dimensions and other properties (materials, layering, revetment, ..) for (different types of) levee in your country*
- *what is the geographical context: what are typical environments / flood types (% urban/rural levees, % river, estuary or coastal levees)*

- ***Could you give also an indication of yearly spendings on levee management and levee reinforcement (or on overall flood risk management if only that is available)? We think it has added value to present these numbers, and especially make clear what Business Case is hidden in the levee issue.***

You may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

There are quite a few levees in Finland. The data of the amounts of levees are being developed and they should be available in 2017. There are about 500 levees stored in the data system of the Environmental Administration. But this might involve some errors and an amount of levees might not be included.

Bottema, Marcel (WVL) 14/4/16 16:12
Commentaire: Perhaps a rough indication of km's of levees is possible already?

Most of the levees are embankments that have been built to protect the agriculture. Many of these levees have been built on a soft ground. Embankments are made of clay or silt and they even may be used for agriculture. Because of the structure, embankments may have to be raised (rebuilt) from time to time. Most of these levees are low and a flood with return period rarer than once in 20 years will overtop the embankment.

The revised Dam Safety Act came into force in Finland in 2009. One of the improvement was that flood embankments were defined as dams. Before the revision one levee had already been classified according to the previous Dam Safety Act (1984). At the moment there are 10 levees that have been classified and they are under the supervision of the dam safety authority. 20 Levees are waiting for the classification. Some of the levees are old and in poor condition. New levees have been built in past few years as a result of the European flood directive work.

The most important dam in Finland is a levee. It protects the city of Pori and around 15 000 people living in the hazard area. Most of the levees have been built in the 1950's and 1970's and for agricultural purposes. The scaling has been pretty low. These levees have been improved since 2008. The levee in Pori is classified as class 1 dam (highest consequence class).

Most levees reduce the risk of the river floods, but some new ones embank sea flood. During the winter time in Finland there is also the risk of frazil ice forming ice jam. This phenomena increases the risk of flooding in rivers.

4.2 Protected value, safety standards and flood risk

This section is meant to give an indication of the following:

- *What is (by and large) the protected value that could flood without levees and flood defences. Both in terms of life and economic value (preferably the assets, otherwise a fraction of the Gross Domectic Product)*
- *Do your levees and structures have a safety standard, and if so what does it refer to and what value has it got*
- *What is the actual protection level of your levees etc. (or what % does or does not satisfy the safety standards)*
- *Coming to the first issue: what is the residual risk (related to flooding despite the levees etc.), and how large is it compared to protected value (the ratio is in fact a measure of the actual protection level)*

The levee in Pori protects 15 000 people and about 5 000 buildings. These are located in the area of 50 km^2. There are also other targets in the hazard area, like industry.

The economic value is around 3 billion euros. Most of the other levees pose a less danger. There is less than 100 residential buildings in the hazard area and the height of flood water is not expected to endanger human life.

At the moment levees are in general built to protect from a flood with the return period of once in 100 years. During the past years many levees have been heightened and improved.

4.3 Recent major floods and (near-)failures of levees

This section is meant to give a brief description of (near-)failures of levees/structures, and their causes and failure modes. Detailed information is not required, but we wish this section to serve as a portal to this detailed information.
Again, you may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

NOTE – Episodes with major storm surges or major high-river-discharge episodes without damage are also be relevant to mention as they give a measure of proven strength of the levees and flood defences.

In 2005 the sea level was exceptionally high. The return period of the flood was estimated to be once in 30 years. Many temporary flood defences were built to protect for example the areas near to sea in Helsinki, the capital on Finland.

River floods are quite common in Finland during the spring time as the snow melts. Very big spring floods have occurred in 1953, 1966, 1984 and 2000. According to the statistics the highest river flooding occurred in 1807 in Rovaniemi as the river water was 9 meters higher than during a normal summer. The spring flood in 1984 had the return period of once in 30-40 years. It caused many residental buildings to wet and it interrupted the use of an important highway and caused many other things. In 2005 spring flooding in the Lapland cost 4,7 million euros.

The Ministry of Agriculture and Forestry has estimated that extremely rare flooding (once in 250 years) would cost around 550 million euros.

4.4 Legislation and governance

Please give a short description about the main legislation related to levees and flood defences.

Please also indicate whether (i) this legislation is similar or even identical to the legislation used for dams (please check the Dam Legislation Report from the ICOLD European Club; levees are mentioned at least for ES, FI, FR and NL) and whether (ii) this legislation is a translation of the EU Floods Directive. The latter is interesting, because it allows to get an indication to what extent the Floods Directive has resulted in a common legal framework throughout Europe.
Besides this, it is also important to describe the key players with respect to Levees and Flood Risk Management and how they interact, i.e. the governance with respect to all life cycle phases of Levees and Flood Defences. Not only to describe the governance, but also to make clear how easy/difficult it is to get relevant information.

The supervision of dams in Finland is made by the Dam Safety Act (494/2009) and the Government Decree on Dam Safety (319/2010). [Both in English: http://www.finlex.fi/en/laki/kaannokset/2009/en20090494.pdf and http://www.finlex.fi/en/laki/kaannokset/2010/en20100319.pdf] The Dam Safety Act

defines that "dam means a structure such as a wall or embankment the purpose of which it is to permanently or temporarily prevent the spread of a liquid or substance that behaves like a liquid impounded by the dam or to regulate the surface level of the impounded substance;" and "flood embankment means a structure the purpose of which is to prevent the spread of water at times when the water level of a watercourse or sea level is unusually high". Therefore flood embankments are dams and if a flood embankment in the event of an accident may cause any danger it has to be classified by the Dam Safety Act. The dam safety authority (the ELY Centre for Kainuu) supervises dams and levees, if they pose a danger.

The EU Flood directive has been implemented in Finland by the Flood Risk Management Act (620/2010) 24th July 2010 and Government Decree on Flood Risk Management (659/2010) 7th July 2010. [Both in English in the internet: http://www.finlex.fi/en/laki/kaannokset/2010/en20100659.pdf and http://www.finlex.fi/en/laki/kaannokset/2010/en20100620.pdf]

The Flood Risk Management Act Section 10 defines Flood risk management plans which has to be prepared for river basins with one or several designated significant flood risk areas and a significant flood risk area in the coastal area. These flood risk management plans are ready and approved by the Ministry of Agriculture and Forestry. These plans are the reason for the construction of some new levees.

4.4.1 Legislation and governance – implementation EU Regulations

Please briefly describe how key EU legislation (mainly/especially the Floods Directive) is translated into national policy and legislation.

See above 11.4.

4.4.2 Legislation and governance – National legislation

Please give a short description about the main national legislation related to levees and flood defences, and whether/how it differs from Dam Legislation.

See above 11.4.

4.4.3 Legislation and governance – Governance

Please give a short description about the governance of levees and flood defences, i.e. the main parties / key players involved and their roles and duties.

If the levee is classified by the Dam Safety Act, the dam safety authority (the ELY Centre for Kainuu) is responsible for the supervision of the dam. Dam (levee) owner is responsible for the design, construction, operation and maintenance of the dam.

If the levee is not classified, the owner is responsible for the design, construction, operation and maintenance of the dam, but there is not any real supervision.

Bottema, Marcel (WVL) 14/4/16 16:24
Commentaire: Is the levee owner ypically a public organisation, private organisation or private person?

4.5 Guidelines and good practices

Please mention what guidelines and good practice documents you use for design, safety assessment and maintenance of levees/flood defences; please give references/weblinks to some key documents.
Please also mention what parts of ICOLD-Bulletins and/or the International Levee handbook ILH are used in your country for the above.

The Dam Safety Act http://www.finlex.fi/en/laki/kaannokset/2009/en20090494.pdf
The Government Decree on Dam Safety
http://www.finlex.fi/en/laki/kaannokset/2010/en20100319.pdf
The Dam Safety Guide http://www.environment.fi/en-US/Waters/Use_of_water_resources/Dams_and_dam_safety/Dam_Safety_Guide

4.6 Common practices during Levee Life Cycle

Bottema, Marcel (WVL) 14/4/16 16:08
Commentaire: To be completed

This section is meant to briefly share some common practices related to various life cycle phases of Levees & structures:

- *Design practice and cost of reinforcement (per km or per object)*
- *Inspection of levees*
- *Maintenance and safety assessment*
- *Flood event management*
- *…*

4.7 Critical knowledge and data gaps; critical research needs

Bottema, Marcel (WVL) 14/4/16 16:08
Commentaire: To be completed

This section is meant to summarise critical data and knowledge gaps, as well as critical research needs.
Please not this is really about the critical knowledge gaps and research needs for proper (risk-based) management of levees, not about nice-to-know knowledge.
We need this information to be able decide on further topics to be explored with our working group

4.8 Summary of key facts

Bottema, Marcel (WVL) 14/4/16 16:09
Commentaire: To be check & completed

This section is meant to summarise some key facts and figures in just a few words, for easy comparison amongst countries, and to facilitate writing the summary and conclusions:

- *Km of levees, no. of structures*
- *% along river, estuary, sea, lake*
- *Protected value, safety standard, actual protection level or flood risk*
- *Recent (near-)failures*
- *Key facts governance (which key players) and legislation*
- *Types of guidelines used*

- About 500 registered levees
- Most levees protect farm land from rivers, also some sea levees and urban levees
- The most important levee (at Pori) protects 15000 people and 3 billion Euro in assets
- Many levees are now being constructed or improved in response to the EU Floods Directive, safety standards are also upgraded to typically 1/100 yr.
- Damage potential for a 1/250 yr flood would be about 550 mln Euro
- Large (springtime/snow-melt) river floods in 1953, 1966, 1984 and 2000 with up to 5 million Euro damage; large (1/30 yr) storm surge in Helsinki in 2005.
- Dams and levees have common legislation/regulation
- Classification of levees is underway; classified dams and levees are supervised by ELY, but the dam/levee owner is responsible for all other aspects

Bottema, Marcel (WVL) 14/4/16 16:20
Commentaire: Consistent with the 550 million Euro damage potential below?0

Bottema, Marcel (WVL) 14/4/16 16:28
Commentaire: Please check/supplement

4.9 References (per country)

Please support the Country-specific facts of the previous sections by references and weblinks as much as possible, so that information remains traceable and easy to update.

5 France [with nearly complete draft text]

TO BE FILLED AS MUCH AS POSSIBLE BY EACH COUNTRY. You do not need to provide lengthy texts; brief fact-sheet like texts are sufficient, at least for now.

You may find your chapter already filled in with some first suggestions; please feel free to use them or replace them with your own text, as you wish. In the end, the text is about your country, and therefore we prefer the final text is primarily your text and not the text of the main editors.

++

INFORMATION THAT MAY BE OF HELP WHEN COMPILING YOUR CHAPTER

The report http://www.crue-eranet.net/partner_area/documents/D5_Main_Report.pdf contains some useful facts and figures on levees and the governance of Flood Risk Management (FRM) of many European countries, even though the data are 10 years old and not always up to date. However, they may be very useful to supplement that data gathered by our Levee Working group members, when they have difficulty in getting the right data:

- Table 34: Total yearly FRM investment Europe: close to or over 3 billion Euro.
- In each country chapter: years with main recent flood events
- CH4 – FRANCE
  - 250 mln Euro annual damage, 500 mln annual investment in flood & coastal protection

The preliminary flood risks assessments (PRFA's) and flood risk management plans (FRMP's) of the EU Floods Directive (http://www.envir.ee/sites/default/files/flooddirective.pdf; http://ec.europa.eu/environment/water/flood_risk/) may also provide useful information; water authorities can be found on http://www.eea.europa.eu/themes/water/interactive/floods-directive-viewer .

Some country- or river specific information can be found on:

- www.climateadaptation.eu: Quite useful site for some general information on vulnerability to for instance river floods, but also coastal floods, flash floods & urban floods, etc. etc., see for example:
- Rhine countries PFRA, FRMP, maps: http://www.iksr.org/en/floods-directive/flood-risk-management-plan/index.html

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NOTE – ALL YELLOW/ITALIC HELP TEXTS BELOW WILL BE MOVED TO APPENDIX ONCE CHAPTER IS COMPLETE

5.1 Facts and figures on levees and flood defences

This section is meant to answer questions like:

- *how many levees and other flood defences do you have (km's / nr's)*
  - *other flood defences may be moveable flood walls, storm-surge-barriers and also ordinary gates and sluices (the latter may be so numerous it may be too difficult to quantify them)*
- *what are typical dimensions and other properties (materials, layering, revetment, ..) for (different types of) levee in your country*
- *what is the geographical context: what are typical environments / flood types (% urban/rural levees, % river, estuary or coastal levees)*
- ***Could you give also an indication of yearly spendings on levee management and levee reinforcement (or on overall flood risk management if only that is available)? We think it has added value to present these numbers, and especially make clear what Business Case is hidden in the levee issue.***

You may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

In France, two main families of hydraulic structures help ensure flood protection:

- levees and similar structures whose purpose is to prevent water (from the sea, a river, a lake or a torrent) to flood a so called "protected" area,

- flood retention dams whose purpose is to store flood water and lower the flood peak discharge, usually found only on rivers; some of these have one or more functions other than flood retention.

Also, some diversion canals can be found, whose function is to divert a part of a river flood flow to another area which can be a pond or lake, the sea, or a flood retention area or basin.

Levee based protection systems often include structures which are multifunctional, as many structures whose main vocation is not flood protection actually have this role. They can be linear transport infrastructures (roads, railways, navigation canals) or other type of structures (harbour infrastructure, buildings, pumping stations, ….).
Protection systems can also include natural features like dunes, rocky high ground, …
Protection systems also include many type of "annex" hydraulic structures, like sluices, gates, culverts, …
There are no or very few temporary protection like temporary raising structures or flood walls, except common gates closed during flood.

Flood retention areas can be natural (unprotected land) or artificial. In the latter case they result from the existence of a dam or basin (in this case the flood in the storage area can be higher than the natural flood in terms of water level) or of a levee system (in this case the flood risk in the storage area is generally reduced from natural flood risk in terms of frequency and/or water level and velocity)

There are no noticeable, moveable storm surge barriers, except some harbour locks.

There are about 9000km of levees in France, about 8000km of inland levees (rivers, lakes, torrents) and 1000km of marine levees (sea, estuaries), these figures include multipurpose structures. These figures concern mainly the first line of defense, and no secondary line of defense or indirect protection structures like groynes, breakwaters or river weirs. Levees height range up to 6 meters high with possible local exceptions higher than this.

According to their size, there are thousands or tens of thousands of dams, probably thousands of flood retention dams, most of them being small or multifunctional. French highest dam, Serre-Ponçon has among other roles, flood retention, and is 124m high for a reservoir volume of 14hm^3. The smallest flood retention dams only have a few meters high and thousands of m^3, they can be built on temporary or permanent rivers, but also sometimes on "dry" thalwegs.

Flood protection levees are usually made from earth material, but there are some other types of dikes (flood walls, "hard" structures, "mixed" structures made partially from earth and "hard" material). Most of the levees are built from local material, with a long and complex history and globally heterogeneous (see ILH section 3.3.3) and poorly known in detail, apart levees which have been recently rebuilt or reinforced. River levee material is generally silty or clayish, while sea levees material is often sandy with a hard protection structure or in other cases made from very fine material from local swamp sludge.

5.2 Protected value, safety standards and flood risk

This section is meant to give an indication of the following:

- *What is (by and large) the protected value that could flood without levees and flood defences. Both in terms of life and economic value (preferably the assets, otherwise a fraction of the Gross Domectic Product)*
- *Do your levees and structures have a safety standard, and if so what does it refer to and what value has it got*
- *What is the actual protection level of your levees etc. (or what % does or does not satisfy the safety standards)*
- *Coming to the first issue: what is the residual risk (related to flooding despite the levees etc.), and how large is it compared to protected value (the ratio is in fact a measure of the actual protection level)*

The stakes of flood risk
An estimation has been made by an official group representing the insurance companies on the annual cost of major floods, it gives a total of 200 to 300 M€ for insured damage and 1 to 1.4 billion € for all damage. This is for both protected and unprotected areas, based on present situation of the protection system. From 12 to 20% of this damage relates to maritime events, this percentage is expected to raise, given the higher hazard due to climate change, and the increase of urbanization close to the seas.

17.1 million people live in river flood hazard areas, which represents 5% of the national surface, with 9 million jobs located in it.
1.4 million people live in sea flood hazard areas, with 850000 jobs located in them.

The major flood protection systems "protect" about 20000km^2 and about 2M people.

Safety standards
The "modern" approach to safety standards is to make a distinction between the protection level (the level up to which the protected area is not flooded), and the safety level (the level up to which there is no chance of the levee breaching, by any mechanism). The first of these is related to the main hydraulic function, the second one to a structural performance.
Old levees can have an *apparent* protection level higher than the safety level, which so becomes the actual protection level. This situation is not acceptable, but is often the case of old levees (a rough estimation gives a rate of one out of three). Furthermore, the higher the apparent protection level, the higher the consequences in the case of a breach before this level.
The optimum situation is a to have a safety margin above the protection level, so the protected area can be flooded above this limit, in a controlled way, without breaching. Systems such as these have resiliency to overtopping/overflowing, either because of existence of a spillway or because of some physical resistance to overflowing/overtopping in the lower sketches, for instance because of a revetment.

There is NO standard for flood protection level, which is up to the local stakeholders to set. Typical (apparent) flood protection level usually ranges from 1/5 to 1/10 years in agricultural areas and from 1/20 to 1/100 years in populated areas. An upgraded and resilient system currently in project in the south of the Rhone river will protect against floods up to 10^{-2} annual probability and will be able to withstand floods up to 10^{-3} annual probability without damage.

actual safety level of existing levees
There is also no standard for the safety level of levees. Engineering rules apply to levees for design or regular verification/justification. French COLD, CFBR, publishes guidance on how to conduct such calculations, but there is no set value for the safety level, which is, like the protection level left to the appreciation of the local stakeholders.

residual risk
The question, as it is phrased does not really relate to the French situation and way to analyse flood risk and levee situation.
1/ there are many areas which are subject to flood risk but not protected by structures.
2/ in protected areas, we should know, because of regulatory Hazard Studies (études de dangers) what is the actual residual flood risk, due to water level being higher than the protection level OR because of levee failure. But these have not been conducted in all systems at the present moment, consequently we don't have a national synthetic situation.

5.3 Recent major floods and (near-)failures of levees

This section is meant to give a brief description of (near-)failures of levees/structures, and their causes and failure modes. Detailed information is not required, but we wish this section to serve as a portal to this detailed information.
Again, you may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

NOTE – Episodes with major storm surges or major high-river-discharge episodes without damage are also be relevant to mention as they give a measure of proven strength of the levees and flood defences.

France did not have any flood defence failure since the 19th century, until the winter 1993-94, when two floods from Rhone river caused multiple breaches in the levees and flooded the Camargue delta. Since this episode, other important events reminder the society the necessity to take proper care of existing flood defences: Aude 1999, southern Rhone 2002, Rhone 2003, coastal storm surge Xynthia 2010.

The breaches and other important damage (to be detailed)

Bottema, Marcel (WVL) 14/4/16 15:55
Commentaire: To be detailed

5.4 Legislation and governance

Please give a short description about the main legislation related to levees and flood defences.

Please also indicate whether (i) this legislation is similar or even identical to the legislation used for dams (please check the Dam Legislation Report from the ICOLD European Club; levees are mentioned at least for ES, FI, FR and NL) and whether (ii) this legislation is a translation of the EU Floods Directive. The latter is interesting, because it allows to get an indication to what extent the Floods Directive has resulted in a common legal framework throughout Europe.
Besides this, it is also important to describe the key players with respect to Levees and Flood Risk Management and how they interact, i.e. the governance with respect to all life cycle phases of Levees and Flood Defences. Not only to describe the governance, but also to make clear how easy/difficult it is to get relevant information.

5.4.1 Legislation and governance – implementation EU Regulations

Please briefly describe how key EU legislation (mainly/especially the Floods Directive) is translated into national policy and legislation.

The European Flood Directive has been implemented in France, with no direct link with the levees management or levee related regulation. Levees are taken into account in the general appreciation of the flood risk, but not in detail for this first implementation.
The first national flood risk management strategy adopted October 7, 2014 is part of the strengthening of the national flood risk management initiated within the framework of the implementation of the EU Floods Directive.
The preliminary assessment of flood risks (évaluation préliminaire des risques d'inondation, EPRI) conducted by the State in 2012, across the country, found that nearly 1 out of 4 French citizen and 1 of 3 jobs are potentially exposed today. Given this situation, and under the impulse of the flood directive, France has mobilized considerable human, technical and financial resources to strengthen its policy of managing the various risks of flooding they both marine submersion, overflow of rivers (river as torrential), slick ascent, urban or agricultural runoff.
Thus for the first time, France has a policy that requires a proactive approach to flood prevention across all risk areas: the aim of this policy is to pay particular attention to sectors most exposed: significant risk flood areas (territoires à risque important d'inondation, TRI), but also to areas unaffected by floods in recent decades.
Beyond the involvement of all territories, and through this strategy, the Government recalls that everyone has a role to play to risk flooding: citizens, businesses, local, state must adapt their behaviour. To better protect themselves, it is essential to participate and to better understand the risks to which it is exposed.
Following a national consultation with the general public, the national flood risk management strategy aims to ensure the coherence of actions in the territory. It was arrested by the Ministers of Ecology, Interior, Agriculture and Housing on October 7, 2014.
The national strategy sets three main objectives:

- increase the security of populations
- reduce the cost of damage
- greatly shorten the time to return to normal in disaster areas.

The collective and concerted development of this strategy of flood risk management in the Flood Joint Commission (Commission mixte inondation, CMI), led to a text shared by both the State and the stakeholders. This strategy responds to the high expectations of all stakeholders, including local authorities, of a shared framework to guide the national flood risk management policy.
Set up exactly one year after the transposition of the European Directive on floods as a national commitment into the environmental law of July 12, 2010, the CMI embodies the shared governance between the government and stakeholders needed to reform the national flood risk management policy. This reform is being written today in the national risk management strategy (stratégie nationale de gestion des risques, SNGRI) whose development is closely monitored by the CMI.
Through the affirmation of the main strategic guidelines, the CMI works, in fact since 2011, to change the policy of prevention to risk management objectives based on the prioritization of territories and fields of action. In support of its work, the CMI puts directly into practice these strategic principles by examining and labelling Flood Prevention Action Programmes (Programmes d'Actions de Prévention des Inondations, PAPI) borne by communities, and by supporting major river basins in the establishment of their flood risk management plan (plan de gestion des risques d'inondation, PGRI) accompanied by local strategies. Many of these PAPIs involve flood protection works.

5.4.2 Legislation and governance – National legislation

Please give a short description about the main national legislation related to levees and flood defences, and whether/how it differs from Dam Legislation.

The same regulation relates to dams, levees and other protection structures, and has for objective the safety of the structures and the security of the population who can be at risk in the case of their failure. Dams are classified according to their height and the volume they can contain, levees are classified according to their height and the population they protect. According to the class of a structure, the responsible organization (owner for a dam, manager for a levee) has to fulfil some obligations:

- maintaining an archive of all documents related to the structure (administrative and technical: design, assessments, works, events, …),
- keeping a day-to-day register of all events (dams only),
- having written instructions for operation and maintenance, including a special section on operation during flood events,
- conducting and reporting detailed regular inspections (periodicity depends of the class),
- preparing an report on operation, maintenance and incidents (obligation and periodicity depend on the class),
- conducting and reporting a monitoring analysis (dams only, obligation and periodicity depend on the class),
- initial safety assessment (only for levees),
- regular complete assessment and risk analysis (obligation and periodicity depend on the class),
- information of the State authorities in case of incident or accident,
- submitting major work projects for Class A dams and levees and risk analysis of levee systems of Class A to the opinion of the Standing Technical Committee on Dams and Hydraulic Structures.

Engineering companies have to be accredited by the Ministry of environment, based on references.
The first version of this regulation (which includes various texts), is based on a decree of December 11, 2007, with 4 classes (A to D) for dams and levees. An adaptation of this regulation is going on (some texts are still being written), with only three classes for both dams and levees, the smaller ones having no obligation.

5.4.3 Legislation and governance – Governance

Please give a short description about the governance of levees and flood defences, i.e. the main parties / key players involved and their roles and duties.

The State (Ministry of Environment) is in charge of regulation, and its local services are in charge of controlling the regulation is applied by the owner or manager. Usually dams have only one owner, so it's the owner responsibility to apply the regulation. Most of the levees, and furthermore levee systems, have many owners so the responsibility of applying the regulation falls to the manager (which does not absolve the owners from any responsibility in case of problem). The safety of the population is an attribution of the Mayor of the commune, wether the levees are managed by it or not.

At the moment levee management organisation are of various type (private: people, associations or companies, public: State, local authorities, association of local authorities, public institutions or companies, …). New laws (No. 2014-58 of 27 January 2014 and n° 2015-991 of 7 August 2015) defines the Management of aquatic environments and flood prevention (gestion des milieux aquatiques et prévention des inondations, GEMAPI) as a scope entrusted to intercommunal level (cities, urban communities), as of January 1, 2018, with the possibility to anticipate now. This assignment, which is exclusive and mandatory, will supersede the existing shares of local authorities and their groupings, actions that were previously optional and not uniformly present in the territory at risk of river flood or marine submersion.

5.5 Guidelines and good practices

Please mention what guidelines and good practice documents you use for design, safety assessment and maintenance of levees/flood defences; please give references/weblinks to some key documents.
Please also mention what parts of ICOLD-Bulletins and/or the International Levee handbook ILH are used in your country for the above.

The French Ministry of Environment has sponsored a "Technical reference manual for sea and river levees". The purpose of this document is to provide a common technical basis for mutual understanding of the actors in the field (works managers, state services, engineering offices, other flood risk manager, territory manager) during their communications; it is not a regulatory document nor prescriptive. The presented concepts and principles are for the purpose of clarification and sharing of vocabulary and even some methods.

There are no specific guidance documents for the design of levees. CFBR issues general guidance documents which can be applied to both dams and levees, with some specificities when needed, including "Recommendations for confirmation of stability of embankment dams and levees".
The ILH is used by some of the profession, but because of the language this is not general. A translation of the ILH in French language is going on.

In terms of guidance for assessment, investigation, inspection and management, Cemagref (now Irstea) published the following handbooks, which are used as reference by many members of the levees community (managers, engineering, …):

- Lino et al., 2000, Méthodologie de diagnostic des digues appliqués aux levees de la Loire moyenne
- Mériaux et al., 2004, Surveillance, entretien et diagnostic des digues de protection contre les inondations : Guide pratique à l'usage des propriétaires et des gestionnaires, (an English version can be ordered here: http://www.quae.com/fr/r141-surveillance-maintenance-and-diagnosis.html)
- Fauchard C., Mériaux P., Méthodes géophysiques et géotechniques pour le diagnostic des digues de protection contre les crues (an English version can be ordered here: http://www.quae.com/fr/r135-geophysical-and-geotechnical-methods-for-diagnosing-flood-protection-dikes.html)

The outputs from the FloodProBE EU project Work Package 3 are also used, regarding geophysics and use of LIDAR (http://www.floodprobe.eu/project-outputs.asp).

5.6 Common practices during Levee Life Cycle

This section is meant to briefly share some common practices related to various life cycle phases of Levees & structures.

- *Design practice and cost of reinforcement (per km or per object)*
- *Inspection of levees*
- *Maintenance and safety assessment*
- *Flood event management*
- *...*

Inspections performed by the levee management in France:

- Complete initial inspection. This inspection is needed in order to initialize the knowledge about the levee. Part of the initial assessment. Helps as a reference for future inspections, up to the next complete inspection.
- Operational inspections by levee guards.
- Detailed inspections performed by engineers, either part of the manager staff or hired contractors. Frequency can vary between one and 5 years based on the magnitude of the protected population.
- Complete inspections including hidden parts (underwater and inside pipes) performed by engineers including possibly specialists, either part of the manager staff or hired contractors. Once every ten years and only for Class A & B levees. Helps as a reference for future inspections, up to the next complete inspection. Part of the periodic safety review process.
- Pre-Flood inspections are not required, but useful.
- During flood inspections are performed by the levee manager, possibly with help from local authorities and levee owners.
- Post-flood inspections are required, and can be a good source of information not normally available (i.e., seepage, closure integrity).
- Special inspections as part of a specific assessment, triggered because of a special event (accident, seismic), because of planned works, or other specific reason.

Levee control authority inspections performed by the French State authorities:

- Initial inspections. In France the control of levees by the State is quite recent and many levee systems are yet to be inspected for the first time. During the initial inspection, the control authority has to obtain all pertinent information about the levee and its management, and check the safety of the levee through the level of knowledge and organization of the levee manager and the result of its own assessments.
- Periodic inspections. For class A, B & C levees (period varying from 1 to 10 years).
- In-flood inspections. Performed by control authorities when managers report safety issues.
- Post-flood inspections. Performed by control authorities when managers report safety issues.
- Special inspections. Control authorities can perform special inspections, particularly when there are safety issues or planned modifications.

Safety assessment and risk analysis have to be conducted at least every ten years for the major levee systems. They should (as indicated in the figure 5.1 of the ILH) be used as a decision making information tool.

Regular maintenance is generally planned in advance, or it can be decided as a result of an inspection which detects some repairs to be done.
SYMADREM (levee management organization for the south of the Rhône river and sea) spends 14000€/km each year for levee inspection and maintenance.

Major repairs need to be decided and defined after a complete assessment, including a diagnosis of the causes of the (eventually potential) problem(s). Typical reinforcement works cost in a range of 1-2 M€/km.

Flood event management is not defined by regulation, but it has to be defined at the local management scale, and described in a written document.

5.7 Critical knowledge and data gaps; critical research needs

This section is meant to summarise critical data and knowledge gaps, as well as critical research needs.

Please not this is really about the critical knowledge gaps and research needs for proper (risk-based) management of levees, not about nice-to-know knowledge.
We need this information to be able decide on further topics to be explored with our working group

[[Text will follow]]

5.8 Summary of key facts

This section is meant to summarise some key facts and figures in just a few words, for easy comparison amongst countries, and to facilitate writing the summary and conclusions:

- *Km of levees, no. of structures*
- *% along river, estuary, sea, lake*
- *Protected value, safety standard, actual protection level or flood risk*
- *Recent (near-)failures*
- *Key facts governance (which key players) and legislation*
- *Types of guidelines used*

- About 9000 km of levees (roughly 90% inland and 10% coastal)
- Usually from locally available earth material, height usually up to 6 m.
- Annual flood damage order 1 billion Euro/yr, roughly 25% insured
- 18 million people live in potential flood hazard areas, 2 million people and 20000 km^2 (roughly 3% of France) are protected by major flood protection systems.
- Some recent flood defence failures, but no failures until 1993
- Levees have no explicit role in Floods Directive implementation
- Similar legislation for levees, dams and other protection structures
- Common practices and obligations depend on levee type/class (depending on height and protected population)
- Many levees to be inspected for first time; for high-risk levees in-depth inspections/assessments every 1-10 yrs.
- Governance: various parties involved: from state to municipality to home/ground owner
- No prescriptive guidelines, but various informal guidance documents
- Annual maintenance+inspection typically 14 kEuro/km, reinforcement typically 1-2 MEuro/km

Bottema, Marcel (WVL) 22/3/16 08:45
Commentaire: summarised by NL, to be checked by France

5.9 References (per country)

Please support the Country-specific facts of the previous sections by references and weblinks as much as possible, so that information remains traceable and easy to update.

- Policy for the management of flood risk: http://www.developpement-durable.gouv.fr/IMG/pdf/13195-2_deploiement-polit-gestion-risques-inondation.pdf
- National strategy for flood risk management: http://www.developpement-durable.gouv.fr/La-strategie-nationale-de-gestion,40051.html
- Preliminary flood risk evaluation (2011): http://catalogue.prim.net/190__evaluation-preliminaire-des-risques-d-inondation-nationale.pdf
- CFBR (and other) documents: http://www.barrages-cfbr.eu/Recommandations.html
- Référentiel technique digues : http://www.barrages-cfbr.eu/IMG/pdf/referentiel_technique_digues_maritimes_et_fluviales.pdf

Bottema, Marcel (WVL) 25/4/16 10:20
Commentaire: Overall german data approximate, since not from all Länder, information could be gathered in time

NOTE – Photo's and figures in low resolution to keep file size manageable.

6 Germany

PLEASE NOTE:

YELLOW MARKED text gives a description of the contents that are requested for this report
GREEN MARKED text gives information that may be of help when you are writing your country chapter.

TO BE FILLED AS MUCH AS POSSIBLE BY EACH COUNTRY. You do not need to provide lengthy texts; brief fact-sheet like texts are sufficient, at least for now.
You may find your chapter already filled in with some first suggestions; please feel free to use them or replace them with your own text, as you wish. In the end, the text is about your country, and therefore we prefer the final text is primarily your text and not the text of the main editors.

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INFORMATION THAT MAY BE OF HELP WHEN COMPILING YOUR CHAPTER

The report http://www.crue-eranet.net/partner_area/documents/D5_Main_Report.pdf contains some useful facts and figures on levees and the governance of Flood Risk Management (FRM) of many European countries, even though the data are 10 years old and not always up to date. However, they may be very useful to supplement that data gathered by our Levee Working group members, when they have difficulty in getting the right data:

- Table 34: Total yearly FRM investment Europe: close to or over 3 billion Euro.
- In each country chapter: years with main recent flood events
- CH5 – GERMANY
  - About 7500 km flood protection dikes and walls
  - Several billion Euro damage due to recent floods

The preliminary flood risks assessments (PRFA's) and flood risk management plans (FRMP's) of the EU Floods Directive (http://www.envir.ee/sites/default/files/flooddirective.pdf; http://ec.europa.eu/environment/water/flood_risk/) may also provide useful information; water authorities can be found on http://www.eea.europa.eu/themes/water/interactive/floods-directive-viewer .

Some country- or river specific information can be found on:
- www.climateadaptation.eu: Quite useful site for some general information on vulnerability to for instance river floods, but also coastal floods, flash floods & urban floods, etc. etc., see for example:
- Rhine countries PFRA, FRMP, maps: http://www.iksr.org/en/floods-directive/flood-risk-management-plan/index.html
- Danube countries PFRA, maps (and FRMP?): https://www.icpdr.org/main/activities-projects/implementation-eu-floods-directive

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6.1 Facts and figures on levees and flood defences

This section is meant to answer questions like:
- *how many levees and other flood defences do you have (km's / nr's)*
  - *other flood defences may be moveable flood walls, storm-surge-barriers and also ordinary gates and sluices (the latter may be so numerous it may be too difficult to quantify them)*
- *what are typical dimensions and other properties (materials, layering, revetment, ..) for (different types of) levee in your country*
- *what is the geographical context: what are typical environments / flood types (% urban/rural levees, % river, estuary or coastal levees)*
- ***Could you give also an indication of yearly spendings on levee management and levee reinforcement (or on overall flood risk management if only that is available)? We think it has added value to present these numbers, and especially make clear what Business Case is hidden in the levee issue.***

You may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

In Germany large areas at the coasts of the North Sea and the Baltic Sea as well as along many Rivers are protected by levees or flood walls. In some cases these flood defences are completed by demountable elements mostly due to architectural or environmental reasons. All common types of flood defences are being used in Germany. Figure 6.1 gives a schematic overview of the existing flood protection works.

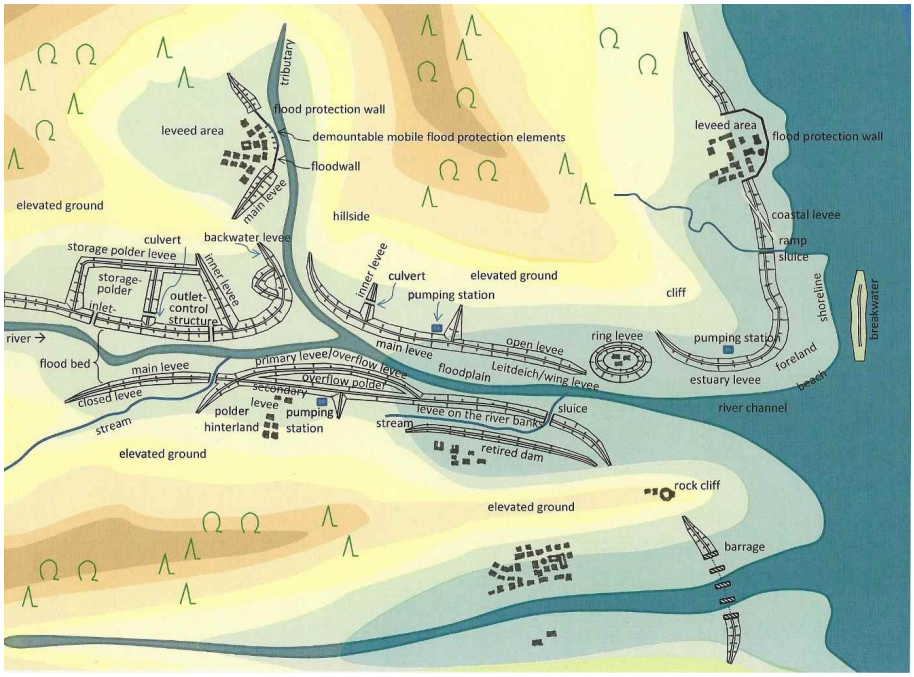

Figure 6.1 Flood defences in Germany (Pohl 2013)

The distribution of the levees referring to the water bodies to protect against may be estimated as follows in Table 6.1.

Table 6.1 percentage of flood defences (of each type) which is linked to the following physical environment / flood threat

following physical environment / flood threat	Estimation for Germany	Estimation for Saxony	Example of a Water Association in North-Rhine Westphalia: Emschergenossenschaft/Lippeverband
Sea	20	-	-
Estuary	3	-	-
Lake	< 1	2	-
River	73	94	100
Torrent	3	4	

The supervision of the flood protection in Germany lies in the hands of the authorities of the 16 federal states (Introduction Law to the German Civil Code (EGBGB) Art. 66). The organization of the flood protection differs from one federal state to another and is regulated within the Water Laws of the different states. In some states the state itself is responsible for the flood protection works and their maintenance. Elsewhere this work is done by communities, water associations or private persons or organizations and only the supervision is carried out by the authorities.

Bottema, Marcel (WVL) 25/4/16 11:05
Commentaire: Table moved to section 6.4.3

That's why there is no nationwide levee inventory existing and some of the following information in this chapter can only be given as examples for certain districts or catchment areas.

About 650 km of levees, about 100 km of flood walls and 10 large pumping stations are situated along waters in Saxony, 1312 km in Saxony-Anhalt and 193 km in the area of the Emschegenossenschaft / Lippeverband in Northrhine-Westphalia. An exact number for the total length of all levees in Germany cannot be given, because it is difficult to define a lower limit of levees.
The height of the levees varies from 50 cm to about 16 m whereas the levee height is defined as the vertical distance between the landside crest level and the ground level at the landside toe.
It is a noteworthiness that there are leveed rivers especially in North-Rhine Westphalia which thalweg is higher than the surrounding ground elevation because of large areal subsidence due to underground coal mining.

Table 6.2 Range Levee Heights

Levee height [m]	Estimation for Germany	Estimation for Saxony	Example of a Water Association in North-Rhine Westphalia: Emschergenossenschaft/Lippeverband
Minimum	0,50	0,50	1
Mean	4	2 … 3	5
Maximum	16	6	16

Figure 6.2 Levees at the floodplains of the Elbe river (federal waterway) and on both sides of the flood bypass channel downstream the city of Dresden at Kaditz Village in the centre of the picture (photograph: R. Pohl)

The History of levees in Germany goes back about 2000 years: The first Levees from the Roman period with a height up to 1,20 meters were found in Friesland at the North Sea Coast. They were erected to protect agricultural areas against inundation and resulting saltination of the topsoil. The first coastal levees were ring-levees which had been connected later to form a closed dike-line at the end of the 13th century. Also the estuaries of the rivers became leveed.

The levees broke from time to time and were rebuilt and heightened step by step, mostly after a breach due to overtopping during a severe flood. Major flood at the German North Sea cost were reported e.g. from 1634 (Burchardiflut), 1717, 1825, 1962 (Hamburg-Sturmflut).
Until the 17th century the levee maintenance was the task of the land owners at the coastline. Often the duty of levee maintenance had overcharged the local people so that they gave up, stuck the spade into the levee crest and left. Those who took the spade got the land and accepted the obligation of levee maintenance. All legal relationships related to levees were regulated by laws like the Bremen Levee Law from 1473.
Later Levee Associations were founded, which organize the flood protection in some federal states of Germany still nowadays.

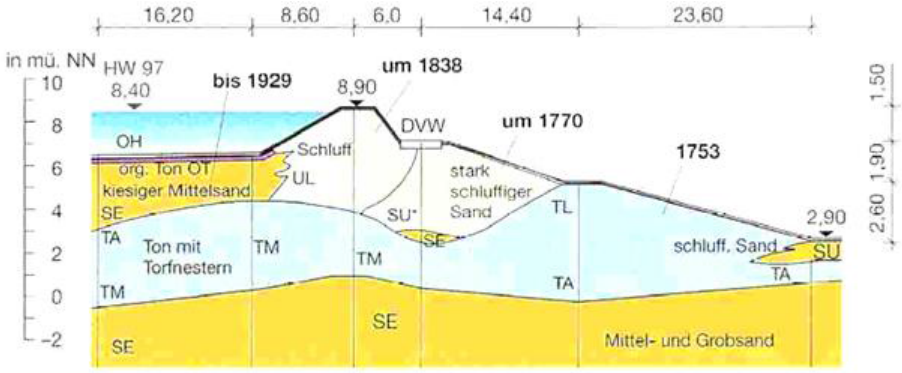

Figure 6.3 Historical development of a levee. Cross section of the Oder-Levee at km 69.45 south of Hohenwutzen (from Krüger et al. 1999)

Some of the disastrous levee failures happened during a storm flood on 16./17. February 1962 in Hamburg and the North Sea Coast, where the levees broke at about 30 sites and 340 people lost their lifes. After this catastrophe the levee lines were straightened, the levees were heightened (up to +8 m asl.) and new levees were built. In the Elbe estuary downstream of the Geesthacht weir, today left of the Elbe river levees with a length of 135.6 km protect a hinterland of 1309 km², on the right bank 99.5 km protect 856 km² and in the city of Hamburg 250 km² are protected by 99.5 km long levees. The total population in this leveed area is 475000 inhabitants (Simon et al. 2005).

Bottema, Marcel (WVL) 25/4/16 11:44
Commentaire: ? => The left bank Ele river levees protect... ?

In the middle reach of the Elbe the first levees were built in 1160 from Elbe km 412 to 450. Today the hinterland (3285 km²) of the Elbe river with 365000 people is flood protected from km 97.7 (downstream Hirschstein Castle) to 585.9 (Geesthacht Weir) with about 730 km levees (Simon et. al 2005). The upper Elbe has in Germany about 20 km of levees in the area of Dresden (in the Czech Republic ≈ 50 km).

In the case of an unforeseen levee failure large damages could arise. Table 6. gives an impression which kind of hazard could be expected.

Table 6.3 percentage of flood damages in the case of a levee failure

Levee height [m]	Estimation for Germany	Saxony: no information available	Example of a Water Association in North-Rhine Westphalia: Emschergenossenschaft/Lippeverband
Almost no hazard	5		16
Material hazard only	45		0
Some life hazard	45		24
Large scale life hazard/economic hazard (say > 100 people/over 100 million €)	5		60

The typical construction and/or rehabilitation costs for 1 km of levee can vary considerably depending on the boundary conditions (height, underground, availability of construction material in the vicinity, level of protection, real estate, compensation, …). Estimated costs range from 100000 €/km to 2.5 million €/km. In Saxony and probably in the most of the other federal states no official statistics concerning the levee costs are available.

6.2 Protected value, safety standards and flood risk

This section is meant to give an indication of the following:

- *What is (by and large) the protected value that could flood without levees and flood defences. Both in terms of life and economic value (preferably the assets, otherwise a fraction of the Gross Domectic Product)*
- *Do your levees and structures have a safety standard, and if so what does it refer to and what value has it got*
- *What is the actual protection level of your levees etc. (or what % does or does not satisfy the safety standards)*
- *Coming to the first issue: what is the residual risk (related to flooding despite the levees etc.), and how large is it compared to protected value (the ratio is in fact a measure of the actual protection level)*

According to the German guidelines and standards different levels of protection are recommended depending on the utilization of the hinterland. The values in Table 6.4 are normally applied to fluvial levees all over Germany.

Table 6.4 Object categories and possible assignment of damage potentials as well as of reference values for the flood recurrence interval (DWA-Guideline 507-1 for fluvial levees and DIN 19712:2013, Table 2)

Object category	Damage potential	Standard reference values derived for the average statistical recurrence interval T_n [in years]. The annual failure probability is $P = 1/T_n$
Special items with extraordinary consequences in the case of flooding	high	To be determined on a case-by-case-basis (in practice recurrence intervals up to 500 years are justifiable and have already been applied.
Urban areas	high	≈ 100
Industrial Plants and Facilities	high	≈ 100
Supraregional Infrastructure Facilities	high	≈ 50 … 100
Single buildings, settlements not permanently inhabited	medium	≈ 25
Regional Infrastructure Facilities	medium	≈ 25
Agricultural Areas	low … medium	up to 5
Natural Landscapes	low	-

Besides these criteria the cost-benefit relation, the licensability, the heaviness of the environmental impact etc.. As there is no statistical information available it is estimated that in Germany might be protected by levees about 12 million people (15%). In the example-area of the above mentioned Water association about 4.1 million people and more than 2 Billion € asset values are protected by levees against floods.

Depending on the structure height above the landside toe and the hazard/damage potential the Flood protection works are classified (Table 6.5):

Table 6.5 Classification of flood protection works in Germany

structure height	hazard/damage potential		
m	high	medium	low
H ≥ 3	class I	class II	class II
3 > H ≥ 1.5	class I	class II	class III
1.5 > H	class I	class III	class III

6.3 Recent major floods and (near-)failures of levees

This section is meant to give a brief description of (near-)failures of levees/structures, and their causes and failure modes. Detailed information is not required, but we wish this section to serve as a portal to this detailed information.
Again, you may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

NOTE – Episodes with major storm surges or major high-river-discharge episodes without damage are also be relevant to mention as they give a measure of proven strength of the levees and flood defences.

During the recent decades many flood events were observed in Germany. The major floods were in 1962 at the North Sea (s. above), 1997 and 2010 in the Oder-watershed, 2002 and 2013 in the catchment areas of the Elbe and Danube rivers with property losses up to 6 … 7 Billion € (2002). While in the recent events no or only few people lost their life more than 300 people died in Hamburg during the 1962 storm tide. After these and many other events the flood protection works were rebuilt, heightened and updated. In Dresden, where many levees and floodgates have been (re-) built after 2002 it has been visible how all newly completed defences were working well during the 2013 summer flood.
During the floods a permanent inspection of the protection works takes place (e. g. in Saxony according to § 85 section Sächs WG). In some cases the evacuation of the people in the lower areas of the hinterland was organized during the above events.

About once in ten years a flood event with fluvial levee failures and large property losses was recorded in Germany during the last decades.

Figure 6.4 Levee Failure at the Oder 1997 near the village Wiesenau. Foreground:large scourholes in the levee axis. Background: remaining levee cross section. Trees at the landside toe hindered the levee slope inspection. On the right side: the Oder river. (photograph: R. Pohl)

About some of these incidents the technical journals in Germany like “Wasserwirtschaft” brought articles from several viewpoints (Pohl, R.; Franke, D.; Engel, J.; Niesche, H.; Krüger, 1999; Bornschein, A., Pohl, R., 2005; Pohl, R., Horlacher, H.-B., Müller, U, 2006 pp 597-615; Brauneck, J., Jüpner, R., Pohl, R., Friedrich, F., 2016).
Further reports from Saxony with the event analysis can be downloaded for free at:

http://www.smul.sachsen.de/lfulg/35756.htm (2010 und 2011 floods)
https://publikationen.sachsen.de/bdb/artikel/15180 (2013 floods)

6.4 Legislation and governance

Please give a short description about the main legislation related to levees and flood defences.

Please also indicate whether (i) this legislation is similar or even identical to the legislation used for dams (please check the Dam Legislation Report from the ICOLD European Club; levees are mentioned at least for ES, FI, FR and NL) and whether (ii) this legislation is a translation of the EU Floods Directive. The latter is interesting, because it allows to get an indication to what extent the Floods Directive has resulted in a common legal framework throughout Europe.
Besides this, it is also important to describe the key players with respect to Levees and Flood Risk Management and how they interact, i.e. the governance with respect to all life cycle phases of Levees and Flood Defences. Not only to describe the governance, but also to make clear how easy/difficult it is to get relevant information.

6.4.1 Legislation and governance – implementation EU Regulations

Please briefly describe how key EU legislation (mainly/especially the Floods Directive) is translated into national policy and legislation.

Bottema, Marcel (WVL) 25/4/16 11:01
Commentaire: Perhaps add short paragraph..?

6.4.2 Legislation and governance – National legislation

Please give a short description about the main national legislation related to levees and flood defences, and whether/how it differs from Dam Legislation.

The basic principles for the water management and flood protection are given in the federal Water Resources Act and in the water legislation of the 16 federal states (Bundesländer). They are responsible for the flood protection (Introduction Law to the German Civil Code (EGBGB) Art. 66). The organization of the flood protection differs from one federal state to another and is regulated within the Water Laws of the different states (e.g. in Saxony: § 85 Abs. 2 Sächs WG).
According to the responsibility for the structures along navigable federal waterways there is a distinction between lower or navigable water levels (discharges) and the flood discharges beyond. For the waterways and its dams up to the navigable water level the responsibility lies in the hands of the national government (Ministry of Transport). For the flood protection at higher water levels the federal states are responsible.

For large dams (i. e. barrages, German: Talsperre) which fulfil the ICOLD criteria ($H \geq 15$ m; $S \geq 1\,000\,000$ m³) a nationwide inventory is existing. They are also listed in the ICOLD dam inventory. The most medium sized dams ($15\text{ m} > H \geq 6$ m; $1\,000\,000\text{ m}^3 > S \geq 100\,000\text{ m}^3$) are registered in data bases of the federal states, their authorities or the owner companies. The small dams might be registered by the communities on whose ground they are situated.
For levees there is no nationwide inventory available. Those who are in charge for the levees and other flood defences (s. above) normally have inventories of their own protection works. It is not in all cases clear from which lower limit a levee has to be regarded as a levee for flood protection in the sense of the levee standard and guidelines.

6.4.3 Legislation and governance – Governance

Please give a short description about the governance of levees and flood defences, i.e. the main parties / key players involved and their roles and duties.

As mentioned before, the supervision of the flood protection in Germany lies in the hands of the authorities of the 16 federal states (Introduction Law to the German Civil Code (EGBGB) Art. 66); the main features of flood protection governance are given in the table below:

Table 6.2 Responsibility for flood protection in the federal states

Federal State (Bundesland)	Responsible for flood protection and maintenance of flood defences
Berlin (city state)	Senate
Hamburg (city state)	Senate
Bremen (city state)	Senate
Schleswig-Holstein	Levee associations /Water boards for fluvial and coastal levees
Mecklenburg-West Pomerania	The federal state is responsible for constuction and maintenance of state flood protection works (appendix 2 des LWaG). All other flood protection works: Water Boards and Land Associations (s.a. § 73 LWaG).
Lower Saxony	Levee associations /Water boards for fluvial and coastal levees
Rhineland-Palatinate	
North-Rhine Westphalia	Levee associations /Water boards
Saxony	Rivers of 1st order, federal waterways, border rivers: state owned enterprise "State Reservoir Administration of Saxony - LTV" (§ 80 Sächs WG), smaller rivers of 2nd order communities (or private persons/organizations) Flood defence: Communities supportet by LTV (§ 84 section 1 SächsWG and § 85 SächsWG) Flood early warning message service: LfULG (HWNAVO)
Thuringia	Levees at rivers of 1st order Free State of Thuringia, smaller rivers of 2nd order: communities
Brandenburg	Rivers of 1st order (big or importend): State Environment Agency, 2nd order (small rivers): Water Boards and Land Associations Flood protection and levees: federal state; flood control and emergency management: County Administration (Civil Protection Office)
Baden-Wuerttemberg	Rivers of 1st order: State Ministry for Environmental Affairs, smaller rivers communities or private persons/organizations
Bavaria	Rivers of 1st, 2nd order: State Ministry for Environmental Affairs, 3rd order (small rivers) communities or private persons/organizations
Saarland	
Hessen	State and private Flood Protection, depending on property
Saxony Anhalt	Rivers of 1st order: State authority for flood protection and water management Saxony-Anhalt (LHW) Rivers of 2nd order: Water Maintenance Associations, communities or private persons/companies/ organizations

Bottema, Marcel (WVL) 25/4/16 11:07
Commentaire: Table moved from section 6.1 and some new text added.

6.5 Guidelines and good practices

Please mention what guidelines and good practice documents you use for design, safety assessment and maintenance of levees/flood defences; please give references/weblinks to some key documents.
Please also mention what parts of ICOLD-Bulletins and/or the International Levee handbook ILH are used in your country for the above.

Figure 6.5 Levee at the Elbe in Dresden. View upstream from Washington st. bridge (photograph: R. Pohl)

In Germany the general accepted codes of good practice for hydraulic structures are given by the national standards (DIN Deutsches Institut für Normung, formerly Deutsche Industrie-Norm) and the technical guidelines of the German Association for Water, Wastewater and Waste (DWA = Deutsche Vereinigung für Wasser, Abwasser und Abfall). All these regulations are only recommendations but they can get legal character if they are introduced officially by the state officials.
The related technical rules in Germany are mainly:

- DIN[1] Standard 19712 Flood protection works at flowing waters (1997, new issue 2013)
- DWA[2] Guideline 507-1 in German and English, Levees along watercourses (2011)
- DWA Guideline 507-2 Levees along watercourses: Landscape ecology (pending, 2017 expected)
- DWA Guideline 507-3 Sealing systems in levees (2005, new guideline planned)
- Recommendations for Coastal Levees (EAU)
- DWA Guideline 512-1 Sealing systems in hydraulic engineering. Part 1: Earthen structures.
- BWK[3] Guideline 6 Demountable flood protection systems (2006)
- MSD[4] Guideline Stability of dams (1998, 2011)

In addition there are guidelines of the authorities in the federal states available, especially concerning the flood defence activities during extreme events beyond the design discharges. Further related standards and guidelines can be found in the list of references.

As the ICOLD Bulletins are mainly made for dams (barrages) they were not used for levee design in Germany in the past. Some of them might be applicable (like Internal erosion) or can be used with some adaption. The International Levee Handbook is being used occasionally to get supplemental information for issues beyond the scope of the national or federal standard and guidelines.

[1] German Institute for Standardisation, Berlin
[2] German Association for Water, Wastewater and Waste, Hennef
[3] Union of Engineers for Water, Waste Management and Soil Improvement, Aachen
[4] Federal Waterways Engineering and Research Institute, Karlsruhe

Figure 6.6 Some standards and guidelines for fluvial levees (left) and coastal levees (right)

6.6 Common practices during Levee Life Cycle

This section is meant to briefly share some common practices related to various life cycle phases of Levees & structures:

- *Design practice and cost of reinforcement (per km or per object)*
- *Inspection of levees*
- *Maintenance and safety assessment*
- *Flood event management*
- *…*

The design practice is usually based on the above mentioned standard and guidelines as well as on local experience.

Inspection of levees is normally made at least once a year (s. a. DIN 19712:2013-01, section 15.4.2) in spring or early summer after the snow melting in the mountains. Additional inspections are made after extreme flood events to check if the defences had been damaged. Also the responsible authority inspects the watercourse and the protection works (e. g. in Saxony according to § 93 Abs. 1 SächsWG).
A more detailed levee safety assessment is foreseen to be made in an interval from 5 to 10 years. The results have to be compiled within a status report.
The Flood event management is carried out in most cases and in most communities by the local fire brigades under the supervision of the authorities of the federal states. During very severe floods the Technical Aid Organization, volunteers and the Army help to defend the flood protection works.
After each flood an event analysis from the hydrological and technical viewpoint is made. In Saxony from these analysis 1600 proposals for measures were derived which are being realized step by step. Since 2006 in Saxony 362 levee status reports for 380 km of protection works have been made.

6.7 Critical knowledge and data gaps; critical research needs

This section is meant to summarise critical data and knowledge gaps, as well as critical research needs. Please not this is really about the critical knowledge gaps and research needs for proper (risk-based) management of levees, not about nice-to-know knowledge.
We need this information to be able decide on further topics to be explored with our working group

In most cases a conventional design procedure is used. This is risk based insofar as the Table 5 is taken into account. Risk based procedures on the basis of probabilistic approaches are more rarely used yet.

For instance in Saxony-Anhalt 57 per cent of the 1312 km levees could be refurbished to meet the technical standards within the last few years[5] . Even in 2015 only in this state 110 million Euros were spent for implementing the flood protection concept and for levee repairs. Inversely this means that 43 % of the levees will have to be upgraded a.s.a.p. It might be assumed that the situation is more or less similar in the other federal states.

Bottema, Marcel (WVL) 25/4/16 11:54
Commentaire: NL: It is not entirely clear what is meant here..

Future issues could be the development of prediction methods for the levee safety depending from the levee condition (status) as well as a real risk mapping based on the integral of probability and consequences according to the risk definition R = P x C. At present the "risk maps" (in fulfilment of the EU directives) are hazard maps and inundation maps respectively with additional information about population at risk, critical infrastructure, hospitals, police stations, chemical industry etc. Another gap of knowledge results from the 100 m distance for ground and levee exploration. Historical grown levees are often highly heterogeneous and can change their properties within these 100 meters, so that they are actually 3-dimensional structures.

6.8 Summary of key facts

Table 3Summary of levee facts in Germany (grey numbers are estimations)

item	Germany (total)	Saxony	Saxony-Anhalt	NRW: Emscher-genossenschaft/ Lippeverband
Total levee length (km)		**650**	**1312**	**193**
- Therefrom hard protection		**100**		**1**
- Therefrom demountable		2		
- Structures in the levee				**200**
Percentage of Coastal levees	20	**0**	**0**	**0**
Percentage of Estuary levees	3	**0**	**0**	**0**
Percentage of Lakeside levees	< 1			**0**
Percentage of Fluvial levees	73			**100**
Percentage of Torrent levees	3			**0**
Maximum levee height	16	5	4	**16**
Medium levee height	4	2	2	**5**
Minimum levee height	0.50	0.50	0.50	**1**
In the case of levee failure - no hazard (percentage %)	5			**16**
- material hazard only (%)	45			**0**
- some life hazard (%)	45			**24**
- large scale life hazard (%) (> 100) / economic hazard	5			**60**
Typical construction/ rehabilitation costs €/km	10000… 2000000			**10000… 100000**
Typical maintenance/ management costs €/km ·a				**5000**
Levee-protected population (mio)	15			**4.1**
Levee-protected material assets (m€)	150000			**2000**
Percentage of levees meets the general accepted codes of good practice			**57**	**98**
Levee failure(s) within the last two decades	**yes**	**yes**	**yes**	**no**
Major Floods with levee failures within the last two decades	**1997 2002 2010 2013**	**2002 2010 2013**	**2002 2013**	

[5] KW Korrespondenz Wasserwirtschaft, 9(2016)3 p. 122

This section is meant to summarise some key facts and figures in just a few words, for easy comparison amongst countries, and to facilitate writing the summary and conclusions:

- *Km of levees, no. of structures*
- *% along river, estuary, sea, lake*
- *Protected value, safety standard, actual protection level or flood risk*
- *Recent (near-)failures*
- *Key facts governance (which key players) and legislation*
- *Types of guidelines used*

- In Germany exist some 10 000 km of levees, and thousands of adjacent structures.
- It is estimated that about 20% of the levees are coastal and 80% fluvial.
- The levees protect over 12 million people and at least 2 billion Euro in asset value.
- The safety standards are set by the actual standard DIN 19712 and the DWA Guideline 507-1 as well as the EAU-Recommendations for the coast. The level of protection for densily inhabitated areas is normally 1/100. More values are given in Table 5.
- Recent levee failures occurred e.g. in 1997 at the Odra river and 2002 and 2013 at the Elbe and Danube.
- The standard DIN 19712 and the DWA Guideline 507-1 as well as the EAU-Recommendations are the main guideline documents for levee planning, design and assessment. ICOLD Bulletins and the International Levee Handbook may be consulted but play no key role.
- Governance reflects the fact that Germany consists of 16 Länder in which governance may differ.
- Key knowledge gaps: flood risk prediction and mapping using the actual condition of levees, and knowing the levee and its underground in greater detail.

Bottema, Marcel (WVL) 25/4/16 11:29
Commentaire: Added by NL

Bottema, Marcel (WVL) 25/4/16 11:26
Commentaire: Added by NL

Figure 6.7 Levees at the Emscher river in Oberhausen (Photograph Emschergenossenschaft-Lippeverband in GRÜN, JOHANN, PFISTER 2014)

6.9 References (per country)

Please support the Country-specific facts of the previous sections by references and weblinks as much as possible, so that information remains traceable and easy to update.

German Standards and related Guidelines

DIN 4020 (April 1996): Geotechnische Untersuchung für bautechnische Zwecke
DIN 4020 Beiblatt (September 2003): Geotechnische Untersuchung für bautechnische Zwecke; Anwendungshilfen, Erklärungen
DIN 4023 (Februar 2006): Geotechnische Erkundung und Untersuchung – Zeichnerische Darstellung der Ergebnisse von Bohrungen und sonstigen direkten Aufschlüssen
DIN 4094 - 1 (Juni 2002): Baugrund; Felduntersuchungen, Drucksondierungen
DIN 4094 - 2 (Mai 2003): Baugrund; Felduntersuchungen, Bohrlochrammsondierung
DIN 4094 - 4 (Januar 2002): Baugrund; Felduntersuchungen, Flügelscherversuche
DIN 4094 - 5 (Juni 2001): Baugrund; Felduntersuchungen, Bohrlochaufweitungsversuche
DIN 4095 (Juni 1990): Baugrund; Dränung zum Schutz baulicher Anlagen; Planung, Bemessung und Ausführung
DWA-M 507-1 Deiche an Fließgewässern 2011
DIN 18123 (November 1996): Baugrund; Untersuchung von Bodenproben, Bestimmung der Korngrößenverteilung
DIN 18130 - 1 (Mai 1998): Baugrund; Untersuchung von Bodenproben, Bestimmung des Wasserdurchlässigkeitsbeiwerts, Laborversuche
E DIN 18130 – 2 (Oktober 2003): Baugrund, Untersuchung von Bodenproben - Bestimmung des Wasserdurchlässigkeitsbeiwertes: Teil 2: Feldversuche
DIN 18196 (Juni 2006): Erd- und Grundbau; Bodenklassifikation für bautechnische Zwecke
DIN 18917 (August 2002): Vegetationstechnik im Landschaftsbau - Rasen und Saatarbeiten
DIN 18918 (August 2002): Vegetationstechnik im Landschaftsbau – Ingenieurbiologische Sicherungsbauweisen und Vegetationsflächen bei Baumaßnahmen
DIN 19657 (September 1973): Sicherungen von Gewässern, Deichen und Küstendünen; Richtlinien
DIN 19661-1 (Juli 1998): Wasserbauwerke Kreuzungsbauwerke (being updated 2016-2017)
DIN 19700 - 10 (Juli 2004): Stauanlagen; Gemeinsame Festlegungen
DIN 19700 - 11 (Juli 2004): Stauanlagen; Talsperren
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7 Hungary

PLEASE NOTE:

YELLOW MARKED text gives a description of the contents that are requested for this report
GREEN MARKED text gives information that may be of help when you are writing your country chapter.

TO BE FILLED AS MUCH AS POSSIBLE BY EACH COUNTRY. You do not need to provide lengthy texts; brief fact-sheet like texts are sufficient, at least for now.

You may find your chapter already filled in with some first suggestions; please feel free to use them or replace them with your own text, as you wish. In the end, the text is about your country, and therefore we prefer the final text is primarily your text and not the text of the main editors.

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INFORMATION THAT MAY BE OF HELP WHEN COMPILING YOUR CHAPTER

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The report http://www.crue-eranet.net/partner_area/documents/D5_Main_Report.pdf contains some useful facts and figures on levees and the governance of Flood Risk Management (FRM) of many European countries, even though the data are 10 years old and not always up to date. However, they may be very useful to supplement that data gathered by our Levee Working group members, when they have difficulty in getting the right data:

- Table 34: Total yearly FRM investment Europe: close to or over 3 billion Euro.
- In each country chapter: years with main recent flood events
- CH2 – AUSTRIA
  - Population and economy concentrated in river valleys
- CH3 – FINLAND
  - Estimated flood damage potential 500-600 mln Euros
- CH4 – FRANCE
  - 250 mln Euro annual damage, 500 mln annual investment in flood & coastal protection
- CH5 – GERMANY
  - About 7500 km flood protection dikes and walls
  - Several billion Euro damage due to recent floods
- CH6 – HUNGARY
  - 25% of country and population flood prone
  - 4200 km of (river) levees
- CH7 – ITALY
  - 3% of territory highly exposed to floods
  - Preservation of Venice 8,5 billion Euro spending in 30 years (nearly 300 mln Euro per year!)
- CH8 – NETHERLANDS
- CH9 – POLAND
- CH10 – SPAIN
  - 1200 large dams and dikes
  - 300 mln Euro annual flood damage
- CH11 – UNITED KINGDOM – ENGLAND
  - About 4-5 mln people and 140000 businesses at risk, representing 400 billion Euro of assets
  - Average annual damage over 1,5 billion Euro per year
- CH12 – UNITED KINGDOM – SCOTLAND
  - ~80000 homes + businesses at risk from river flooding (commonly occurring), another 100000 for coastal flooding (rare)

The preliminary flood risks assessments (PRFA's) and flood risk management plans (FRMP's) of the EU Floods Directive (http://www.envir.ee/sites/default/files/flooddirective.pdf; http://ec.europa.eu/environment/water/flood_risk/) may also provide useful information; water authorities can be found on http://www.eea.europa.eu/themes/water/interactive/floods-directive-viewer .

Some country- or river specific information can be found on:

- www.climateadaptation.eu: Quite useful site for some general information on vulnerability to for instance river floods, but also coastal floods, flash floods & urban floods, etc. etc., see for example:
  - Slovenia: http://www.climateadaptation.eu/slovenia/river-floods/
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- Finland, flood maps and other information: http://www.environment.fi/en-US/Waters/Floods/Flood_risk_management/Flood_risk_management_planning
- Danube countries PFRA, maps (and FRMP?): https://www.icpdr.org/main/activities-projects/implementation-eu-floods-directive
- PFRA Ireland: http://www.cfram.ie/wordpress/wp-content/uploads/2013/06/PFRA-Main-Report.pdf
- Italy:
  - MOSE Project storm surge protection Venice: https://en.wikipedia.org/wiki/MOSE_Project
  - River basin authorities: http://www.pcn.minambiente.it/GN/en/direttiva-alluvioni/171-spalla-destra/spalla-destra-uk-up/431-floods-directive?showall=1&limitstart=

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7.1 Facts and figures on levees and flood defences

This section is meant to answer questions like:

- *how many levees and other flood defences do you have (km's / nr's)*
  - *other flood defences may be moveable flood walls, storm-surge-barriers and also ordinary gates and sluices (the latter may be so numerous it may be too difficult to quantify them)*
- *what are typical dimensions and other properties (materials, layering, revetment, ..) for (different types of) levee in your country*
- *what is the geographical context: what are typical environments / flood types (% urban/rural levees, % river, estuary or coastal levees)*
- ***Could you give also an indication of yearly spendings on levee management and levee reinforcement (or on overall flood risk management if only that is available)? We think it has added value to present these numbers, and especially make clear what Business Case is hidden in the levee issue.***

You may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

7.2 Protected value, safety standards and flood risk

This section is meant to give an indication of the following:

- *What is (by and large) the protected value that could flood without levees and flood defences. Both in terms of life and economic value (preferably the assets, otherwise a fraction of the Gross Domectic Product)*
- *Do your levees and structures have a safety standard, and if so what does it refer to and what value has it got*
- *What is the actual protection level of your levees etc. (or what % does or does not satisfy the safety standards)*
- *Coming to the first issue: what is the residual risk (related to flooding despite the levees etc.), and how large is it compared to protected value (the ratio is in fact a measure of the actual protection level)*

7.3 Recent major floods and (near-)failures of levees

This section is meant to give a brief description of (near-)failures of levees/structures, and their causes and failure modes. Detailed information is not required, but we wish this section to serve as a portal to this detailed information.
Again, you may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

NOTE – Episodes with major storm surges or major high-river-discharge episodes without damage are also be relevant to mention as they give a measure of proven strength of the levees and flood defences.

7.4 Legislation and governance

Please give a short description about the main legislation related to levees and flood defences.

Please also indicate whether (i) this legislation is similar or even identical to the legislation used for dams (please check the Dam Legislation Report from the ICOLD European Club; levees are mentioned at least for ES, FI, FR and NL) and whether (ii) this legislation is a translation of the EU Floods Directive. The latter is interesting, because it allows to get an indication to what extent the Floods Directive has resulted in a common legal framework throughout Europe.
Besides this, it is also important to describe the key players with respect to Levees and Flood Risk Management and how they interact, i.e. the governance with respect to all life cycle phases of Levees and Flood Defences. Not only to describe the governance, but also to make clear how easy/difficult it is to get relevant information.

7.4.1 Legislation and governance – implementation EU Regulations

Please briefly describe how key EU legislation (mainly/especially the Floods Directive) is translated into national policy and legislation.

7.4.2 Legislation and governance – National legislation

Please give a short description about the main national legislation related to levees and flood defences, and whether/how it differs from Dam Legislation.

7.4.3 Legislation and governance – Governance

Please give a short description about the governance of levees and flood defences, i.e. the main parties / key players involved and their roles and duties.

7.5 Guidelines and good practices

Please mention what guidelines and good practice documents you use for design, safety assessment and maintenance of levees/flood defences; please give references/weblinks to some key documents.
Please also mention what parts of ICOLD-Bulletins and/or the International Levee handbook ILH are used in your country for the above.

7.6 Common practices during Levee Life Cycle

This section is meant to briefly share some common practices related to various life cycle phases of Levees & structures:

- *Design practice and cost of reinforcement (per km or per object)*
- *Inspection of levees*
- *Maintenance and safety assessment*
- *Flood event management*
- *…*

7.7 Critical knowledge and data gaps; critical research needs

This section is meant to summarise critical data and knowledge gaps, as well as critical research needs. Please not this is really about the critical knowledge gaps and research needs for proper (risk-based) management of levees, not about nice-to-know knowledge.
We need this information to be able decide on further topics to be explored with our working group

7.8 Summary of key facts

This section is meant to summarise some key facts and figures in just a few words, for easy comparison amongst countries, and to facilitate writing the summary and conclusions:

- *Km of levees, no. of structures*
- *% along river, estuary, sea, lake*
- *Protected value, safety standard, actual protection level or flood risk*
- *Recent (near-)failures*
- *Key facts governance (which key players) and legislation*
- *Types of guidelines used*

7.9 References (per country)

Please support the Country-specific facts of the previous sections by references and weblinks as much as possible, so that information remains traceable and easy to update.

8 Italy

PLEASE NOTE:

YELLOW MARKED text gives a description of the contents that are requested for this report
GREEN MARKED text gives information that may be of help when you are writing your country chapter.

TO BE FILLED AS MUCH AS POSSIBLE BY EACH COUNTRY. You do not need to provide lengthy texts; brief fact-sheet like texts are sufficient, at least for now.
You may find your chapter already filled in with some first suggestions; please feel free to use them or replace them with your own text, as you wish. In the end, the text is about your country, and therefore we prefer the final text is primarily your text and not the text of the main editors.

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INFORMATION THAT MAY BE OF HELP WHEN COMPILING YOUR CHAPTER

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The report http://www.crue-eranet.net/partner_area/documents/D5_Main_Report.pdf contains some useful facts and figures on levees and the governance of Flood Risk Management (FRM) of many European countries, even though the data are 10 years old and not always up to date. However, they may be very useful to supplement that data gathered by our Levee Working group members, when they have difficulty in getting the right data:

- Table 34: Total yearly FRM investment Europe: close to or over 3 billion Euro.
- In each country chapter: years with main recent flood events
- CH2 – AUSTRIA
  - Population and economy concentrated in river valleys
- CH3 – FINLAND
  - Estimated flood damage potential 500-600 mln Euros
- CH4 – FRANCE
  - 250 mln Euro annual damage, 500 mln annual investment in flood & coastal protection
- CH5 – GERMANY
  - About 7500 km flood protection dikes and walls
  - Several billion Euro damage due to recent floods
- CH6 – HUNGARY
  - 25% of country and population flood prone
  - 4200 km of (river) levees
- CH7 – ITALY
  - 3% of territory highly exposed to floods
  - Preservation of Venice 8,5 billion Euro spending in 30 years (nearly 300 mln Euro per year!)
- CH8 – NETHERLANDS
- CH9 – POLAND
- CH10 – SPAIN
  - 1200 large dams and dikes
  - 300 mln Euro annual flood damage
- CH11 – UNITED KINGDOM – ENGLAND
  - About 4-5 mln people and 140000 businesses at risk, representing 400 billion Euro of assets
  - Average annual damage over 1,5 billion Euro per year
- CH12 – UNITED KINGDOM – SCOTLAND
  - ~80000 homes + businesses at risk from river flooding (commonly occurring), another 100000 for coastal flooding (rare)

The preliminary flood risks assessments (PRFA's) and flood risk management plans (FRMP's) of the EU Floods Directive (http://www.envir.ee/sites/default/files/flooddirective.pdf; http://ec.europa.eu/environment/water/flood_risk/) may also provide useful information; water authorities can be found on http://www.eea.europa.eu/themes/water/interactive/floods-directive-viewer .

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9 The Netherlands [with nearly complete draft text]

Please do not worry if the contribution of your country does not seem as complete as the present one, as long as it contains the main information that is relevant in relation to your country.

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INFORMATION THAT MAY BE OF HELP WHEN COMPILING YOUR CHAPTER

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NOTE – ALL YELLOW/ITALIC HELP TEXTS BELOW WILL BE MOVED TO APPENDIX ONCE CHAPTER IS COMPLETE

9.1 Facts and figures on levees and flood defences

This section is meant to answer questions like:

- *how many levees and other flood defences do you have (km's / nr's)*
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You may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

In the Netherlands, the following types of flood defence are common:

- mostly natural sand dunes along the North Sea coast
- levees along rivers, lakes and part of the coast (often referred to as 'dikes' or 'dykes')
- dams (similar to levees, but generally across rather than along the water, separating two large water bodies)
- moveable storm surge barriers (similar role as dams, but not levee-like, but moveable hydraulic structure)
- hydraulic structures (sluices, etc.)
- moveable flood barriers (in some urban areas)

Please note that the above typology might be somewhat coloured by the Dutch context.

An important distinction is made between primary flood defences and secondary or regional flood defences. Primary flood defences protect against floods that are large enough to cause life risk and major economic damage; they have a safety standard referred to in National Law. Secondary flood defences merely protect against local or regional damage and have a safety standard from the regional province. Some of the smallest

levees even have no explicit safety standard, such as the summer levees which make sure that river flood plains normally only inundate during the winter season.

There is over 3500 km of primary flood defence in The Netherlands. A small fraction of these consist of dunes (nearly 300 km), dams (order 100 km), an even smaller fraction of moveable flood barriers (along some city waterfronts) and of storm-surge barriers. In addition there are nearly 1500 hydraulic structures that are considered as a primary flood defence.
The length and number of regional flood defences is not exactly known, but most probably in the order of 5 times as large as the length and number of primary flood defences, with a very dense network of secondary levees in the low-lying polder area (often even below sea level) in the West and partly also the North of the country.

Bottema, Marcel (WVL) 5/2/16 11:45
Commentaire: Numbers estimated from 3e rapportage Landelijke Toetsing

The main difference between primary flood defence levees and regional or secondary flood defence levees is in their size and revetment, but otherwise they are quite similar.
Both are usually constructed using locally available clay, sand or (mainly in the case of secondary levees) peat, and both often have slopes in the order of 1:3. Steeper slopes tend to become unstable when saturated and are becoming less common, unless pile walls are used for support; generally intrinsic safety is preferred over safety provided by drawing down the phreatic line by means such as filters. Especially for primary levees and dams, berms are commonly used to reduce slope instability and piping, but on the outer slope also to reduce wave-runup and wave overtopping.
When sand is used for levees, especially the outward facing top layer generally consists of a clay layer to prevent quick saturation (and weakening) of the sand as well as internal erosion; also a deep layer with partly non-weathered clay has some resistance against wave erosion. Grass revetments are used where possible, but especially primary lake-side and coastal levees often have a placed-stone or asphalt revetment on their outer slopes, which have to resist wind waves with a height of 1 metre up to several metres.
Typical heights are up to a few metres for secondary levees, whereas primary levees have typical heights of order 6 metres (range roughly 3-10 metres). Estuary dams have even larger heights, not as much when referred to sea level, but rather measured from toe to top since many estuary dams are built across tidal channels which may be 10 to over 40 metres deep. The latter type of dam is also included in the ICOLD dam register.
Roughly one-third of primary levees is along the branches of the Rhine and Meuse rivers, another one-third along the estuaries, and the remaining one-third along large lakes and along the coast. Typically, levees along the rivers have to deal with several days of high water levels during river floods, but not with excessive wave loading. On the contrary, coastal and lake levees usually have rather short periods (order 1 day) with strong wind-setup and heavy wave-attack as a result of severe storms. In the estuaries, both situations may play a role.

9.2 Protected value, safety standards and flood risk

This section is meant to give an indication of the following:

- *What is (by and large) the protected value that could flood without levees and flood defences. Both in terms of life and economic value (preferably the assets, otherwise a fraction of the Gross Domectic Product)*
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Without levees, dunes and other flood defences, nearly 60% of the Netherlands would be prone to flooding. This includes the demographic and economic centre of the country including the cities of Amsterdam and Rotterdam, so that about 70% of our population and economy is prone to flooding, or even somewhat more. This implies that without flood protection, about 12 million people would be prone to flooding and about 400-500 billion of economic production, given the Gross Domestic Product of about 660 billion Euro/year.

Bottema, Marcel (WVL) 5/2/16 13:53
Commentaire: I still need to find out the value of economic assets prone to flooding.

The safety standard of all primary flood defences has ranged from a probability of 1/10000 per year for Central Holland, to 1/1250 per year for low-lying inland areas which are only prone to river floods, and 1/250 per year for the upper Meuse valley. So the most stringent safety standards have been for the most densely populated areas prone to coastal flooding (little warning time, salt water inundation), whereas the standard become more lenient for rivers (more warning time). These safety standards are related to the probability of water levels (or more generally hydraulic loads) that flood defences must safely (with order 90% probability) must withstand. In the last 2011 assessment round, nearly two-thirds of the levees (and a somewhat smaller fraction of the hydraulic structures) satisfied the safety standards.
Meanwhile, more differentiated risk-based safety standards are about to be implemented. These standards express the probability of flooding due to a breach in a given stretch of levees, and are therefore not easily comparable with the former safety standards. The allowed flooding probability is based on personal risk targets (less than 10^{-5}/yr mortality probability on a given location) including evacuation possibilities, or on cost-benefit considerations if these are more critical. Safety standards are also more stringent when a breach will severely affect critical infra structure, or cause massive damage or massive life risk.
The new safety standards (in terms of flooding probability) range from 1/100000 per year for the city of Rotterdam and parts of the Western Scheldt and 1/30000 per year for many other high-risk areas along rivers, lakes and population centres, to about 1/3000 per year for many other levee stretches and 1/300 per year for the upper Meuse valley.

Bottema, Marcel (WVL) 5/2/16 14:16
Commentaire: Add reference and find picture with sufficient quality

The report "Eindrapportage VNK" gives an impression of the actual flooding risk. Economic risk is strongly variable and highest for some urbanised hotspots, where the economic risk may exceed 5 MEuro per km per year; as a region, the Betuwe region between the "Nederrijn/Lek" and "Waal" branch of the Rhine stands out, as well as the Beveland area along the Western Scheldt. The Betuwe area also stands out with respect to personal risk (order 10^{-4} mortality risk per year), although many areas (especially deep polders) along the rivers, major lakes and Wadden Sea coast do not yet satisfy the intended risk target of 10^{-5} per year.
Besides overtopping of levees, piping of river levees (internal erosion through sandy underground layers) appears to be the main contributor to this risk.
On a national level, actual flood probabilities (including the present levee protection) are highly variable, but most often roughly in the order of a 1/500 year probability. This results in a flood risk equivalent to on average a few dozen victims per year (for all of the Netherlands) and an expected damage of over 500 million Euro per year. If a flood were to occur, the damage would have been much larger, but luckily, floods and levee breaches are a rare phenomenon in the Netherlands. One can also note that the actual expected risk is several orders of magnitude smaller than the protected value mentioned in the beginning of this section. Still, the above safety assessment results were one of the triggers for major levee reinforcements which are currently underway, and also for the adoption of a more risk-based set of safety standards as described above.

Bottema, Marcel (WVL) 5/2/16 14:20
Commentaire: Give REF

9.3 Recent major floods and (near-)failures of levees

This section is meant to give a brief description of (near-)failures of levees/structures, and their causes and failure modes. Detailed information is not required, but we wish this section to serve as a portal to this detailed information.
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NOTE – Episodes with major storm surges or major high-river-discharge episodes without damage are also be relevant to mention as they give a measure of proven strength of the levees and flood defences.

- Former centuries
  - Up to thousands of casualties when levees breached due to coastal storm surges or due to river floods (ice dams still occurred and significantly increased flood risk along rivers)
- Zuiderzeevloed 1916
  - Order 1/100 yr Storm surge and moderately high river discharges (Lobith 13m and 3900 m3/s to be checked), with damage and minor breaches along the coast and the Ijssel-Vecht

river delta, but especially much damage along the Zuiderzee estuary where record water levels were measured
    - Also record water levels in Rotterdam-Dordrecht area but much less damage
    - Marked spatial variations in water level return period (order 30-300yr) depending on whether surge peak coincided with high tide or not.
    - Waterland area just north of Amsterdam flooded, island of Marken also flooded. Much damage, few victims (dozens)
    - One of triggers for building the Afsluitdijk (refer to ICOLD Zuiderzee /Afsluitdijk Bulletin)
    - Trigger for SVSD storm surge warning service
    - https://nl.wikipedia.org/wiki/Stormvloed_van_1916;
    - http://historiek.net/stormvloed-van-1916/5841/#.VrSo3JckpyE
    - http://www.kennislink.nl/publicaties/1916-de-watersnoodramp-die-nederland-veranderde
    - http://repository.tudelft.nl/view/hydro/uuid%3A3ff3fdab-003b-477e-bad3-2d89361420d3/
    - Peat levees with rubble (and rubble roads on top); easy infiltration due to rubble; stability failure (statement of Reigersberg, Source: Noord Hollands Dagblad special issue 9 Jan 2016); since then no roads on top of levee in that region. In SE part of estuary many small breaches due to overtopping and inner slope saturation + failure (similar to 1953 disaster).
- 1926 river floods
    - Highest discharges in recent history (roughly 1/150 yr)
    - Several small levee breaches along Rhine, Meuse and Vecht river branches , both piping (mainly along Rhine branches), stability and overflow problems.
    - Major breach near Cuijk and Land Maas & Waal
    - Sudden piping breach near Zalk – Ijssel
    - http://repository.tudelft.nl/view/hydro/uuid%3A5aee4476-3245-42da-a9aa-5807f2b77b6e/
    - http://www.knag.nl/index.php?id=640&tx_ttnews[swords]=gis&tx_ttnews[pointer]=71&tx_ttnews[tt_news]=335&tx_ttnews[backPid]=502&cHash=01e7984a42
    - Few victims
- 1953 disaster
    - Major storm surge (roughly 1/200 yr), massive overtopping or even overflow, failure often due to slope instability for slopes steeper than 1/3; levee top roads often prevented worse (failure), foreshores limited breach depth.
    - 1835 lives lost, 200000 homeless in SW-NL
    - https://en.wikipedia.org/wiki/North_Sea_flood_of_1953
    - Trigger to develop safety standards and guidelines, trigger for Delta works
    - Check further references: http://repository.tudelft.nl/view/ir/uuid%3A0e28dfd8-4e67-4267-a443-54b74a062bcb/ ; http://repository.tudelft.nl/view/hydro/uuid%3Ab5ef3731-92b0-4404-8dfc-8ab7f63619ae/
- 1960 tuindorp oostzaan; http://www.npogeschiedenis.nl/nieuws/2010/januari/50-jaar-geleden-Tuindorp-Oostzaan-onder-water.html; http://www.historischarchief-toz.nl/watersnood_1960.htm
    - 0-1 victims, up to 2m inundation depth
    - Spontaneous failure due to broken water supply pipe?
- 1993+1995 river floods (roughly 1/50yr discharge)
    - No major levee breaches, perhaps some minor ones such as along the small river Dommel near Bossche Broek.
    - Imminent threat of piping failure during 1995 flood: Massive evacuation from Betuwe and also from parts of Limburg: 200000 people evacuated
    - Trigger for Flood Defence Act (safety standards implemented by law, regular safety assessments and reinforcement rounds) and for Room the River floodplain restoration project
- 2003 wilnis
    - No victims, but 30 cm water on street in village of Wilnis
    - Spontaneous failure of dried-out peat levee during prolonged drought period, causing levee to “float” away
    - Trigger for peat research, and to make sure peat levees no longer dry out in summer

- http://files.kennisplein.intranet.minienm.nl/2/5/251123/Onderzoekers_ontrafelen_raadsel_van_Wilnis_().pdf
- http://files.kennisplein.intranet.minienm.nl/3/0/30723/2004-28_-_Hoofdrapport_Wilnis_ex_bijlagen.pdf
- http://www.hansmiddendorp.nl/dijkdoorbraak-in-wilnis-in-2003/

- 2004 Stein
  - Failing water supply pipe, serious dike damage, just briefly mention as confirmation of lessons 1960 failure (risk of pipes through levees)
  - http://kennisplein.intranet.minienm.nl/documenten/318902

⇨ To be converted from bullet lists into text, final paragraph summarizing causes of failure to be checked

Bottema, Marcel (WVL) 14/4/16 15:57
Commentaire: To be converted from bullet lists into text.

Most but not all failure occurred during flood situations: exceptions were the 1960 failure and 2004 near-failure due to failing water supply pipes, and the 2003 peat levee failure due to drought.
Storm surge failures were typically caused by overtopping/overflowing in combination with slope stability failure, either due to too much infiltration (rubble materials in 1916 levees and levee-top roads/tracks) or due to saturation and failure of steep slopes.
For river floods, failure and near-failures were often due to piping, which is also illustrated by the fact that many historical levee breach locations (recognisable by the ponds at the erosion hole ["wielen"] and the levee curving around those ponds) coincide with underground sand strips.

9.4 Legislation and governance

Please give a short description about the main legislation related to levees and flood defences.

Please also indicate whether (i) this legislation is similar or even identical to the legislation used for dams (please check the Dam Legislation Report from the ICOLD European Club; levees are mentioned at least for ES, FI, FR and NL) and whether (ii) this legislation is a translation of the EU Floods Directive. The latter is interesting, because it allows to get an indication to what extent the Floods Directive has resulted in a common legal framework throughout Europe.
Besides this, it is also important to describe the key players with respect to Levees and Flood Risk Management and how they interact, i.e. the governance with respect to all life cycle phases of Levees and Flood Defences. Not only to describe the governance, but also to make clear how easy/difficult it is to get relevant information.

9.4.1 Legislation and governance – implementation EU Regulations

Please briefly describe how key EU legislation (mainly/especially the Floods Directive) is translated into national policy and legislation.

Requirements of the EU Floods Directive are mainly satisfied through the National Legislation as described in the section(s) below. The Flood Risk Management plans as described by the EU Floods Directive can be consulted through http://www.helpdeskwater.nl/onderwerpen/wetgeving-beleid/eu-richtlijn/plannen/ (Dutch version only). The plans mainly give an integral description of Flood Risk Management actions and their background; protection through levees is only one aspect of this. Chapter 7 of these FRM plans does not discuss levee management in detail, but rather gives a description of legislation (as described in the paragraphs above) and policy plans & targets; in addition the FRM-plans gives various hazard maps for three probability levels (yearly, rare, extremely rare).

9.4.2 Legislation and governance – National legislation

Please give a short description about the main national legislation related to levees and flood defences, and whether/how it differs from Dam Legislation.

In the Netherlands, the same legislation generally applies for levees and dams with a flood protection function, the main difference being that for some storm surge barriers, an additional target is set for the reliability of closure, and that for some dams flood risk from either side of the dam has to be considered, rather than just from one side. Details of the legislation are given in the Dam legislation Report of the ICOLD European Club, so only the main features are given here.

In the context of levees, the Water Act http://wetten.overheid.nl/BWBR0025458 is the most relevant, although environmental legislation (Environmental Impact Assessment procedures etc.) is equally important in the case of construction. The Water Act contains provisions related to Flood Risk Management and to Water Management in a general sense. By and large, the Water Act contains the following elements:

1. Chapter 1 – General provisions, mainly definitions
2. Chapter 2 – Aims and Standards: refers to general aspects of the safety standards and the safety assessment, hydraulic boundary conditions for safety assessment and guidelines for design,
3. Chapter 3 – Roles of different organisations involved in water and flood risk management, and provisions related to flood warnings
4. Chapter 4 – Policy and implementation plans
5. Chapter 5 – Construction, operation and maintenance of water works
6. Chapter 6 – Water permits and related issues
7. Chapter 7 – Financial issues
8. Chapter 8 – Law enforcement
9. Chapter 9/10 – various issues
10. Annex I + II: Dike rings and safety standards for those dike rings

The Water Act (2009) integrates a range of former water-related legislation including the Flood Defences Act of 1996. In relation to water defences, the Water Act contains an Annex with an overview of primary water defences, and sets conditions for the primary flood protection structures in terms of the responsibilities of the authorities involved, the safety standards, the regular safety assessment, the procedure for reconstruction of structures and the framework for financing of reconstruction and maintenance. The contents of the Annex will most probably change within short notice because of a safety standard update (standards in terms of flooding probabilities rather than water level exceedance probabilities, and referring to dike stretches rather than full dike rings to allow for differentiation).
Primary water defences which directly protect the hinterland, are directly assigned a safety standard from the Water Act. For (mainly estuarine) dams which separate two water bodies, it generally has been not the Water Act itself but the underlying regulations which assign the safety standards.

The Water Act prescribes a safety assessment every twelve years. The instruments for safety assessment are provided by the ministry and are known as the "WTI" Legal Assessment Instrument; the WTI consists of hydraulic boundary conditions (so-called "HR")and guidelines for safety assessment (the so-called "VTV"). The local water boards are to report the results of the safety assessment to the ministry (and the Inspectorate on Environment and Transport). In turn, the ministry reports to parliament. Levees which do not pass the safety assessments due to changes in the safety standard or the "WTI" instrument are eligible for (50%) subsidies for reinforcement.
Besides in-depth safety assessments every 6/12 years, there are also regular maintenance actions and frequent visual inspections, the latter especially around flood events.

The Water Act also prescribes that the ministry shall issue warnings to local water boards when water levels exceeding so called alarm levels are expected. Local water boards are obliged to prepare emergency plans and train their personnel and equipment regularly. However, the responsible parties for general calamity management (rather than actions to preserve a levee) are not the water boards but local communities, Provinces and the Ministry of Safety and Justice.

9.4.3 Legislation and governance – Governance

Please give a short description about the governance of levees and flood defences, i.e. the main parties / key players involved and their roles and duties.

The primary flood protection structures are mostly managed by local authorities, regional water authorities formally called water boards. The water boards, democratically elected bodies with the equivalent status as a municipality (presently about 23) have the authority to raise taxes on the inhabitants of the low lying polders for maintenance and construction of the structures.
The national Inspectorate of Environment and Transport has the supervision over all aspects of Flood Risk Management by the water boards.
The national government, more specifically, the Ministry of Infrastructure and the Environment, has the overall responsibility for Flood Risk Management in the Netherlands, both for policy, policy implementation and inspection. The ministry issues safety standards for primary flood defences, and the hydraulic boundary conditions associated to the safety standards, and makes sure guidelines for design, safety assessment and maintenance are made available, whilst promoting (and providing significant funding for) research in the fields of dams and flood protection. The ministry is also responsible for environmental legislation.
The public body in charge with the policy implementation and other actions on a national level is the Directorate General of Public Works and Water Management, also known as "Rijkswaterstaat" (or briefly: "RWS"). As opposed to levees, most large dams (especially the estuarine storm surge barriers) in the Netherlands are owned and maintained by Rijkswaterstaat. Rijkswaterstaat also maintains the coastline by sand nourishments.

Flood protection in the Netherlands is a public matter. The majority of the flood protection structures is owned by the local water boards or the ministry. Private ownership of flood protection structures however is possible, but the owner has to comply to regulations issued by the local water board or the ministry. Maintenance responsibility and (sometimes private) ownership may be separated, but this situation is mainly restricted to small (and secondary) structures, rather than large levees or dams.

9.5 Guidelines and good practices

Please mention what guidelines and good practice documents you use for design, safety assessment and maintenance of levees/flood defences; please give references/weblinks to some key documents.
Please also mention what parts of ICOLD-Bulletins and/or the International Levee handbook ILH are used in your country for the above.
Through the Water Act, the ministry recommends guidelines for the design, construction and maintenance of flood protection structures. Where necessary, the guidelines refer to specific building codes. The guidelines are to be used as a general framework and may be adapted to specific local circumstances. The guidelines are prepared in co-operation with local water boards, consultancies and research institutes. For Quality assurance the parties involved co-operate in the framework of the Expertise Network on Flood Risk Management ENW who advise on all guidelines (www.enwinfo.nl); note that ENW is the official flood risk management advisory committee, appointed by the Dutch government. The final responsibility remains however with the central government. A major updating and restructuring action of the above guidelines is now underway.
The main types of Guidance Document are:

- Framework for Duty of Care ("Kader Zorgplicht"); see http://www.helpdeskwater.nl/onderwerpen/waterveiligheid/primaire/zorgplicht/ . This comprises a broad range of topics such as juridical document requirements, reporting requirements, data/information/knowledge management, regular inspection & maintenance & operation, permits and oversight over permits and calamity management
- "WTI": Instruments for periodic safety assessments as prescribed by law
- "OI": Design instruments for design and reinforcement of levees and flood protection structures
- Various guidelines from Expertise Network on Flood Risk Management, www.enwinfo.nl.

Details and web links are given in the references section of this chapter.
Finally, it is noted that there is a strong reliance on dedicated national guidelines; the International Levee Handbook is not yet commonly used, and this applies even stronger to the ICOLD-Bulletins.

9.6 Common practices during Levee Life Cycle

This section is meant to briefly share some common practices related to various life cycle phases of Levees & structures.

- *Design practice and cost of reinforcement (per km or per object)*
- *Inspection of levees*
- *Maintenance and safety assessment*
- *Flood event management*
- *…*

Bottema, Marcel (WVL) 5/2/16 16:02
Commentaire: It also turns out to be a rather difficult section when it comes to writing !

It is hard to report on such a wide range of topics, so just some observations and general trends are given:

- Given the huge protected value, the Netherlands requires a very high protection level, which in turn results in an extreme reliance on flood protection through levees etc.
- This also results in a very strong reliance on modelling approaches rather than observational approaches or engineering judgement, even though it is recognised that accurate (geotechnical) modelling is only possible through thorough ground investigations.
- The above aspects, together with the fact that the Netherlands has a small Inspectorate with large responsibilities, also result in a strongly standardised approach with explicit (legal) safety standards and guidelines which are strongly recommended by law, if not prescribed.
- Despite the above, inspections are mainly visual (with digital storage tools) and range from weekly/monthly global inspections, to yearly in-depth inspections and 12-yearly quantitative safety assessments prescribed by law. Maintenance has been based on good engineering practices for a long time, but has in recent years become more and more risk-based.
- Real flood events are quite rare in The Netherlands and if they occur, the scale of flooding can be huge. This, and the weather conditions during coastal flooding (major storm!) make calamity management a real challenge.
- Despite the high costs of levee reinforcement (from about 1 million Euro/km for very ‘easy’ cases to order 30 million Euros in for example complex cases in built-up areas), their investment is nearly always worthwhile, and now supported by safety standards (partly) based on cost-benefit analysis. By the way, the all-in-cost of regular levee maintenance (including inspections and safety assessments) is only of the order of 50000 Euro per kilometre per year, in fact the yearly national budget for upgrading the primary levees and protection structures is larger (360 mln Euros)
- More information on storm surge barriers can be found on the site of the international network www.i-storm.org.

9.7 Critical knowledge and data gaps; critical research needs

This section is meant to summarise critical data and knowledge gaps, as well as critical research needs. Please not this is really about the critical knowledge gaps and research needs for proper (risk-based) management of levees, not about nice-to-know knowledge.
We need this information to be able decide on further topics to be explored with our working group

In 2017, some research agendas were drafted for the WBI2023 project for safety assessment tools and also in the wider context of the National Water and Climate Knowledge program NKWK. Below, just of a few of those items are given:

- Uncertainties about the foundations and geotechnical and geohydrological properties of levees are often critical in safety assessments, all the more so because the underground can have strong small-scale variability.
- Properties and effect of physical maxima on extreme value statistics of wind (main driving factor for coast, estuaries and lakes !), river discharges, storm surge and wind waves and earthquake loads, and

the associated uncertainties. Alternatives for extreme value distributions based on (too short) measured data sets.
- Improved modelling of internal erosion and piping compared to Sellmeijer, to achieve less conservative approach
- Interaction of failure mechanisms (overtopping and slope instability, etc.)
- Strength of transitions between different types of structure, revetment, etc.
- Modelling (induced and natural) earthquake loads and other vibrational loads (wind turbines, ..) and their effects on levees
- Added value of levee monitoring and remote sensing

9.8 Summary of key facts

This section is meant to summarise some key facts and figures in just a few words, for easy comparison amongst countries, and to facilitate writing the summary and conclusions:

- *Km of levees, no. of structures*
- *% along river, estuary, sea, lake*
- *Protected value, safety standard, actual protection level or flood risk*
- *Recent (near-)failures*
- *Key facts governance (which key players) and legislation*
- *Types of guidelines used*
- About 3500 km of primary flood defence; about 3000 km of levee, typically 3-10 m high (average ~6m); slopes mainly order 1:3, often interrupted with a berm
- In addition about 1500 hydraulic structures as primary flood defence
- 3% along rivers, 30% estuaries, remainder along lakes and coast
- present safety standards by law: withstand 1/250 to 1/10000 per year water level; nearly two-thirds of defences are OK
- New safety standards by law: 1/300 to 1/100000 per year flood probability; probably more stringent.
- 60% of land and about 70% of population/economy at risk without levees
- This is 12 million people or 400-500 billion Euro of yearly economic production
- Present actual protection level about 1/1000 per year, but this used to be less
- 6-7 floods or near-failures in last century, typically during 1/100 yr events. Various causes (overtopping and slope failure coastal levees, piping for levees, as well as failure due to non-flood causes like water supply pipes and drought, ..)
- Strong reliance on protection (by levees), and on standardised (and often model-based) approach for safety assessment, design, and to some extent also daily management
- Damage cost is limited due to strong protection, national reinforcement budget is 360 mln Euro/yr, regular maintenance spending probably less. Typical cost per kilometre is order 50000 Euro/yr for regular (all-in) maintenance and 1-30 mln Euro per kilometre for each major upgrading.
- Safety standards included in law, guidelines referred to in general sense
- strong reliance on dedicated national guidelines; the International Levee Handbook is not yet commonly used, and this applies even stronger to the ICOLD-Bulletins

9.9 References (per country)

Please support the Country-specific facts of the previous sections by references and weblinks as much as possible, so that information remains traceable and easy to update.

Bottema, Marcel (WVL) 5/2/16 16:00
Commentaire: Needs to be checked and completed for this whole chapter.

2. **Useful documents on www.helpdeskwater.nl**

Bottema, Marcel (WVL) 5/2/16 15:59
Commentaire: All weblnks to be checked and updated

a. **English translation (2009) of the original Dutch Water Act**, more recent modifications not yet included: http://www.helpdeskwater.nl/algemene-onderdelen/serviceblok/english/legislation/@29167/dutch-water-act/
b. **Brief brochure on the Water Act (2009)**, not yet updated: http://www.helpdeskwater.nl/algemene-onderdelen/serviceblok/english/legislation/@21831/the-dutch-water-act/
c. Relatively recent (2012) though not fully updated **overview of Flood Risk and Water Management Policies in the Netherlands** – http://www.helpdeskwater.nl/algemene-onderdelen/serviceblok/english/legislation/@34443/flood-risk-and-water/
d. Booklet describing the **main insights from the FLORIS Flood Risk Study**, major source of inspiration for the "WTI" Legal [water defence safety] Assessment Instrument, which is now under development: http://www.helpdeskwater.nl/algemene-onderdelen/serviceblok/english/water-and-safety/@34327/vnk-nader-verklaard/

e. In Dutch language only:

i. **Present version of the "WTI" Legal [water defence safety] Assessment Instrument**, used for the last safety assessment: http://www.helpdeskwater.nl/onderwerpen/waterveiligheid/primaire/toetsen/wti2006-vigerend/
ii. **New version of the "WTI" Legal [water defence safety] Assessment Instrument "WTI2017", under development**, using the new flood probability safety standards:http://www.helpdeskwater.nl/onderwerpen/waterveiligheid/primaire/toetsen/wti2017-ontwikkeling/
iii. **Formal design tool "OI2014"** to be used for the present dike reinforcement round (in http://www.hoogwaterbeschermingsprogramma.nl/Documenten+openbaar/Kennis+en+Innovatie/274378.aspx?t=Ontwerpinstrumentarium+2014+%28OI2014%29
iv. **References to other/various documents related to design**: http://www.helpdeskwater.nl/onderwerpen/waterveiligheid/primaire/ontwerpen-beheer/

3. **Useful documents on www.enwinfo.nl (ENW Guidelines)**

a. Overview of Dutch-language publications of ENW: http://www.enwinfo.nl/tool//view/overzicht.php
b. Overview of English-language publications **http://www.enwinfo.nl/asp/uk.asp?DocumentID=112&niveau=1,** containing the following guidelines (note that there not yet a translation of the "LeidraadKunstwerken" (Guidelines on Hydraulic Structures), which is currently being updated, given –amongst others- the introduction of new European Building Codes (Eurocode)**:**

1. **#PDF05 Fundamentals on Water Defences**
2. **#PDF07 Guidelines on Sea and Lake Dikes**
3. **#PDF13 Technical Report Clay for Dikes**

4. **#PDF14 Technical Report Erosion Resistance of Grassland as Dike Covering**
5. **#PDF15 Technical Report Wave Run-up and Overtopping at Dikes**
6. **#PDF16 Technical Report on Sand Boils (Piping)**
7. **#PDF17 Technical Report on Soil Structures**

10 Poland

PLEASE NOTE:

YELLOW MARKED text gives a description of the contents that are requested for this report
GREEN MARKED text gives information that may be of help when you are writing your country chapter.

TO BE FILLED AS MUCH AS POSSIBLE BY EACH COUNTRY. You do not need to provide lengthy texts; brief fact-sheet like texts are sufficient, at least for now.

You may find your chapter already filled in with some first suggestions; please feel free to use them or replace them with your own text, as you wish. In the end, the text is about your country, and therefore we prefer the final text is primarily your text and not the text of the main editors.

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INFORMATION THAT MAY BE OF HELP WHEN COMPILING YOUR CHAPTER

-

The report http://www.crue-eranet.net/partner_area/documents/D5_Main_Report.pdf contains some useful facts and figures on levees and the governance of Flood Risk Management (FRM) of many European countries, even though the data are 10 years old and not always up to date. However, they may be very useful to supplement that data gathered by our Levee Working group members, when they have difficulty in getting the right data:

- Table 34: Total yearly FRM investment Europe: close to or over 3 billion Euro.
- In each country chapter: years with main recent flood events

The preliminary flood risks assessments (PRFA's) and flood risk management plans (FRMP's) of the EU Floods Directive (http://www.envir.ee/sites/default/files/flooddirective.pdf; http://ec.europa.eu/environment/water/flood_risk/) may also provide useful information; water authorities can be found on http://www.eea.europa.eu/themes/water/interactive/floods-directive-viewer .

Some country- or river specific information can be found on:

- www.climateadaptation.eu: Quite useful site for some general information on vulnerability to for instance river floods, but also coastal floods, flash floods & urban floods, etc. etc., see for example:
- Appendix A of http://www.starflood.eu/documents/2013/06/flood-risk-management-in-europe-similarities-and-differences-between-the-star-flood-consortium-countries.pdf (for PL: Interesting figures on damage and on p78 1st indication of the large number of levees: over 4500 km !)
    -

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10.1 Facts and figures on levees and flood defences

This section is meant to answer questions like:

- *how many levees and other flood defences do you have (km's / nr's)*
    - *other flood defences may be moveable flood walls, storm-surge-barriers and also ordinary gates and sluices (the latter may be so numerous it may be too difficult to quantify them)*
- *what are typical dimensions and other properties (materials, layering, revetment, ..) for (different types of) levee in your country*
- *what is the geographical context: what are typical environments / flood types (% urban/rural levees, % river, estuary or coastal levees)*

- ***Could you give also an indication of yearly spendings on levee management and levee reinforcement (or on overall flood risk management if only that is available)? We think it has added value to present these numbers, and especially make clear what Business Case is hidden in the levee issue.***

You may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

Answers from Questionnaire

How many levees (Levees are raised, predominantly earth, structures that are not reshaped under normal conditions by the action of waves and currents, whose primary objective is to provide protection against fluvial and coastal flood events along coasts, rivers and artificial waterways (from the definition in the ILH)) do you have (in km)

- In our registry we have 7365 km of levees.

How many hydraulic structures (like gates, pumping stations, closure structures, …) do you have (in numbers)

- In our registry we have 8 gates and 70 pumping stations

How many flood defences of other type do you have (in km, or in numbers according to the type)

- In our registry we have 301 of dams, 343 of weirs, 401 of canal locks, 19 levees which are controlled as structure of reservoir

What % of your flood defences (of each type) is linked to the following physical environment / flood threat: (The numbers need to add up to 100)

- Sea 5
- Lake 5
- River 90

What would be a typical flood defence height in your country (please give min, max, medium if possible). The height is defined as difference top of the levee and ground level.

- Min 1
- Max 5
- Medium 3

10.2 Protected value, safety standards and flood risk

This section is meant to give an indication of the following:

- *What is (by and large) the protected value that could flood without levees and flood defences. Both in terms of life and economic value (preferably the assets, otherwise a fraction of the Gross Domectic Product)*
- *Do your levees and structures have a safety standard, and if so what does it refer to and what value has it got*
- *What is the actual protection level of your levees etc. (or what % does or does not satisfy the safety standards)*
- *Coming to the first issue: what is the residual risk (related to flooding despite the levees etc.), and how large is it compared to protected value (the ratio is in fact a measure of the actual protection level)*

Answers from Questionnaire

If they break what % of your flood defences represent: no hazard, material hazard, some life hazard and large scale life have hazard. (The numbers need to add up to 100)

- Material hazard only 90
- Some life hazard 9
- Large scale life hazard/economic hazard (say > 100 people/over 100 million) 1

Levee-related costs:
What would be a typical construction and/or rehabilitation cost for 1 km of levee in your country
- Performace of seals

What are typical (levels of) safety requirements for the hazard categories mentioned?
No hazard
- Fulfillment all requirements of the Regulations.

Material hazard only
- Fulfillment all requirements of the Regulations.

Some life hazard
- Fulfillment all requirements of the Regulations.

Large scale life hazard/economic hazard (say > 100 people/over 100 million)
- Fulfillment all requirements of the Regulations.

Safety requirement definitions may differ across countries. Please explain how the above safety requirements are defined (for example maximum allowable values of risk level, flood probability, water level a levee can just withstand, ...)
No hazard
- **Depending of class of the levee there are defined dispalcements of the ordinate of the top of the levee over ordinate of the water with defined probability of occure.**

To what type of Limit State do these requirements refer (if you are familiar with Box 5.11 of the International Levee Handbook, please use the terms Protection Level or Safety Level or Danger Level; if easier you can also use the 'Some Damage', 'Serious Damage', and 'Ultimate' Limit State).
No hazard
- Assurement of stability for defined class of levee and fulfill requirements of filtration curve in top of the levee.

Most countries have a system for periodic safety assessment or inspection of the flood defences. If such status reports are available, please add this information (sufficient, insufficient, unknown). If possible add a map with this information in the next question. (The numbers need to add up to 100)
- Sufficient 100%

10.3 Recent major floods and (near-)failures of levees

This section is meant to give a brief description of (near-)failures of levees/structures, and their causes and failure modes. Detailed information is not required, but we wish this section to serve as a portal to this detailed information.
Again, you may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

NOTE – Episodes with major storm surges or major high-river-discharge episodes <u>without</u> damage are also be relevant to mention as they give a measure of proven strength of the levees and flood defences.

Answers from Questionnaire

Is there coordinated operation and/or crisis management of upstream dams and downstream levees in the case of immediate flood threat?
- Yes

Did you have any recent (near-)failures of levees or other flood defences in recent years/decades
- Yes

Did you have large scale life hazard (say > 100 people) (near-) failures
- *No*

How often do large scale life hazard (near-)failures roughly occur?

- < 1/100

In which type of environment?
- River

Are there reports regarding lessons learnt from these (near-)failures, and have the conclusions from these report been followed in actual actions later?
- Preventative measures proposed

Did you have some life hazard (near-) failures
- Yes

How often do some life hazard (near-)failures roughly occur?
- 1/50

In which type of environment?
- River

Are there reports regarding lessons learnt from these (near-)failures, and have the conclusions from these report been followed in actual actions later?
- Preventative measures proposed

Did you have some material hazard (near-) failures
- Yes

How often do some life hazard (near-)failures roughly occur?
- 1/50

In which type of environment?
- River

Are there reports regarding lessons learnt from these (near-)failures, and have the conclusions from these report been followed in actual actions later?
- Preventative measures proposed

Did you have no hazard (near-) failures
- Yes

How often do some life hazard (near-)failures roughly occur?
- 1/50

In which type of environment?
- River

Are there reports regarding lessons learnt from these (near-)failures, and have the conclusions from these report been followed in actual actions later?
- Preventative measures proposed

10.4 Legislation and governance

Please give a short description about the main legislation related to levees and flood defences.

Please also indicate whether (i) this legislation is similar or even identical to the legislation used for dams (please check the Dam Legislation Report from the ICOLD European Club; levees are mentioned at least for ES, FI, FR and NL) and whether (ii) this legislation is a translation of the EU Floods Directive. The latter is interesting, because it allows to get an indication to what extent the Floods Directive has resulted in a common legal framework throughout Europe.
Besides this, it is also important to describe the key players with respect to Levees and Flood Risk Management and how they interact, i.e. the governance with respect to all life cycle phases of Levees and Flood Defences. Not only to describe the governance, but also to make clear how easy/difficult it is to get relevant information.

Answers from Questionnaire

Indicate the organization(s) that manage the flood defences. If management is distributed over different organizations, indicate which organization manages a certain fraction of the levees.

- Regional Water Managements Authority (RZGW) and Regional Authority of Melioration and /Water Devices (ZMiUW)

From a management viewpoint, and from a viewpoint of roles and responsibilities (i.e. governance), are there any differences between (i) levees, (ii) flood control dams and (iii) other types of dams worth mentioning, including the way these roles and responsibilities are referred to in law.
Levees

- Every informations are in National Regulation.

flood control dams

- Every informations are in National Regulation.

other types of dams worth mentioning

- Every informations are in National Regulation.

Does your country have central dam and/or levee registers

- Yes Dams and levees

If so, what information is included?

- Safety regulation
- Maintenance
- Cross section

Who has access to the data?

- State control authorities
- Dam and levee management organizations
- Local authorities

10.4.1 Legislation and governance – implementation EU Regulations

Please briefly describe how key EU legislation (mainly/especially the Floods Directive) is translated into national policy and legislation.

10.4.2 Legislation and governance – National legislation

Please give a short description about the main national legislation related to levees and flood defences, and whether/how it differs from Dam Legislation.

10.4.3 *Legislation and governance – Governance*

Please give a short description about the governance of levees and flood defences, i.e. the main parties / key players involved and their roles and duties.

10.5 Guidelines and good practices

Please mention what guidelines and good practice documents you use for design, safety assessment and maintenance of levees/flood defences; please give references/weblinks to some key documents.
Please also mention what parts of ICOLD-Bulletins and/or the International Levee handbook ILH are used in your country for the above.

What is your personal view on the applicability of ICOLD Bulletins/publications to levees and flood defences in your country?

- Some are applicable with adaptation

Is the previous answer just your personal point of view or do you represent a group of people

- Group of people (please specify)

10.6 Common practices during Levee Life Cycle

This section is meant to briefly share some common practices related to various life cycle phases of Levees & structures:

- *Design practice and cost of reinforcement (per km or per object)*
- *Inspection of levees*
- *Maintenance and safety assessment*
- *Flood event management*
- *…*

10.7 Critical knowledge and data gaps; critical research needs

This section is meant to summarise critical data and knowledge gaps, as well as critical research needs.
Please not this is really about the critical knowledge gaps and research needs for proper (risk-based) management of levees, not about nice-to-know knowledge.
We need this information to be able decide on further topics to be explored with our working group

10.8 Summary of key facts

This section is meant to summarise some key facts and figures in just a few words, for easy comparison amongst countries, and to facilitate writing the summary and conclusions:

- *Km of levees, no. of structures*
- *% along river, estuary, sea, lake*
- *Protected value, safety standard, actual protection level or flood risk*
- *Recent (near-)failures*
- *Key facts governance (which key players) and legislation*
- *Types of guidelines used*

10.9 References (per country)

Please support the Country-specific facts of the previous sections by references and weblinks as much as possible, so that information remains traceable and easy to update.

11 Slovenia

PLEASE NOTE:

YELLOW MARKED text gives a description of the contents that are requested for this report
GREEN MARKED text gives information that may be of help when you are writing your country chapter.

TO BE FILLED AS MUCH AS POSSIBLE BY EACH COUNTRY. You do not need to provide lengthy texts; brief fact-sheet like texts are sufficient, at least for now.

You may find your chapter already filled in with some first suggestions; please feel free to use them or replace them with your own text, as you wish. In the end, the text is about your country, and therefore we prefer the final text is primarily your text and not the text of the main editors.

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INFORMATION THAT MAY BE OF HELP WHEN COMPILING YOUR CHAPTER

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The report http://www.crue-eranet.net/partner_area/documents/D5_Main_Report.pdf contains some useful facts and figures on levees and the governance of Flood Risk Management (FRM) of many European countries, even though the data are 10 years old and not always up to date. However, they may be very useful to supplement that data gathered by our Levee Working group members, when they have difficulty in getting the right data:

- Table 34: Total yearly FRM investment Europe: close to or over 3 billion Euro.
- In each country chapter: years with main recent flood events
- CH9 – SLOVENIA
- CH10 – SPAIN
  - 1200 large dams and dikes
  - 300 mln Euro annual flood damage

The preliminary flood risks assessments (PRFA's) and flood risk management plans (FRMP's) of the EU Floods Directive (http://www.envir.ee/sites/default/files/flooddirective.pdf; http://ec.europa.eu/environment/water/flood_risk/) may also provide useful information; water authorities can be found on http://www.eea.europa.eu/themes/water/interactive/floods-directive-viewer .

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11.1 Facts and figures on levees and flood defences

This section is meant to answer questions like:

- *how many levees and other flood defences do you have (km's / nr's)*
  - *other flood defences may be moveable flood walls, storm-surge-barriers and also ordinary gates and sluices (the latter may be so numerous it may be too difficult to quantify them)*
- *what are typical dimensions and other properties (materials, layering, revetment, ..) for (different types of) levee in your country*
- *what is the geographical context: what are typical environments / flood types (% urban/rural levees, % river, estuary or coastal levees)*

- ***Could you give also an indication of yearly spendings on levee management and levee reinforcement (or on overall flood risk management if only that is available)? We think it has added value to present these numbers, and especially make clear what Business Case is hidden in the levee issue.***

You may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

Answers from Questionnaire

What types of flood defences do you have in your country:
How many levees (Levees are raised, predominantly earth, structures that are not reshaped under normal conditions by the action of waves and currents, whose primary objective is to provide protection against fluvial and coastal flood events along coasts, rivers and artificial waterways (from the definition in the ILH)) do you have (in km)

- over 100 km

How many flood walls (flood walls are hard structures which, like levees, protect against flooding, the difference being the type of material) do you have (in km)

- over 50 km

How many hydraulic structures (like gates, pumping stations, closure structures, …) do you have (in numbers)

- between 100-200 structures

How many flood defences of other type do you have (in km, or in numbers according to the type)

- 69 dams

What % of your flood defences (of each type) is linked to the following physical environment / flood threat: (The numbers need to add up to 100)

- Sea 2
- Estuary 0
- Lake 5
- River 20
- Torrent 73

What would be a typical flood defence height in your country (please give min, max, medium if possible). The height is defined as difference top of the levee and ground level.

- Min 1,00m
- Max 53m
- Medium 7m

Bottema, Marcel (WVL) 15/4/16 15:43
Commentaire: This seems no ordinary flood defence; some explanation may be welcome.

11.2 Protected value, safety standards and flood risk

This section is meant to give an indication of the following:

- *What is (by and large) the protected value that could flood without levees and flood defences. Both in terms of life and economic value (preferably the assets, otherwise a fraction of the Gross Domectic Product)*
- *Do your levees and structures have a safety standard, and if so what does it refer to and what value has it got*
- *What is the actual protection level of your levees etc. (or what % does or does not satisfy the safety standards)*
- *Coming to the first issue: what is the residual risk (related to flooding despite the levees etc.), and how large is it compared to protected value (the ratio is in fact a measure of the actual protection level)*

Answers from Questionnaire

If they break what % of your flood defences represent: no hazard, material hazard, some life hazard and large scale life have hazard. (The numbers need to add up to 100)

- No hazard 2

- Material hazard only 50
- Some life hazard 45
- Large scale life hazard/economic hazard (say > 100 people/over 100 million) 3

Levee-related costs:
What would be the typical maintenance and management cost for 1 km of levee in your country (including inspections and minor repairs)?
- 10000-15000

In our report we wish to give an impression of the importance of levees in terms of protected value. Could you give a rough indication of the (levee-)protected population size and economic value in your country?
- 700.000-800.000 people

What are typical (levels of) safety requirements for the hazard categories mentioned?
No hazard
- no measurements

Material hazard only
- regular manteinance of the river flow bassins

Some life hazard
- regular manteinance of the river flow bassins

Large scale life hazard/economic hazard (say > 100 people/over 100 million)
- levees and other water works (such as gates, acumulations etc.)

11.3 Recent major floods and (near-)failures of levees

This section is meant to give a brief description of (near-)failures of levees/structures, and their causes and failure modes. Detailed information is not required, but we wish this section to serve as a portal to this detailed information.
Again, you may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

NOTE – Episodes with major storm surges or major high-river-discharge episodes without damage are also be relevant to mention as they give a measure of proven strength of the levees and flood defences.

11.4 Legislation and governance

Please give a short description about the main legislation related to levees and flood defences.

Please also indicate whether (i) this legislation is similar or even identical to the legislation used for dams (please check the Dam Legislation Report from the ICOLD European Club; levees are mentioned at least for ES, FI, FR and NL) and whether (ii) this legislation is a translation of the EU Floods Directive. The latter is interesting, because it allows to get an indication to what extent the Floods Directive has resulted in a common legal framework throughout Europe.
Besides this, it is also important to describe the key players with respect to Levees and Flood Risk Management and how they interact, i.e. the governance with respect to all life cycle phases of Levees and Flood Defences. Not only to describe the governance, but also to make clear how easy/difficult it is to get relevant information.

11.4.1 Legislation and governance – implementation EU Regulations

Please briefly describe how key EU legislation (mainly/especially the Floods Directive) is translated into national policy and legislation.

11.4.2 Legislation and governance – National legislation

Please give a short description about the main national legislation related to levees and flood defences, and whether/how it differs from Dam Legislation.

11.4.3 Legislation and governance – Governance

Please give a short description about the governance of levees and flood defences, i.e. the main parties / key players involved and their roles and duties.

11.5 Guidelines and good practices

Please mention what guidelines and good practice documents you use for design, safety assessment and maintenance of levees/flood defences; please give references/weblinks to some key documents.
Please also mention what parts of ICOLD-Bulletins and/or the International Levee handbook ILH are used in your country for the above.

11.6 Common practices during Levee Life Cycle

This section is meant to briefly share some common practices related to various life cycle phases of Levees & structures:

- *Design practice and cost of reinforcement (per km or per object)*
- *Inspection of levees*
- *Maintenance and safety assessment*
- *Flood event management*
- *Role of flood maps and flood risk management plans as required by EU Floods Directive*
- *…*

11.7 Critical knowledge and data gaps; critical research needs

This section is meant to summarise critical data and knowledge gaps, as well as critical research needs.
Please not this is really about the critical knowledge gaps and research needs for proper (risk-based) management of levees, not about nice-to-know knowledge.
We need this information to be able decide on further topics to be explored with our working group

11.8 Summary of key facts

This section is meant to summarise some key facts and figures in just a few words, for easy comparison amongst countries, and to facilitate writing the summary and conclusions:

- *Km of levees, no. of structures*
- *% along river, estuary, sea, lake*
- *Protected value, safety standard, actual protection level or flood risk*
- *Recent (near-)failures*
- *Key facts governance (which key players) and legislation*
- *Types of guidelines used*

11.9 References (per country)

Please support the Country-specific facts of the previous sections by references and weblinks as much as possible, so that information remains traceable and easy to update.

12 Spain

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INFORMATION THAT MAY BE OF HELP WHEN COMPILING YOUR CHAPTER

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Floods in Spain may seriously impact on people and cause important economic losses. Although in recent years there has not been major disasters, every year around 10 people die as a result of floods. Economic losses are very important, and are estimated at 800 million euros per year, that is, about 0.1% of GDP (for example, every year an average of 200 million euros are allocated to compensate for damage to insured properties).

The enforcement of the Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (hereafter, the Floods Directive) allows the development of a common framework to reduce losses due to flooding. During the first cycle of the Directive implementation, Spanish authorities have produced flood hazard and risk maps. As a conclusion drawn from these maps, the following table shows estimated figures regarding existing population in areas at risk of flooding:

Source of flooding	*Estimated population living in areas at risk*	
	Medium probability (100 year-event)	*Low probability (500 year-event)*
Fluvial	1,939,447	2,818,585
Marine	321,372	365,692

Nearly 300 IPPC industries located in flood zones have also been identified. The total surface of the Areas of Potential Significant Flood Risk (APSFR) is about 6000 km^2, representing roughly 1% of the surface of Spain.

Due to the high variability of the Mediterranean climate, Spain has needed to build more than 1,000 large dams. These usually have multiple uses, mainly water storage for summertime and especially for drought periods. But most of these dams are also really important for flood risk mitigation, since rarely they are specifically designed only to reduce flooding. Regarding other floods defences common in many rivers such as dykes and levees, usually they are not high enough; in addition, their maintenance and security management are not as regulated as those of dams and reservoirs.

12.1 Facts and figures on levees and flood defences

This section is meant to answer questions like:

- *how many levees and other flood defences do you have (km's / nr's)*
  - *other flood defences may be moveable flood walls, storm-surge-barriers and also ordinary gates and sluices (the latter may be so numerous it may be too difficult to quantify them)*
- *what are typical dimensions and other properties (materials, layering, revetment, ..) for (different types of) levee in your country*
- *what is the geographical context: what are typical environments / flood types (% urban/rural levees, % river, estuary or coastal levees)*
- ***Could you give also an indication of yearly spendings on levee management and levee reinforcement (or on overall flood risk management if only that is available)? We think it has added value to present these numbers, and especially make clear what Business Case is hidden in the levee issue.***

You may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

Since more than 50 years ago, there is an official inventory of dams and reservoirs in Spain. However, there are no official and/or complete inventories of levees and other structures. River basin districts with more defences usually have a lot of croplands in areas at risk.

For instance, the Ebro River, one of the more important rivers in Spain, has an existing partial inventory in 225 Km along its middle course. This inventory shows that 48% of the river stretches have levees, which mostly defend croplands.

Another example would be the Duero Basin District, where channelling rivers and levees have been studied in an inventory of pressures for the river basin management plan. These studies identified around 10,000 km of heavily modified channels of which at least 7,000 included levees. Likewise, almost every river in the upper Guadiana basin district (over 1,000 km) is channelled with levees built with material from the dredging of rivers.

Figure 1: Aerial view of a flood event in Jabalón River (Guadiana basin). Existing levees were overflowed, what delayed the water drainage.

With the implementation of the Water Framework Directive and the Floods Directive, different studies are currently being developed, which will help to know the real situation of levees in Spain.

Levees in tributaries and small streams have a moderate size and rarely exceed three meters high. Levees in large rivers reach more important dimensions, with maximum heights around five meters.

These levees began to be built out of materials from the river dredging (mainly gravels and sands). When levees were overflowed or eroded, they were usually repaired with similar materials or, in some cases, debris or rubble. For this reason, some levees suffer from leakage and other structural problems. Only a few have been well designed and constructed with and impervious core.

Figure 2. Different types of levee built out of material available in the riverbed: River Curueño and River Valdeginate (River Douro basin).

In most of the water bodies levees aim for the protection of cultivated areas and small towns linked to agricultural production. Big cities often have a channelled river, in some cases accompanied by levees. Anyway, levees are usually located in riverine areas, and only in a few cases in coastal areas.

Levee maintenance is rare and usually limited to improvements in the upper layer of the structure, in order to allow the movement of vehicles when there is room enough. These actions are generally carried out by local authorities or users. Major repairs as well as reinforcement are undertaken after flood events, when these defence structures have been damaged by the water. Investments required for these works are normally funded by the state or by regional governments.

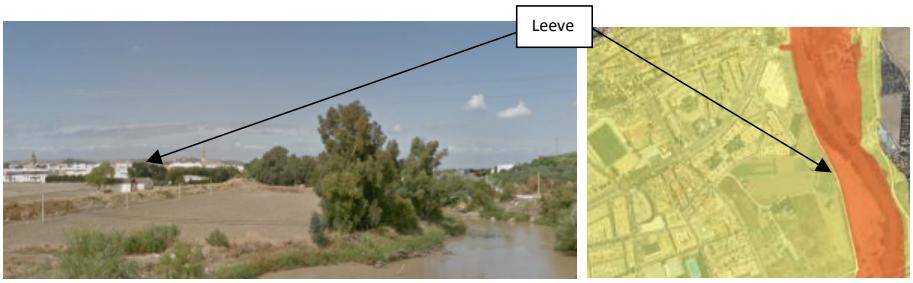

Figure 3. Example of a levee: Genil River in Ecija (Seville, River Guadalquivir basin). Levee works fine until the scenario of 10-year flood (in red). In a 500-year flood scenario (in yellow) the levee has no function.

12.2 Protected value, safety standards and flood risk

This section is meant to give an indication of the following:

- *What is (by and large) the protected value that could flood without levees and flood defences. Both in terms of life and economic value (preferably the assets, otherwise a fraction of the Gross Domectic Product)*
- *Do your levees and structures have a safety standard, and if so what does it refer to and what value has it got*
- *What is the actual protection level of your levees etc. (or what % does or does not satisfy the safety standards)*
- *Coming to the first issue: what is the residual risk (related to flooding despite the levees etc.), and how large is it compared to protected value (the ratio is in fact a measure of the actual protection level)*

Information on protected value is not available because there is not an official inventory. As already mentioned, levees usually protect agricultural areas and small villages for low return periods, but they may have negative effects when water runs over them.
There is no specific legislation concerning levees, dikes or other embankment type. They are designed with the best available technical criteria, but there are no specific rules.
Neither is there information on residual risk. It is scheduled to start working on these issues with the development of the Flood Risk Management Plans of the Floods Directive.

12.3 Recent major floods and (near-)failures of levees

This section is meant to give a brief description of (near-)failures of levees/structures, and their causes and failure modes. Detailed information is not required, but we wish this section to serve as a portal to this detailed information.
Again, you may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

NOTE – Episodes with major storm surges or major high-river-discharge episodes without damage are also be relevant to mention as they give a measure of proven strength of the levees and flood defences.

The safety level of levees in Spain depends mainly on their characteristics and how they have been built: design and materials (strength size, height, impervious core, adequate foundation, compaction, slope protection against erosion, etc.) and execution of works. In that sense, levees protecting towns have a gradual improvement over time (both stability and permeability) through specific actions or coincident with repairs after a flood event. Levees protecting agricultural areas, as already mentioned, do not have a planned maintenance.

Therefore, levee failures in Spain are frequent. Overtopping, lack of stability, slope erosion, excessive seepage or internal erosion are usually the main source of problems.

Figure 4. View of a levee during an overflow.

Figure 5. View of a partial failure of a levee caused by the slope erosion in contact with the water flow.


Figure 6. Example of partial failure in a levee due to an inadequate foundation.


Figure 7. Seepage through a levee that may cause its collapse.

12.4 Legislation and governance

Please give a short description about the main legislation related to levees and flood defences.

Please also indicate whether (i) this legislation is similar or even identical to the legislation used for dams (please check the Dam Legislation Report from the ICOLD European Club; levees are mentioned at least for ES, FI, FR and NL) and whether (ii) this legislation is a translation of the EU Floods Directive. The latter is interesting, because it allows to get an indication to what extent the Floods Directive has resulted in a common legal framework throughout Europe.
Besides this, it is also important to describe the key players with respect to Levees and Flood Risk Management and how they interact, i.e. the governance with respect to all life cycle phases of Levees and Flood Defences. Not only to describe the governance, but also to make clear how easy/difficult it is to get relevant information.

Spain has a detailed legislation on dam and reservoir safety since more than 50 years ago. Our dams have a broad range of requirements for safety operation, risk classification, emergency action plans, etc. However,

in terms of levees, there is not a specific legislation for the design, construction, maintenance and safety management.

Since 2008 a royal decree regulates where levees can be located, establishing a clear limitation to the construction of levees too close to rivers: "*Except in exceptional cases, levees can only be built in the floodway for protecting existing populations*".

With the same objective, some River Basin Management Plans (e.g., that of the Douro River Basin District) include additional requirements to locate levees, so as to coordinate the objectives of the Water Framework Directive with flood risk management.

The implementation of the programme of measures of the Flood Risk Management Plans (Floods Directive) and the River Basin Management Plans (Water Framework Directive) are a good opportunity to identify all the existing levees; assess their functionality, status and environmental impact; and, with all this information, establish a policy allowing the optimization of all these aspects.

Figure 8 . Example of a measure included in the Órbigo River Restoration Project (Douro River Basin): removal of a useless levee.

Figure 9 . Example of a civil work developed in the Esla River (Douro River Basin). The owner of the field located in the flood prone area had to undertake the removal of an old levee as a precondition for planting poplar trees.

12.4.1 Legislation and governance – implementation EU Regulations

Please briefly describe how key EU legislation (mainly/especially the Floods Directive) is translated into national policy and legislation.

Floods Directive was incorporated into Spanish legislation through the Royal Decree 903/2010 on the assessment and management of flood risks. The Government has already approved most of the Flood Risk Management Plans. All information is available at:

Royal Decree:
https://www.boe.es/diario_boe/txt.php?id=BOE-A-2010-11184

Floods Directive implementation: http://www.magrama.gob.es/es/agua/temas/gestion-de-los-riesgos-de-inundacion/

12.4.2 Legislation and governance – National legislation

Please give a short description about the main national legislation related to levees and flood defences, and whether/how it differs from Dam Legislation.

As already mentioned, dams and levees have different safety legislation. The main rules are stated in the Water Act and in the Royal Decree establishing the uses of the hydraulic public domain.

The Water Act provides the basis for managing the safety of dams and reservoirs, but not levees. In the Royal Decree establishing the uses of the hydraulic public domain, many aspects about water management and rivers are regulated. As for levees, There are only regulations concerning where they can be located, as already mentioned.

Therefore, the difference with the dam and reservoir regulation is enormous. Spain has a detailed legislation on dam and reservoir safety since more than 50 years ago. Our dams have a broad range of requirements for safety operation, risk classification, emergency action plans, etc. However, in terms of levees, there is not a specific legislation for the design, construction, maintenance and safety management.

12.4.3 Legislation and governance – Governance

Please give a short description about the governance of levees and flood defences, i.e. the main parties / key players involved and their roles and duties.

In general, levees were built by public administrations (e.g. the Ministry of Agriculture, Food and Environment through River Basin Authorities, or Regional Administrations). Their maintenance is mainly performed after flood events. In some cases, levees may be built by other stakeholders, provided that they have the required permissions from the River Basin Authority and, in all of the cases, the required environmental impact assessment.

The safety level of levees in Spain depends mainly on their characteristics and how they have been built: design, materials, and execution of works. In that sense, levees protecting towns have a gradual improvement over time (both stability and permeability) through specific actions or coincident with repairs after a flood event. Levees protecting agricultural areas, as already mentioned, do not have a planned maintenance.

With the implementation of the Water Framework Directive and the Floods Directive, different studies are currently being developed, which will help to know the real situation of levees in Spain.

In recent years, works on the optimization of levees have started, taking into account the objectives of the Water Framework Directive, recovering space for the rivers and improving their functionality. For instance, in the Douro River District (www.chduero.es) more than 80 km of levees with poor functionality have been already removed.

12.5 Guidelines and good practices

Please mention what guidelines and good practice documents you use for design, safety assessment and maintenance of levees/flood defences; please give references/weblinks to some key documents.
Please also mention what parts of ICOLD-Bulletins and/or the International Levee handbook ILH are used in your country for the above.

Currently, we do not have Guidelines and Good Practice documents specifically for levees. They are planned to be developed during the implementation of the Flood Risk Management Plans.

As significant examples of good practices in optimizing existing levees, Spain has recently implemented two important river restoration projects:

- Órbigo River in Douro basin (http://www.chduero.es/VerVideo-previo-orb2.aspx)
- Arga River and Aragon River in Ebro basin (http://www.territoriovison.eu/)

12.6 Common practices during Levee Life Cycle

This section is meant to briefly share some common practices related to various life cycle phases of Levees & structures:

- *Design practice and cost of reinforcement (per km or per object)*
- *Inspection of levees*
- *Maintenance and safety assessment*
- *Flood event management*
- *…*

Generally, it is complex for the different authorities and stakeholders to be able to develop planned management in levees safety, because of the limited budget available. In recent years, there has been only budget for repairs after flooding events.

12.7 Critical knowledge and data gaps; critical research needs

This section is meant to summarise critical data and knowledge gaps, as well as critical research needs.
Please not this is really about the critical knowledge gaps and research needs for proper (risk-based) management of levees, not about nice-to-know knowledge.
We need this information to be able decide on further topics to be explored with our working group

In our case, the first knowledge gap is to have a real knowledge of the location and status of existing levees. It is necessary to carry out detailed inventories.

Then, it would be very interesting to have basic criteria for the design of the levees: location, materials and construction techniques, and basic aspects of maintenance as well as management of the residual risk arising from an eventual failure and its relationship with urban planning behind the levees. Another big challenge is the removal or relocation of existing levees with low functionality.

12.8 Summary of key facts

This section is meant to summarise some key facts and figures in just a few words, for easy comparison amongst countries, and to facilitate writing the summary and conclusions:

- *Km of levees, no. of structures*
- *% along river, estuary, sea, lake*
- *Protected value, safety standard, actual protection level or flood risk*
- *Recent (near-)failures*

- *Key facts governance (which key players) and legislation*
- *Types of guidelines used*

The current situation can be summarized in the following items:

- There are no official inventories of levees, dykes or embankments. A first estimate of their total length could be of several thousand kilometres.
- Levees have usually small heights (up to 3-5 metres), protecting agricultural areas and small villages for low return periods.
- In recent years there have been frequent failures after flooding events.
- Unlike dams and reservoirs, there is no specific legislation or technical guidelines on the design, maintenance and safety management of levees.
- Since 2008 a royal decree regulates where levees can be located, establishing a clear limitation to the construction of levees too close to rivers: "Except in exceptional cases, levees can only be built in the floodway for protecting existing populations".
- The implementation of the programme of measures of the Flood Risk Management Plans (Floods Directive) and the River Basin Management Plans (Water Framework Directive) are a good opportunity to identify all the existing levees; assess their functionality, status and environmental impact; and, with all this information, establish a policy allowing the optimization of all these aspects.
- This optimization, based also on green infrastructure and natural water retention measures, will produce an increase of the river areas and the improvement of their status, all within the framework of adaptation to climate change.

12.9 References (per country)

Please support the Country-specific facts of the previous sections by references and weblinks as much as possible, so that information remains traceable and easy to update.

http://www.magrama.gob.es/es/agua/temas/gestion-de-los-riesgos-de-inundacion/

13 [Please fill in name of your country or insert new chapter]

PLEASE NOTE:

YELLOW MARKED text gives a description of the contents that are requested for this report
GREEN MARKED text gives information that may be of help when you are writing your country chapter.

TO BE FILLED AS MUCH AS POSSIBLE BY EACH COUNTRY. You do not need to provide lengthy texts; brief fact-sheet like texts are sufficient, at least for now.

You may find your chapter already filled in with some first suggestions; please feel free to use them or replace them with your own text, as you wish. In the end, the text is about your country, and therefore we prefer the final text is primarily your text and not the text of the main editors.

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INFORMATION THAT MAY BE OF HELP WHEN COMPILING YOUR CHAPTER

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The report http://www.crue-eranet.net/partner_area/documents/D5_Main_Report.pdf contains some useful facts and figures on levees and the governance of Flood Risk Management (FRM) of many European countries, even though the data are 10 years old and not always up to date. However, they may be very useful to supplement that data gathered by our Levee Working group members, when they have difficulty in getting the right data:

- Table 34: Total yearly FRM investment Europe: close to or over 3 billion Euro.
- In each country chapter: years with main recent flood events
- CH2 – AUSTRIA
  - Population and economy concentrated in river valleys
- CH3 – FINLAND
  - Estimated flood damage potential 500-600 mln Euros
- CH4 – FRANCE
  - 250 mln Euro annual damage, 500 mln annual investment in flood & coastal protection
- CH5 – GERMANY
  - About 7500 km flood protection dikes and walls
  - Several billion Euro damage due to recent floods
- CH6 – HUNGARY
  - 25% of country and population flood prone
  - 4200 km of (river) levees
- CH7 – ITALY
  - 3% of territory highly exposed to floods
  - Preservation of Venice 8,5 billion Euro spending in 30 years (nearly 300 mln Euro per year!)
- CH8 – NETHERLANDS
- CH9 – POLAND
- CH10 – SPAIN
  - 1200 large dams and dikes
  - 300 mln Euro annual flood damage
- CH11 – UNITED KINGDOM – ENGLAND
  - About 4-5 mln people and 140000 businesses at risk, representing 400 billion Euro of assets
  - Average annual damage over 1,5 billion Euro per year
- CH12 – UNITED KINGDOM – SCOTLAND
  - ~80000 homes + businesses at risk from river flooding (commonly occurring), another 100000 for coastal flooding (rare)

The preliminary flood risks assessments (PRFA's) and flood risk management plans (FRMP's) of the EU Floods Directive (http://www.envir.ee/sites/default/files/flooddirective.pdf; http://ec.europa.eu/environment/water/flood_risk/) may also provide useful information; water authorities can be found on http://www.eea.europa.eu/themes/water/interactive/floods-directive-viewer .

Some country- or river specific information can be found on:

- www.climateadaptation.eu: Quite useful site for some general information on vulnerability to for instance river floods, but also coastal floods, flash floods & urban floods, etc. etc., see for example:
  - Slovenia: http://www.climateadaptation.eu/slovenia/river-floods/
  - Italy: http://www.climateadaptation.eu/italy/river-floods/
  - Romania: http://www.climateadaptation.eu/romania/river-floods/
- Rhine countries PFRA, FRMP, maps: http://www.iksr.org/en/floods-directive/flood-risk-management-plan/index.html
- Finland, flood maps and other information: http://www.environment.fi/en-US/Waters/Floods/Flood_risk_management/Flood_risk_management_planning
- Danube countries PFRA, maps (and FRMP?): https://www.icpdr.org/main/activities-projects/implementation-eu-floods-directive
- PFRA Ireland: http://www.cfram.ie/wordpress/wp-content/uploads/2013/06/PFRA-Main-Report.pdf
- Italy:
  - MOSE Project storm surge protection Venice: https://en.wikipedia.org/wiki/MOSE_Project
  - River basin authorities: http://www.pcn.minambiente.it/GN/en/direttiva-alluvioni/171-spalla-destra/spalla-destra-uk-up/431-floods-directive?showall=1&limitstart=

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13.1 Facts and figures on levees and flood defences

This section is meant to answer questions like:

- *how many levees and other flood defences do you have (km's / nr's)*
  - *other flood defences may be moveable flood walls, storm-surge-barriers and also ordinary gates and sluices (the latter may be so numerous it may be too difficult to quantify them)*
- *what are typical dimensions and other properties (materials, layering, revetment, ..) for (different types of) levee in your country*
- *what is the geographical context: what are typical environments / flood types (% urban/rural levees, % river, estuary or coastal levees)*
- ***Could you give also an indication of yearly spendings on levee management and levee reinforcement (or on overall flood risk management if only that is available)? We think it has added value to present these numbers, and especially make clear what Business Case is hidden in the levee issue.***

You may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

13.2 Protected value, safety standards and flood risk

This section is meant to give an indication of the following:

- *What is (by and large) the protected value that could flood without levees and flood defences. Both in terms of life and economic value (preferably the assets, otherwise a fraction of the Gross Domectic Product)*
- *Do your levees and structures have a safety standard, and if so what does it refer to and what value has it got*
- *What is the actual protection level of your levees etc. (or what % does or does not satisfy the safety standards)*
- *Coming to the first issue: what is the residual risk (related to flooding despite the levees etc.), and how large is it compared to protected value (the ratio is in fact a measure of the actual protection level)*

13.3 Recent major floods and (near-)failures of levees

This section is meant to give a brief description of (near-)failures of levees/structures, and their causes and failure modes. Detailed information is not required, but we wish this section to serve as a portal to this detailed information.
Again, you may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

NOTE – Episodes with major storm surges or major high-river-discharge episodes without damage are also be relevant to mention as they give a measure of proven strength of the levees and flood defences.

13.4 Legislation and governance

Please give a short description about the main legislation related to levees and flood defences.

Please also indicate whether (i) this legislation is similar or even identical to the legislation used for dams (please check the Dam Legislation Report from the ICOLD European Club; levees are mentioned at least for ES, FI, FR and NL) and whether (ii) this legislation is a translation of the EU Floods Directive. The latter is interesting, because it allows to get an indication to what extent the Floods Directive has resulted in a common legal framework throughout Europe.
Besides this, it is also important to describe the key players with respect to Levees and Flood Risk Management and how they interact, i.e. the governance with respect to all life cycle phases of Levees and Flood Defences. Not only to describe the governance, but also to make clear how easy/difficult it is to get relevant information.

13.4.1 Legislation and governance – implementation EU Regulations

Please briefly describe how key EU legislation (mainly/especially the Floods Directive) is translated into national policy and legislation.

13.4.2 Legislation and governance – National legislation

Please give a short description about the main national legislation related to levees and flood defences, and whether/how it differs from Dam Legislation.

13.4.3 Legislation and governance – Governance

Please give a short description about the governance of levees and flood defences, i.e. the main parties / key players involved and their roles and duties.

13.5 Guidelines and good practices

Please mention what guidelines and good practice documents you use for design, safety assessment and maintenance of levees/flood defences; please give references/weblinks to some key documents.
Please also mention what parts of ICOLD-Bulletins and/or the International Levee handbook ILH are used in your country for the above.

13.6 Common practices during Levee Life Cycle

This section is meant to briefly share some common practices related to various life cycle phases of Levees & structures:

- *Design practice and cost of reinforcement (per km or per object)*
- *Inspection of levees*
- *Maintenance and safety assessment*
- *Flood event management*
- *…*

13.7 Critical knowledge and data gaps; critical research needs

This section is meant to summarise critical data and knowledge gaps, as well as critical research needs. Please not this is really about the critical knowledge gaps and research needs for proper (risk-based) management of levees, not about nice-to-know knowledge.
We need this information to be able decide on further topics to be explored with our working group

13.8 Summary of key facts

This section is meant to summarise some key facts and figures in just a few words, for easy comparison amongst countries, and to facilitate writing the summary and conclusions:

- *Km of levees, no. of structures*
- *% along river, estuary, sea, lake*
- *Protected value, safety standard, actual protection level or flood risk*
- *Recent (near-)failures*
- *Key facts governance (which key players) and legislation*
- *Types of guidelines used*

13.9 References (per country)

Please support the Country-specific facts of the previous sections by references and weblinks as much as possible, so that information remains traceable and easy to update.

14 Conclusions and outlook (NL+F?)

14.1 Summary conclusions

This section gives an overview of the key facts (see the key fact sections in the previous chapters), and then summarizes the conclusions.

The main general conclusions from this inventory are [*to be completed!!*]

- At least 8 European Countries have at least 3000 km of levee, in each case exceeding the equivalent of the distance from Madrid to Helsinki.
- Most levees are along rivers, but in some countries (especially in Western Europe), a significant part is along the coast or along lakes. Urban levees and floodwalls, and hydraulic structures represent a smaller but still important fraction.
- Typical levee heights are a few metres, but may occasionally be over 10 metres. Thus they are of the similar size as ICOLD small dams; perhaps even somewhat wider as levee slopes may tend to be somewhat smaller.
- Several countries have experienced levee failures in recent years, or before. Common failure causes are overtopping, internal erosion, problems with conduits through levees, problems with transition structures and in one occasion even due to drought. In some cases, soil subsidence (for example due to drainage or mining) may also increase hazard and risk.
- The hazard by levee failure seems small because most levee failures only represent material damage or some (rather than large-scale) life risk. Yet, the fraction of levees where failure implies large scale life risk can certainly not neglected.
- In fact, at least an estimated 50 million people in Europe are at risk from flooding, and many of those are protected by levees. The protected economic value is over 2000 billion Euros.
- In the period 1950-2005, over 45 major flood events occurred across Europe, each causing a damage of at least 0,005 % of the full European Gross Domestic product or at least 70 fatalities. Recent floods in central Europe led to several billion Euros of damage.
- Legislation and governance
  - Levees often are not explicitly addressed in the products required by the EU Floods Directive as these products often focus on a general policy level. However, in some countries, the Floods Directive was an incentive for revised safety standards and/or levee reinforcement
  - In several countries, dams and levees fall under the same legislation and thus under the same regulations. This clearly demonstrates the need to verify whether and to what extent general guidelines and best practices for dams are applicable to levees, and vice versa.
  - Safety standards often are (or used to be) in the order of 1/100 yr, but especially in high-risk areas, they tend to be raised because of risk and/or cost-benefit considerations, and standards of order 1/1000 or 1/10000yr are becoming more common.
  - Levee-related governance (who is responsible for what) is quite complex in many countries, with quite some differences among countries, or even amongst states within federal countries.
  - Some but certainly not all countries have central levee registers, along with their dam registers.
- Current practices
  - Most countries largely rely on national guidelines, although these may be inspired on international best practices; ICOLD Bulletins and the International Levee Handbook are rarely used directly.
  - Often, levees inspections and safety assessments are scheduled less often/systematically than for large dams, somewhat in line with the ICOLD experiences for small dams.
  - It is interesting to know that levee maintenance has a relatively low financial cost. It is the (re)construction of levees that is relatively expensive, often of the order of 1-2 million Euro per kilometre, in complex/urban areas even more.

A brief summary of facts and figures per country is given below:

- Czech Republic
  - About 4000 km of levees including urban floodwalls up to which are often used; the number of structures is not identified but probably several hundreds,
  - Mostly up to 4 m high, with (required) crest width > 3m and inner slopes up to about 1:2 (outer about 1:3)
  - 90 % along rivers, 10% along streams and/or torrents
  - In 16 years time, 4 major floods with return periods > 500 years, causing about 130 fatalities and order 6 billion Euro damage.
  - Failures mostly due to overtopping and internal erosion, many a times close to conduits in the levee. Until 2004 failure rate in Morava river basin order 0,003 failures/km/yr.
  - [[Protected value will be identified later]]
  - Safety standard not unique, according to the property in floodplain, determined by the cost benefit analysis using risk approaches, (?) often in the order of 1/100, recently raised up to 1/10000 when high risk.
  - Regulations spread across several laws, standards and guidelines, dams and levees fall under same legislation.
  - Key facts governance - levee owners, state interventions, key role of river agencies.
  - Guidelines - mostly national technical standards and national guidelines; Levee handbook and ICOLD Bulletins generally not directly applied
  - Main knowledge gap related to lack of central levee register.
- England
  - *2.4 million properties and a significant amount of critical infrastructure at risk from sea or river flooding (and 3 million more by surface runoff), representing an annual economic consequences of river/coastal flooding risk about 960 million pound (slightly over 1 billion Euro).*
  - *About 8000 km of levees of 1-6 m height, and 22000 hydraulic / flood protection structures*
  - *70% of them along rivers, another 18% along estuaries and 10 % along the coast*
  - *Safety requirements up to 1/1000yr for large scale life hazard (depending on cost-benefit), typically 1/100yr or 1/200yr for some life hazard, and 1/5yr - 1/100yr for metrial hazard only.*
  - *Some failures during the winters of 2013/2014 and 2015/2016, due to overtopping and inner slope erosion and along transitions. No lives lost, but some people evacuated. Improvements implemented or under investigation.*
  - *Levees along sea and main rivers managed by state (Environment Agency), the remaining 50% by third (public or private) parties)*
  - *Dam legislation appears to be more restrictive/specific than levee legislation.*
  - *There are central registers for dams, and also for major levees.*
  - *Common practices are annual risk-based maintenance programmes, risk-based inspections every 0,5-5 years (depending on risk) and flood event management. Reinforcement cost is slightly less than 1 MEuro/km*
  - *Critical knowledge gaps relate to climate change/adaptation, levee performance and failure modes (especially near transitions), predicting life stage of levee and vegetation management.*
  - *2.4 million properties at risk from sea or river flooding (and 3 million more by surface runoff)*
- Finland
  - About 500 registered levees
  - Most levees protect farm land from rivers, also some sea levees and urban levees
  - The most important levee (at Pori) protects 15000 people and 3 billion Euro in assets
  - Many levees are now being constructed or improved in response to the EU Floods Directive, safety standards are also upgraded to typically 1/100 yr.

Bottema, Marcel (WVL) 15/4/16 15:57
Commentaire: To be checked (and perhaps supplemented

Bottema, Marcel (WVL) 13/4/16 16:02
Commentaire: To be checked by UK !

- Damage potential for a 1/250 yr flood would be about 550 mln Euro
- Large (springtime/snow-melt) river floods in 1953, 1966, 1984 and 2000 with up to 5 million Euro damage; large (1/30 yr) storm surge in Helsinki in 2005.
- Dams and levees have common legislation/regulation
- Classification of levees is underway; classified dams and levees are supervised by ELY, but the dam/levee owner is responsible for all other aspects

Bottema, Marcel (WVL) 14/4/16 16:29
Commentaire: To be checked/completed bu FI

- France
  - About 9000 km of levees (roughly 90% inland and 10% coastal)
  - Usually from locally available earth material, height usually up to 6 m.
  - Annual flood damage order 1 billion Euro/yr, roughly 25% insured
  - 18 million people live in potential flood hazard areas, 2 million people and 20000 km^2 (roughly 3% of France) are protected by major flood protection systems.
  - Some recent flood defence failures, but no failures until 1993
  - Levees have no explicit role in Floods Directive implementation
  - Similar legislation for levees, dams and other protection structures
  - Common practices and obligations depend on levee type/class (depending on height and protected population)
  - Many levees to be inspected for first time; for high-risk levees in-depth inspections/assessments every 1-10 yrs.
  - Governance: various parties involved: from state to municipality to home/ground owner
  - No prescriptive guidelines, but various informal guidance documents
  - Annual maintenance+inspection typically 14 kEuro/km, reinforcement typically 1-2 MEuro/km

Bottema, Marcel (WVL) 13/4/16 16:05
Commentaire: summarised by NL, to be checked by France

- Germany
  - In Germany exist some 10 000 km of levees, and thousands of adjacent structures.
  - It is estimated that about 20% of the levees are coastal and 80% fluvial.
  - The levees protect over 12 million people and at least 2 billion Euro in asset value.

Bottema, Marcel (WVL) 25/4/16 11:30
Commentaire: Added by NL

  - The safety standards are set by the actual standard DIN 19712 and the DWA Guideline 507-1 as well as the EAU-Recommendations for the coast. The level of protection for densily inhabitated areas is normally 1/100. More values are given in Table 5.
  - Recent levee failures occurred e.g. in 1997 at the Odra river and 2002 and 2013 at the Elbe and Danube.
  - The standard DIN 19712 and the DWA Guideline 507-1 as well as the EAU-Recommendations are the main guideline documents for levee planning, design and assessment. ICOLD Bulletins and the International Levee Handbook may be consulted but play no key role.
  - Governance reflects the fact that Germany consists of 16 Länder in which governance may differ
  - Key knowledge gaps: flood risk prediction and mapping using the actual condition of levees, and knowing the levee and its underground in greater detail.
- Hungary
  - 25% of country and population flood prone
  - 4200 km of (river) levees
- Italy
  - 3% of territory highly exposed to floods
  - Preservation of Venice 8,5 billion Euro spending in 30 years (nearly 300 mln Euro per year!)

Bottema, Marcel (WVL) 15/4/16 15:56
Commentaire: to be checked/supplemented

- The Netherlands
  - About 3500 km of primary flood defence; about 3000 km of levee, typically 3-10 m high (average ~6m); slopes mainly order 1:3, often interrupted with a berm
  - In addition about 1500 hydraulic structures as primary flood defence
  - 30% along rivers, 30% estuaries, remainder along lakes and coast
  - present safety standards by law: withstand 1/250 to 1/10000 per year water level; nearly two-thirds of defences are OK

Bottema, Marcel (WVL) 14/4/16 16:31
Commentaire: to be checked and completed

- New safety standards by law: 1/300 to 1/100000 per year flood probability; probably more stringent.
- 60% of land and about 70% of population/economy at risk without levees
- This is 12 million people or 400-500 billion Euro of yearly economic production
- Present actual protection level about 1/1000 per year, but this used to be less
- 6-7 floods or near-failures in last century, typically during 1/100 yr events. Various causes (overtopping and slope failure coastal levees, piping for levees, as well as failure due to non-flood causes like water supply pipes and drought, ..)
- Strong reliance on protection (by levees), and on standardised (and often model-based) approach for safety assessment, design, and to some extent also daily management
- Damage cost is limited due to strong protection, national reinforcement budget is 360 mln Euro/yr, regular maintenance spending probably less. Typical cost per kilometre is order 50000 Euro/yr for regular (all-in) maintenance and 1-30 mln Euro per kilometre for each major upgrading.
- Safety standards included in law, guidelines referred to in general sense
- strong reliance on dedicated national guidelines; the International Levee Handbook is not yet commonly used, and this applies even stronger to the ICOLD-Bulletins

- Poland
  - Answers from Questionnaire
  - In our registry we have 7365 km of levees, 8 gates, 70 pumping stations, 301 dams, 343 weirs, 401 canal locks, 19 levees which are controlled as structure of reservoir
  - 90% protects from river hazard, the remainder from lake or sea hazard; in 90% there is only material hazard, the remaining 10% also presents some life hazard.
  - Typical levee heights are about 3 metres (1-5)
  - There are central dam and levee registers

Bottema, Marcel (WVL) 15/4/16 15:56
Commentaire: to be checked / supplemented

- Slovenia
  - Answers from Questionnaire
  - Over 100 km of levee and 50 km of flood wall; 100-200 hydraulic structures and 69 dams
  - 73% along torrent, 20% along river, 5% along lake, 2% along sea
  - Height 1-53 m, medium height 7m (probably including the dams)
  - 700000-800000 protected people
  - 3% represents a large scale life hazard (if the levee/dam breaks), another 50% represents some life hazard, the remainder material hazard only
  - Maintenance cost about 10000-15000 Euro/km

Bottema, Marcel (WVL) 15/4/16 15:56
Commentaire: to be checked / supplemented

- Spain
  - Over 1000 large dams, several thousand km of typically 3-5m high levees, especially in Ebro, Duero and Guadiana basins, mostly to protect cultivated areas and small towns
  - 2-3 million people at risk from flooding (of which ~300000 from marine flooding), about 10 flood casualties per year and order 800 MEuro yearly damage.
  - Marked difference between regulation and practices for dams and levees. Highly regulated for dams, much less so for levees: no official/complete inventory, no specific rules and regulations and often incidental maintenance and quite frequent failures. Guidelines under development as part of the Floods Directive implementation.
  - Floodplain restoration gets quite some attention, and levee removal of (obsolete) levees is often part of it.

Bottema, Marcel (WVL) 7/10/16 15:18
Commentaire: to be checked/supplemented

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14.2 Outlook

Outlook towards further activities of the EURCOLD Woring Group on Levees and Flood Defenses.

The previous section clearly states the importance of levees across the European ICOLD countries.

Further activities that could be envisaged are:

- Further steps towards building a Community of Practice for Levees and Flood Defences for sharing knowledge and experiences within ICOLD, and where appropriate also extending outside ICOLD.
- Extending the present report to provide a more complete overview over Europe, and perhaps include some key countries outside Europe
- Mapping similarities and differences between levees and dams, and showing synergy opportunities when including levee experience in ICOLD, and use ICOLD experience for levees.
- Map where the applicability of ICOLD Bulletins to levees could be enhanced
- Map how/where the International Levee handbook could be enhanced to be more complete with respect to levee management in all life cycle stages, and to enhance its suitability for dam applications.
- Joint role of reservoir dams (operation) and levees in flood risk management

Bijlage A Appendix A – Levee inventory Questionnaire

The following Questionnaire was used to gather the initial data to be included in this report:

1. **(*) Country**
2. **(*) Name**
3. **Organisation**
   a. Function
4. **(*) Contact Information :**
   a. (*) mail
   b. Phone
   c. post
5. **Flood defences, physical environment and hazard**
   a. What types of flood defences do you have in your country:
      i. How many levees [6]do you have (in km)
      ii. How many flood walls[7] do you have (in km)
      iii. How many hydraulic structures[8] do you have (in numbers)
      iv. Remarks.
   b. What % of your flood defences (of each type) is linked to the following physical environment / flood threat:
      i. Sea
      ii. Estuary
      iii. Lake
      iv. River
      v. Torrent
   c. What would be a typical flood defence height in your country (please give min, max, medium if possible)
   d. Do you have one or more maps and/or GIS-files showing the flood defences position? If possible please upload it here
   e. What % of your flood defences represent, if they break:
      i. No hazard
      ii. Material hazard only
      iii. Some life hazard
      iv. Large scale life hazard/economic hazard (say > 100 people/over 100 million)
      v. Explanatory remarks (if you had to adapt the hazard categories to what is commonly used in your country)
   f. Levee-related costs:
      i. What would be a typical construction and/or rehabilitation cost for 1 km of levee in your country
      ii. What would be the typical maintenance and management cost for 1 km of levee in your country (including inspections and minor repairs)?
      iii. Other information you wish to add (for example on other flood defence types?)
   g. In our report we wish to give an impression of the importance of levees in terms of protected value. Could you give a rough indication of the (levee-)protected population size and economic value in your country?
   h. Explanatory remarks you wish to add (for example levee types that are not included in your answers because they are too small/numerous/cumbersome to elaborate upon, or remarks you wish to make about natural flood protection features like dunes).

[6] Levees are raised, predominantly earth, structures that are not reshaped under normal conditions by the action of waves and currents, whose primary objective is to provide protection against fluvial and coastal flood events along coasts, rivers and artificial waterways (from the definition in the ILH)
[7] flood walls are hard structures which, like levees, protect against flooding, the difference being the type of material
[8] like gates, pumping stations, closure structures, …

6. **Safety standards:**
    a. What are typical (levels of) safety requirements for the hazard categories mentioned in the previous question [5e]?
        i. No hazard
        ii. Material hazard only
        iii. Some life hazard
        iv. Large scale life hazard/economic hazard (definitions of this category may differ across countries; as rough indication, large scale may mean at least 100 victims or 100 million Euro damage)
    b. Safety requirement definitions may differ across countries. Please explain how the above safety requirements are defined (for example maximum allowable values of risk level, flood probability, water level a levee can just withstand, water level a levee can just withstand, …)
    c. To what type of Limit State do these requirements refer (*if you are familiar with Box 5.11 of the International Levee Handbook, please use the terms Protection Level or Safety Level or Danger Level; if easier you can also use the 'Some Damage', 'Serious Damage', and 'Ultimate' Limit State*).
    d. Are these safety standards included in, or referred to in law? How?
        i. Included in law
        ii. referred to in law, included in underlying legislation
        iii. Not included in formal legislation
        iv. Please give further specifications/explanations if appropriate.
    e. Further to subquestion "c". Are legal requirements for dams and levees roughly similar? If not, please point out the main differences between (i) levees, (ii) flood control dams and (iii) regular dams, considering the aspects of question 5?
    f. Do you have maps with safety requirements you can upload?
    g. Explanatory remarks you may wish to add…

7. **Safety assessment / inspection status:**
    a. Most countries have a system for periodic safety assessment and/or inspection of the flood defences. If such status reports are available, please add this information (sufficient, insufficient, unknown). If possible add a map with this information
        - Sufficient safety (%)
        - Insufficient safety (%)
        - Unknown safety (%)

    b. Is there coordinated operation and/or crisis management of upstream dams and downstream levees in the case of immediate flood threat?
    c. Did you have any recent (near-)failures of levees or other flood defences in recent years/decades for **large scale hazard**? (Y/N)
    d. How often do these (near-)failures roughly occur?
        - >1/year
        - 1/year
        - 1/10 years
        - 1/50 years
        - 1/100 years
        - <1/100 years
    e. In which type of environment?
        - Sea
        - Estuary
        - Lake
        - River
        - Torrent
    f. What are the most common failure mechanisms for these incidents?
        - Overtopping/overflowing
        - Internal erosion
        - Geotechnical instability
        - Other (May include revetment failure, non-closure or structural failure of hydraulic structures, failure at (hard-soft-)transitions, etc.)
    g. Do you have any well-described events that are suitable for case studies? (Y/N)[9]
        i. If YES, please give a brief description and upload relevant web links and document
    h. Are there reports regarding lessons learnt from these (near-)failures.
        i. If yes, could you provide some weblinks or report;
        ii. and have the conclusions from these reports have had follow-up in actual actions later?
            - No preventative measures proposed
            - Preventative measures proposed

[9] an internationally open database for a more complete description of (near)failure of levees and flood defenses is likely to become available in the near future

- Preventative measures proposed and implemented

i. Did you have any recent (near-)failures of levees or other flood defences in recent years/decades for **some life hazard**? (Y/N)
    i. Same sub-questions as under item d-h above
j. Did you have any recent (near-)failures of levees or other flood defences in recent years/decades for **material hazard**? (Y/N)
    i. Same sub-questions as under item d-h above
k. Did you have any recent (near-)failures of levees or other flood defences in recent years/decades for **no hazard**? (Y/N)
    i. Same sub-questions as under item d-h above

8. Management information:

a. indicate the organization(s) or type of organizations that manage the flood defences. If management is distributed over different organizations, indicate which organization manages which fraction of the levees.
b. From a management viewpoint, and from a viewpoint of roles and responsibilities (i.e. governance), are there any differences between (i) levees, (ii) flood control dams and (iii) other types of dams worth mentioning, including the way these roles and responsibilities are referred to in law.

9. Dams, levees and the EU Floods Directive (EUFD)

a. What aspects of dams and levees are included in the products (Preliminary Risk Assessment, Risk Maps and Flood Risk Management Plans) required by the EU Floods Directive (EUFD)?
b. Are dams and levees similarly dealt with under your countries EUFD-implementation or differently (and in which respects).
c. Are there any important dam- or levee-related aspects (related to their management, their flood risk, combined risk assessment / management of upstream dams and downstream levees, etc.) the national implementation of EUFD do not consider?
d. Remarks, lessons and or documents you want to share

10. Dam and levee registers.

a. Does your country have central dam and/or levee registers?
    - Yes Dams and levees
    - Yes Dams only
    - Yes Levees Only
    - No
b. If so, what information is included?
    - Profile
    - Safety regulation
    - Maintenance
    - Cross section
    - Other
c. Who has access to the data?
    - Public information
    - State control authorities
    - Dam and levee management organizations
    - Local authorities
    - other

11. Levees and ICOLD Bulletins

a. What is your view on the applicability of ICOLD Bulletins/publications to levees and flood defences in your country?
    - Not helpful (yet)
    - Educational but not applicable
    - Some are applicable with adaptation
    - Some are directly applicable
    - Very helpful and applicable
b. Is the previous answer your personal point of view or do you represent a group of people
c. Any specific remarks?

12. Other guidance

a. Apart form ICOLD bulletins and the International Levee Handbook, is there some other type of guidance available in your country?
b. Can you list the main guidance documents with possibly weblinks?

13. **Knowledge gaps**:

a. What levee- and flood-defence related issues and knowledge gaps are critical (to guarantee safety, and the integrity of the structure)?

14. **Other remarks:**

Bijlage B Report Chapter Template

This Appendix gives an overview of the template that was used to fill each Chapter of this report:

XX [Please fill in name of your country or insert new chapter]

PLEASE NOTE:
YELLOW MARKED text gives a description of the contents that are requested for this report
GREEN MARKED text gives information that may be of help when you are writing your country chapter.

TO BE FILLED AS MUCH AS POSSIBLE BY EACH COUNTRY. You do not need to provide lengthy texts; brief fact-sheet like texts are sufficient, at least for now.

You may find your chapter already filled in with some first suggestions; please feel free to use them or replace them with your own text, as you wish. In the end, the text is about your country, and therefore we prefer the final text is primarily your text and not the text of the main editors.

The report http://www.crue-eranet.net/partner_area/documents/D5_Main_Report.pdf contains some useful facts and figures on levees and the governance of Flood Risk Management (FRM) of many European countries, even though the data are 10 years old and not always up to date. However, they may be very useful to supplement that data gathered by our Levee Working group members, when they have difficulty in getting the right data:

- Table 34: Total yearly FRM investment Europe: close to or over 3 billion Euro.
- In each country chapter: years with main recent flood events
- CH2 – AUSTRIA
  - Population and economy concentrated in river valleys
- CH3 – FINLAND
  - Estimated flood damage potential 500-600 mln Euros
- CH4 – FRANCE
  - 250 mln Euro annual damage, 500 mln annual investment in flood & coastal protection
- CH5 – GERMANY
  - About 7500 km flood protection dikes and walls
  - Several billion Euro damage due to recent floods
- CH6 – HUNGARY
  - 25% of country and population flood prone
  - 4200 km of (river) levees
- CH7 – ITALY
  - 3% of territory highly exposed to floods
  - Preservation of Venice 8,5 billion Euro spending in 30 years (nearly 300 mln Euro per year!)
- CH8 – NETHERLANDS
- CH9 – POLAND
- CH10 – SPAIN
  - 1200 large dams and dikes
  - 300 mln Euro annual flood damage
- CH11 – UNITED KINGDOM – ENGLAND
  - About 4-5 mln people and 140000 businesses at risk, representing 400 billion Euro of assets
  - Average annual damage over 1,5 billion Euro per year
- CH12 – UNITED KINGDOM – SCOTLAND
  - ~80000 homes + businesses at risk from river flooding (commonly occurring), another 100000 for coastal flooding (rare)

The preliminary flood risks assessments (PRFA's) and flood risk management plans (FRMP's) of the EU Floods Directive (http://www.envir.ee/sites/default/files/flooddirective.pdf; http://ec.europa.eu/environment/water/flood_risk/) may also provide useful information; water authorities can be found on http://www.eea.europa.eu/themes/water/interactive/floods-directive-viewer .

Some country- or river specific information can be found on:

- www.climateadaptation.eu: Quite useful site for some general information on vulnerability to for instance river floods, but also coastal floods, flash floods & urban floods, etc. etc., see for example:
  - Slovenia: http://www.climateadaptation.eu/slovenia/river-floods/

- Italy: http://www.climateadaptation.eu/italy/river-floods/
- Romenia: http://www.climateadaptation.eu/romania/river-floods/

- Rhine countries PFRA, FRMP, maps: http://www.iksr.org/en/floods-directive/flood-risk-management-plan/index.html
- Finland, flood maps and other information: http://www.environment.fi/en-US/Waters/Floods/Flood_risk_management/Flood_risk_management_planning
- Danube countries PFRA, maps (and FRMP?): https://www.icpdr.org/main/activities-projects/implementation-eu-floods-directive
- PFRA Ireland: http://www.cfram.ie/wordpress/wp-content/uploads/2013/06/PFRA-Main-Report.pdf
- Italy:
  - MOSE Project storm surge protection Venice: https://en.wikipedia.org/wiki/MOSE_Project
  - River basin autohories: http://www.pcn.minambiente.it/GN/en/direttiva-alluvioni/171-spalla-destra/spalla-destra-uk-up/431-floods-directive?showall=1&limitstart=

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XX.1 Facts and figures on levees and flood defences

This section is meant to answer questions like:

- *how many levees and other flood defences do you have (km's / nr's)*
  - *other flood defences may be moveable flood walls, storm-surge-barriers and also ordinary gates and sluices (the latter may be so numerous it may be too difficult to quantify them)*
- *what are typical dimensions and other properties (materials, layering, revetment, ..) for (different types of) levee in your country*
- *what is the geographical context: what are typical environments / flood types (% urban/rural levees, % river, estuary or coastal levees)*
- *Could you give also an indication of yearly spendings on levee management and levee reinforcement (or on overall flood risk management if only that is available)? We think it has added value to present these numbers, and especially make clear what Business Case is hidden in the levee issue.*

You may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

XX.2 Protected value, safety standards and flood risk

This section is meant to give an indication of the following:

- *What is (by and large) the protected value that could flood without levees and flood defences. Both in terms of life and economic value (preferably the assets, otherwise a fraction of the Gross Domectic Product)*
- *Do your levees and structures have a safety standard, and if so what does it refer to and what value has it got*
- *What is the actual protection level of your levees etc. (or what % does or does not satisfy the safety standards)*
- *Coming to the first issue: what is the residual risk (related to flooding despite the levees etc.), and how large is it compared to protected value (the ratio is in fact a measure of the actual protection level)*

XX.3 Recent major floods and (near-)failures of levees

This section is meant to give a brief description of (near-)failures of levees/structures, and their causes and failure modes. Detailed information is not required, but we wish this section to serve as a portal to this detailed information.

Again, you may add a few photographs, but please make sure the file size will not increase more than 1MB or it will be a tough job sharing this document given the limited mail-box-capacity of some of us.

NOTE – Episodes with major storm surges or major high-river-discharge episodes without damage are also be relevant to mention as they give a measure of proven strength of the levees and flood defences.

XX.4 Legislation and governance

Please give a short description about the main legislation related to levees and flood defences.

Please also indicate whether (i) this legislation is similar or even identical to the legislation used for dams (please check the Dam Legislation Report from the ICOLD European Club; levees are mentioned at least for ES, FI, FR and NL) and whether (ii) this legislation is a translation of the EU Floods Directive. The latter is interesting, because it allows to get an indication to what extent the Floods Directive has resulted in a common legal framework throughout Europe.
Besides this, it is also important to describe the key players with respect to Levees and Flood Risk Management and how they interact, i.e. the governance with respect to all life cycle phases of Levees and Flood Defences. Not only to describe the governance, but also to make clear how easy/difficult it is to get relevant information.

XX.4.1 Legislation and governance – implementation EU Regulations

Please briefly describe how key EU legislation (mainly/especially the Floods Directive) is translated into national policy and legislation.

XX.4.2 Legislation and governance – National legislation

Please give a short description about the main national legislation related to levees and flood defences, and whether/how it differs from Dam Legislation.

XX.4.3 Legislation and governance – Governance

Please give a short description about the governance of levees and flood defences, i.e. the main parties / key players involved and their roles and duties.

XX.5 Guidelines and good practices

Please mention what guidelines and good practice documents you use for design, safety assessment and maintenance of levees/flood defences; please give references/weblinks to some key documents. Please also mention what parts of ICOLD-Bulletins and/or the International Levee handbook ILH are used in your country for the above.

XX.6 Common practices during Levee Life Cycle

This section is meant to briefly share some common practices related to various life cycle phases of Levees & structures:

- *Design practice and cost of reinforcement (per km or per object)*
- *Inspection of levees*
- *Maintenance and safety assessment*
- *Flood event management*
- …

XX.7 Critical knowledge and data gaps; critical research needs

This section is meant to summarise critical data and knowledge gaps, as well as critical research needs.
Please not this is really about the critical knowledge gaps and research needs for proper (risk-based) management of levees, not about nice-to-know knowledge.
We need this information to be able decide on further topics to be explored with our working group

XX.8 Summary of key facts

This section is meant to summarise some key facts and figures in just a few words, for easy comparison amongst countries, and to facilitate writing the summary and conclusions:

- *Km of levees, no. of structures*
- *% along river, estuary, sea, lake*
- *Protected value, safety standard, actual protection level or flood risk*
- *Recent (near-)failures*
- *Key facts governance (which key players) and legislation*
- *Types of guidelines used*

XX.9 References (per country)

Please support the Country-specific facts of the previous sections by references and weblinks as much as possible, so that information remains traceable and easy to update.

Bijlage C Appendix C (if we need it)

- …

C.1 Appendix B.1 (if needed)

This appendix section contains….[to be seen]

C.2 Appendix B.2 (if needed)

This appendix section contains….[to be seen]

C.3 Appendix B.3 (if needed)

This appendix section contains….[to be seen]