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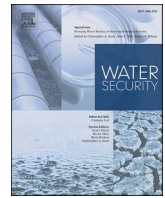
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Tailored flood risk management: Accounting for socio-economic and cultural differences when designing strategies

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ABSTRACT

Climate change and socio-economic development result in increasing flood risk which challenges flood risk management policy making and practice. Each situation, however, is different and calls for not only understanding the natural context, but also the socio-economic and cultural context. Only then Flood Risk Management strategies can be designed that are not only 1) fit for purpose but also 2) feasible for local implementation and 3) sustainable into the future. Flood consequences that are accepted in some cultures (fatalist), may not be acceptable in other cultures (controlist). This calls for considering the local normative context in order to understand current differences in policy and practice. More importantly, the design of strategic alternatives for Flood Risk Management into the future should consider this socio-economic and cultural context as well because not every society aims for the same goals in the same proportion, nor is equally willing or capable to implement and maintain sophisticated infrastructure and dedicated institutions. Based on literature on cultural theory and national cultures, we hypothesized that acknowledging socio-economic and cultural differences would allow to better appreciate the rationale of current flood risk management policies and practices in different parts of the world. By analysing cases related to Deltares projects abroad, we explored whether these factors explain the main differences observed. Based on this preliminary exploration, we propose a shortlist of factors to consider when designing future flood risk management strategies tailored to local socio-economic and cultural contexts.

1. The setting

Flood risk management is one of many means to achieve sustainable development, and not a goal in itself. Reducing risks is quintessential to support socio-economic development, because recovering from disasters costs lots of money and effort which cannot be spent on development (cf. OECD, 2019). It is noted that some flood-prone countries, like Bangladesh or Mozambique, are perhaps trapped in a vicious cycle of recurrent disasters and only partial recovery, slowing down their development. This notion lies behind the policy of international agencies like the World Bank or Asian Development Bank, who support flood risk management projects and capacity building in view of enhancing economic development. In contrast, implementing and maintaining a preventative flood risk management strategy also costs substantial amounts of money and effort and hence requires a certain degree of development.

Flood risk management can thus be considered a balancing act in which the costs of designing, implementing and sustaining a strategy

should be proportional to the benefits of having the strategy in terms of reduced risks (Van der Most et al., 2014; Kind, 2014) and hence development potential. This is the simple, utilitarian perspective (cf. Eijgenraam et al., 2017). It gives preference to designing strategies that are fit for purpose, in the sense that they achieve the largest reduction of risk against the least costs. But strategies and interventions that have proved successful in one country, may fail to be so when transferred to another country, often because they are insufficiently suited to the local socio-economic situation or the cultural setting.

Increasingly, developing countries complain about the many plans, drafted by foreign consultants that do not come with the required funding or call for huge loans, or that are otherwise unsuited for local implementation. From the perspective of the consultants, it is frustrating to see that projects that have been proposed are not implemented or not being adequately used or maintained, or simply not finalized and hence not effective (Minkman et al., 2019). To our opinion, both frustrations call for another approach to the design of flood risk management strategies, which we call tailored flood risk management in the sense that

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they should not only be

- 1) fit for purpose, but they should also be
- 2) feasible for local implementation and
- 3) sustainable into the future.

Tailored flood risk management requires an understanding of not only the risk situation, but also of the local policy context. An analysis and assessment of the risk situation is already commonplace, as defined by hazard, vulnerability and the intersect of these, exposure (FLOODsite, 2009b; Klijn et al., 2015). Or in other terms: the physiographic setting, the existing flood management infrastructure and the people and their assets at stake. Such an analysis and assessment of risk increasingly not only considers current flood risk, but also the development of flood risk into the future, as physical developments, e.g. climate change and subsidence, as well as socio-economic developments, e.g. demographic and economic developments, cause a steady increase. As WMO et al. (2017) state: ‘Development of a well-balanced strategy ... should start with a proper understanding of the flood risk. Not only examining the characteristics of past floods but also looking into possible future situations.’ And also: ‘Effective measures for reducing flood risk will be location-specific, there is no single solution for all flood problems; a variety of measures (a strategy) will be required to reduce flood risk to a societally agreed upon, acceptable level.’ These views were also expressed in the ‘Ten golden rules to guide a sound approach for strategic flood management’ by Sayers et al. (2015), for example in rules 4 (‘Recognize that the future will be different from the past. The world is changing.’) and 10 (‘The development of any strategy will therefore be location-specific ... reflecting the specific risks that must be faced.’ (sentence parts swapped by the authors).

As evidenced by these examples, there is already quite some consensus and guidance about what should be done for a sound flood risk analysis and assessment, and how it should be done to be as instrumental as possible for the next stage. A sound policy analysis (Mayer, Van der Most & Bots, 2002) requires that the flood risk assessment is followed by the design of strategic alternatives, as well as their full assessment, and culminating in the definition of a preferred strategy. In this context, a flood risk management strategy can be defined by its content, i.e. as a comprehensive set of physical interventions and policy instruments (cf. FLOODsite, 2009; Marchand et al., 2012; WMO, 2017). But a strategy is usually also understood as implying a process of implementation and maintenance, thus comprising an institutional governance structure and funding arrangements.

As for the content of alternative strategies, their fitness for purpose is usually assessed by evaluating their effectiveness and efficiency, as well as all relevant side-effects on society, economy, and ecology (cf. FLOODsite, 2009). This relates to the three main objective domains of sustainable development (people, prosperity and planet), so including social equity and environmental issues as currently captured by the term ‘inclusive green growth’. Nowadays, one might also refer to the widely endorsed Sustainable Development Goals (UN, 2015). We might therefore conclude that designing or selecting a strategy that is fit for purpose is already sufficiently sustained by appropriate assessment methods, whether societal cost-benefit analysis, ecosystem-service-based assessment or multi-criteria analysis.

But what about assessing the feasibility for implementation and sustainability into the future? As for the first, a partial — and hence limited — assessment of technical feasibility is often applied, or simply expert judgement. Whether a strategy really fits in certain socio-economic and cultural settings, may require a more thorough analysis, however. And as for the second, the sustainability into the future, this is of course partly covered by looking into long-term and off-site side-effects of interventions and policy instruments, but usually does not cover an assessment of the sustainability of operation and maintenance, which so often causes a strategy to not remain effective. Indeed, it is sustained governance we need to consider as well.

Regarding the governance of flood risk management, OECD recently issued a report titled *Applying the OECD Principles on Water Governance to Floods* (OECD, 2019), in which 11 principles for good water governance (OECD, 2015) were specified to flood (risk) management. Literally, it is stated that ‘The OECD Principles on Water Governance are developed on the premise that there is no one-size-fits-all solution to water challenges worldwide, They recognize that governance is highly contextual, that water policies need to be tailored to different water resources and places, ...’. Whereas the need for tailoring is acknowledged, the actual principles are quite prescriptive and formulated from the perspective of the OECD members, i.e. developed countries. Whether they apply equally well elsewhere is yet to be seen.

In this paper, we therefore adopt a more analytical, investigative perspective, and first try to establish how a policy context co-defines current strategies as applied in different parts of the world. Our aim is therefore to not prescribe a certain approach too soon, but to rather sensitize technical specialists and consulting engineers who work or are going to work abroad.

2. Research approach and set-up of this paper

This paper firstly explores why different flood risk management strategies are being applied in different situations and in different parts of the world, and more specifically, to what extent socio-economic and cultural differences explain the differences in strategy relative to differences in the physical risk situation. Secondly, we aim to make recommendations on how to account for socio-economic and cultural differences in order to ensure that flood risk management strategies are not only fit for purpose but also feasible for implementation and sustainable into the future; i.e. are truly tailored.

To this end, we first delve shallowly into the literature on relevant socio-economic and cultural characteristics, as well as into common practice within the World Bank and similar institutions that support development planning, flood risk management projects and programmes, or Disaster Risk Reduction policies. From this literature search, we propose a shortlist of key socio-economic and cultural characteristics which we hypothesize should be considered when analyzing a certain risk management policy context.

Next, we test our hypothesis by exploring a number of cases and comparing these to the Netherlands and Bangladesh as references. We selected 5 cases, spread over several continents and different cultures, based on the pragmatic criterion that we have been or are currently engaged in flood risk management policy planning and design (Fig. 1).

Our home country is our first reference case, for obvious reasons (though the Netherlands may be regarded distinctly off-average), and Bangladesh is the second as it is the most threatened delta in the world with the longest experience in living with floods (cf. Zevenbergen et al., 2018) whilst socio-economically and culturally it is almost the opposite of the Netherlands, and hence an adequate counterpart.

For each case we described the current flood risk management strategy and subsequently tried to establish to what extent the observed differences between them could be attributed to differences in the



Fig. 1. The location of the 5 investigated cases and the Netherlands and Bangladesh as reference cases.

potentially explanatory socio-economic and cultural characteristics, using the proposed shortlist of relevant characteristics.

Finally, we discuss our findings and try to translate our understanding into recommendations on how to proceed when designing a flood risk management strategy abroad.

3. What literature says about relevant socio-economic and cultural characteristics

Many countries have a distinct 'flood risk management culture', often related to their history (e.g. Bubeck et al., 2017). This constitutes what we may call the policy context. An analysis of the policy context therefore may help understand why certain flood risk management approaches and interventions have been chosen; i.e. in hindsight. To define a policy context, we may look at 1) the general socio-economic context in which a management policy and related institutional setting developed (e.g. Kaufman et al., 2010), and 2) the cultural/normative context.

First, however, we want to emphasize that there are obvious differences in policy between well-established democracies and countries that have been more centrally and autocratically led for decades, centuries or ages. Both, however, have shown to be able to persist and both may have well-established institutions. And regardless of how a country is led or organized, managing flood risk can be a concern. It is important to realize that for flood risk management planning the state system is not something that can be easily changed or even influenced in behalf of a more desirable strategy and must be considered as a given. It is undeniably 'context'. Still, we may desire to roughly qualify a particular country's governance setting, which we may derive from the Worldwide Governance Indicators (WGI) (Kaufman et al., 2010), for example those representing Rule of Law and Control of Corruption.

The importance of the general socio-economic setting is especially stressed by the United Nations (UN), the OECD, the International Monetary Fund (IMF), and the World Bank (WB) and other donor institutions. This setting, or state of development, may also partly clarify a country's priorities in flood risk management. There is, for example, a correlation between the degree of development of a country and the degree of protection that is being aimed for. In most developed countries protection levels of about 1: 100 to 1: 500 apply, related to the magnitude of the expected economic consequences of flooding, whereas in developing countries such levels are often regarded as unattainable.

The general socio-economic context also relates to the availability of funding and willingness and capability to spend money on flood protection. Here we may thus recognize three other relevant characteristics, namely: 1) the degree of institutionalization, 2) the availability of money for investments in flood risk reduction, and 3) the education level of the population in general and of the responsible authorities and engineers in particular. This is what we might call the institutional setting, related to the general socio-economic context. For a first estimate, the degree of institutionalization can also be derived from the already mentioned Worldwide Governance Indicators, in particular Government Effectiveness. Similarly, the availability of money for investments in flood risk management can be deduced from databases on Gross Domestic Product, whether per country or per capita, or translated into per capita Purchasing Power Parity (PPP), as made available by the World Bank (WB) or the International Monetary Fund (IMF). The level of education in a country, finally, can be retrieved from the Human Development Index of the United Nations (UN) or from a list of the OECD (see Wikipedia). The latter specifies the percentage of a country's population that has received primary, secondary or tertiary education, but is limited to the OECD countries plus some other large countries only. The UN-HDI mapped all countries and translated the outcomes into a single index.

With the databases on indices mentioned above, we might obtain quantitative information about many individual indicators of governance, economic development and human development and hence an adequate overview of a country's or regions socio-economic development status. This is relevant for the question how feasible expensive

technical interventions requiring highly skilled personnel or computerized operation, or complicated institutional arrangements would be in a certain policy setting. One might say: to cover the idea of 'governance feasibility'. This does, however, not yet cover the cultural dimension. So, let us have a closer look at cultural differences next.

In the 1980ies and 1990ies cultural differences have attained lots of interest in anthropology and sociology, usually to identify the most distinguishing factors in a multi-dimensional hyperspace of possibly relevant factors. From a wealth of empirical research, especially by groups around Thompson and Wildavsky (cf. Thompson et al., 1990) the factors 'group' and 'grid' emerged as being the most differentiating. The terms group and grid represent a) the degree of individualism versus collectivism and b) the degree of freedom of choice: prescribing (free) or prescribed (externally imposed restrictions on choice) (Schwarz and Thompson, 1990). These two factors have proved quite useful as main axes in attempts to distinguish different cultures (e.g. Sun-ki Chai et al., 2009).

The two factors also proved useful in communicating 'cultural theory' (see Thompson, 2002) as they allowed the characterization of four distinct perspectives of the world: a hierarchist/controlist, an individualist/market-optimist, an egalitarian/environmental pessimist and a fatalist. In turn, these four perspectives helped to understand conflicting opinions on preferred policy directions, as they could be translated into 1) views on how the world functions and 2) preferred management styles (after Van Asselt et al., 2001; Fig. 2; cf. also Offermans et al., 2013).

Another possibility to characterize cultural contexts is by dimensions of national culture, as identified by Hofstede (2001); Hofstede et al. (2010). He proposes six dimensions of culture, viz. Collectivism-Individualism; Power Distance; Femininity-Masculinity; Uncertainty avoidance; Long-term orientation; and Indulgence.

We consider Hofstede's dimensions as more useful to understand the perceptions and behavior of individual people in a certain culture, than for characterizing a national or regional cultural setting. That is because the perspective of Hofstede's dimensions is primarily psychological, rather than related to a country's institutions and capacities to address public policy issues — although the same could be maintained about Thompson's factors. Still, the perceptions and related behavior of most of the people are very relevant, as the majority of the people tend to determine tacit culture.

One would expect that at least Collectivism-Individualism (e.g. Germany vs. USA) and Long-term Orientation (e.g. China vs. African countries) are relevant differentiating factors at national level. And,

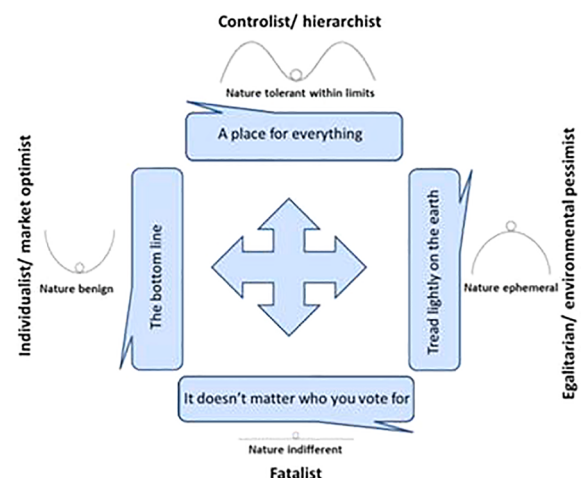


Fig. 2. From cultural theory distinct perspectives can be derived, representing different beliefs about how ecosystems behave and on how management should account for that (adapted from Schwarz & Thompson, 1990, by successively Middelkoop et al., 2004; De Bruijn et al., 2008 and the present authors).

obviously, collectivism-individualism is very similar to Thompson's interpretation of 'group' whereas it has already been identified as partly explaining differences in flood risk management between e.g. the Netherlands and the USA (Bubeck et al., 2017). In contrast, we consider Femininity-Masculinity as not really relevant as it primarily describes whether it is accepted that a strong leader/institution enforces his/its will. But if interpreted in this sense, Power Distance is very similar, as it describes whether less strong parties accept that their power and influence is limited. On the other hand, it is not unlikely that some of Hofstede's psychological dimensions are also already partly covered by what we above called 'state system' and (dominant) 'world view', i.e. if we consider these as reflecting a country's 'culture'. This applies especially for Power Distance and Indulgence.

4. Key socio-economic and cultural characteristics: A proposal

From the above-mentioned literature (esp. Thompson and Hofstede) and practice (World Bank and OECD), we first derived a longlist of possibly relevant socio-economic and cultural characteristics. Next, we did some profound pruning in order to derive a homologous short-list of about 6–10 characteristics only. We achieved this by scrutiny of each characteristic, cross-comparison and in many cases simply by sound reasoning. We thus got rid of most redundancies and overlaps, and propose the following shortlist of 8 relevant socio-economic and cultural differentiating characteristics to characterize a policy context:

- **state system:** varying from restrained to free and from top-down control to bottom-up self-organizing. Examples: centrally led/strong leader (e.g. China, Russia); democratic decentralized and strongly institutionalized (Germany, Nordic countries); free market mechanism/capitalism (USA, UK);
- **institutions:** presence of well-established organizations, rules and regulations to implement a policy and to maintain technical interventions;
- **funds:** availability of or access to funding, for both the implementation of interventions as well as their management and maintenance;
- **skills:** capacity to plan, design, build and maintain complex technical interventions;
- **orientation:** (long-term vs. short term, uncertainty avoidance) in a long-term oriented culture, a basic notion is that preparing for the future is always needed, whereas a short-time oriented culture considers the past to provide an adequate moral and practical compass; uncertainty avoidance refers to a society's tolerance for uncertainty and ambiguity, and hence has to do with anxiety in the face of the unknown. It strongly corresponds to the difference between controlism and fatalism, as reflected by support to institutionalization (rules and regulations, large role for authorities and experts) versus the opposite;
- **collectivism-individualism:** the extent to which people trust authorities and support public services, as opposed to fostering independence and favouring private action;
- **degree of commitment:** degree to which all relevant flood risk management actors (often primarily the responsible authorities) are committed to implement and sustain a certain strategy. Also including commitment to integration and co-operation;
- **public support:** likelihood of support or opposition from stakeholders and NGO's who may benefit or bear the burden of interventions and may feel unheard.

Of these 8, the first is an unchangeable given which, although it cannot be changed, does constrain the freedom of choice of interventions and especially policy instruments. The next three define the overall degree of development and its likely development into the future, which primarily constrains how institutionally complex a policy might be, and how technically sophisticated and expensive to implement

and maintain technical interventions. The next two characteristics, orientation and collectivism-individualism are the most truly culturally-rooted differences. They reflect the main dimensions found in 'cultural theory' and related empirical studies and wrap-together some of the cultural dimensions proposed by Hofstede. They further constrain the range of interventions and policy instruments that are feasible. Finally, the degree of commitment of the responsible authorities is added as stakeholders identified it as *the* key to successful implementation, whereas — the counterpart — public support by the stakeholders was considered *the* key to success by the responsible authorities (e.g. Klijn et al., 2013; see also Bogdan, 2019).

Of all 8 factors, the last two may be the most easily accommodated in the course of designing a flood risk management strategy. It could therefore be questioned whether they should be part of the context analysis or part of the strategy development. For our current case study analysis, they are certainly relevant context.

4.1. Operationalization: Preliminary indicators

In order to be able to compare our 5 cases mutually and with our reference countries the Netherlands and Bangladesh, we operationalized our 8 proposed characteristics by using readily available indicators that allow adequate (semi-)quantification. Therefore, we used indicators that are available in databases covering all, or at least most, countries, as follows:

- for the **state system** we used the World Bank's governance indicators Rule of Law and Control of Corruption, which are closely correlated. The Rule of Law 'reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.' The indicator Control of Corruption 'reflects perceptions of the extent to which public power is exercised for private gain, ..., as well as "capture" of the state by elites and private interests.' Both indicators are ranked as percentile, so ranging from 0 to 100, and as they proved strongly correlated, we simply calculated the mean.
- For an indication of the adequacy of **institutions** we consider the Worldbank's governance indicator Government Effectiveness an adequate representation. This 'reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.' Despite its being limited to civil, i.e. public, services and hence not covering possible private institutions, we consider it a good indicator, as flood risk management is largely a matter of public policy making.
- for **funds** we regard the gross domestic product (GDP at purchasing power parity: PPP) per capita a good indicator, i.e. the purchasing power parity value of all final goods and services produced within a country in a given year, divided by the average (or mid-year) population for the same year. This indicator takes into account the relative cost of living and the inflation rates of the countries. Wikipedia gives a list of countries ranked by their PPP (International Monetary Fund, 2019), which we transformed to a measure from 0 to 100.
- For an mere first indication of **skills** we draw from the Human Development Index (HDI) of UNDP and the Global Innovation Index (GII) of Cornell University et al. (2019). The Human Development Index is partly based on an education index, but unfortunately also partly on GDP. The GII focuses on medical innovation, but its ranking is based on the presence of and relationships with science and technology clusters. Both rankings were transformed to a scale from 0 to 100. Interestingly, it was found that the HDI scores much lower than the GII, which might reflect inequities. Still, we calculated their mean, as the ranking was quite similar.

- for **orientation** we use two of the cultural dimensions as recognized by Hofstede as indicators, namely Long Term Orientation and Uncertainty Avoidance. Hofstede's dimensions already range from 0 to 100. As the correlation between the two was less than expected and resulted in different rankings, we kept their individual scores and distinguish orientation 1 and 2.
- for **collectivism-individualism** we can directly use Hofstede's quantification for this dimension.
- For the **degree of commitment** of the policy makers we have not found any worldwide database that might apply. On the other hand, the description of the Worldbank's governance indicator for Government Effectiveness suggests that it includes 'the *credibility* of the government's commitment' (italics by us). As this indicator was already used for institutions (see above), we have not attempted to identify any other indicator for this (left out).
- for **public support** we can use both Hofstede's dimension Power Distance or the Worldbank's governance indicator Voice and Accountability. As these are negatively correlated, we transformed Power Distance to Power Proximity, such that both indicators are positively correlated and represent an increasing degree of potential stakeholder involvement or participation.

5. Case studies

First, we described all the cases in terms of flood risk situation, governance arrangements and management strategy. The focus was on understanding the specific risk situation as well as its management. Next, we tried to identify whether the socio-economic and cultural setting explained the current management strategy or desired changes to it.

5.1. Different physical risk contexts

The 5 cases are quite different. **Vancouver** (British Columbia, Canada) and the **Vietnamese Mekong delta** are both located in a delta, hence relatively flat and threatened by river floods as well as coastal storm surges. The Mekong delta, however, lies in a tropical monsoon climate, with extreme amounts of rainfall on the delta itself during the wet season, whereas Vancouver is primarily threatened by the Fraser River coming from the maritime west side of the Rocky Mountains. **Calgary** (Alberta, Canada) is also threatened by river floods originating in the Rocky Mountains, but it lies on the continental, i.e. dry, side of the mountains; the northern extensions of the Great Plains with a badland-like topography. The rivers here tend to rather lose water than grow during their flow to the east (Great Lakes). **Miami and Fort Lauderdale** (Florida, USA) is special in the sense that it is very low above sea level, and mainly composed of raised coral reefs and their weathering products: sandy beach ridges on calcareous rocks, all very permeable. This implies that groundwater levels rise and drop with the tides at sea. It also means that sea level rise influences the inland water levels almost proportionally and uncontrollably. The coast is primarily threatened by hurricanes with huge amounts of rainfall, storm surges and huge waves. The Democratic Republic of **São Tomé and Príncipe** (STP), finally, is an archipelago comprised of two main islands and several islets in the Gulf of Guinea (Afrika). Here, coastal communities are being threatened by swell waves and storm surges but they are also affected by runoff from the hills and pluvial flooding; the climate is tropical with average rainfall ranging up to 7,000 mm in the southeast.

As for the exposure and vulnerability, we see large differences between the case study areas, partly related to their size. In **São Tomé and Príncipe** (STP) the rural coastal communities at risk vary in size from 270 to 3300 people, and mainly live from fisheries in timber houses that are usually raised a few meters above ground level, except for those closest to the beach — because of the high wind speeds there. **Vancouver** and **Calgary** instead are large cities of about 2.5 (i.e. metropolitan Vancouver) and 1.2 million inhabitants (town only) respectively, with

business centres with high rise buildings ('downtown'). Calgary's downtown is spatially confined and largely located on the alluvial fan of the Elbow River, at the confluence with the Bow River. This fact, and the development of parts of the floodplain of these rivers for urban sprawl, explains the large damage incurred during the 2013 flood: an about 1:100 per year probability flood that affected 8% of Calgary's population and did 7 billion dollars of damage (Fig. 3a). Vancouver's downtown, in contrast, lies mainly on elevated ground, but parts of larger Vancouver and adjacent towns are in embanked polders along the Fraser River or on the actual delta.

Miami and Fort Lauderdale are almost fully built-up areas along Florida's long coast (Fig. 3b), which is regarded the place to be for the better-off Americans during holidays (second homes) or after retirement. This attracted a huge recreational industry with many hotels on the outer ridge. During heavy rainfall events or storms at sea the streets are very regularly but shallowly flooded; still regarded as a common nuisance rather than as life-threatening, except for the occasional hurricane landfall when evacuation is required. **Vietnam's Mekong Delta** is again totally different, in the sense that it is primarily agricultural, with settlements since ancient times on slightly higher beach ridges and river levees. Each year, the daily life of more than 2 million people is affected when about half the delta's surface area is flooded. This 'normal flooding' has been welcomed for ages as it supports the growing of rice (Fig. 3d) and hence contributed to Vietnam being the second largest rice exporter in the world (Marchand et al., 2012). It also explains why the people of the Mekong Delta are originally so well-adapted to flooding (Pham Cong Cuu, 2011). Recently, however, industrial development and accelerated urbanization increasingly take up space in the delta, especially near major cities such as Can Tho. Moreover, agriculture has intensified opting for artificially irrigated triple rice cultivation instead of traditional double rice. Consequently, the delta's vulnerability to extreme flooding has increased.

5.2. Different risk management strategies

Adequately but briefly characterizing the flood risk management strategy of each case is difficult, if not impossible. As stated in the introduction, a flood risk management strategy can be defined by its content or also by its governance structure. In our analysis, we focused on the content only, implying an interpretation in terms of the physical interventions and policy instruments applied (cf. FLOODsite, 2009; ASCE, 2014; Marchand et al., 2012; WMO, 2017; cf. Fig. 4).

Instead of presenting a systematic analysis of each case's strategy here, we only give a brief characterization. This is obviously selective and hence biased, but a full description would require too much text (the case descriptions are available on request), whereas a list of each case's interventions and instruments would, to our opinion, not yield an adequate overview of the complexity and historical development of the different management strategies either.

Until the 2013 flood, neither the city of **Calgary** nor the province of Alberta had a clear risk management strategy. Since then, plans were drafted, which not only included an initiative to increase the protection level by flood mitigation and protection measures, but also included measures to reduce the vulnerability of people and objects, e.g. by making money available for buy-outs (relocate or rebuild) and by issuing a building code bulletin. That might be considered an indication of an underlying integrated view, although there does not appear to be one common and well-defined policy on preventative flood risk management, neither at local, provincial nor federal level. Instead, however, at all levels relevant elements of such a comprehensive strategy can be found, including a legal framework, dedicated departments in provincial ministries and the city, flood maps, warning systems, involvement of consulting engineers and well-established stakeholder groups (WaterSmart Solutions Ltd, 2013).

Vancouver, or rather the lower mainland of British Columbia, relies strongly on flood defences, but complemented by early warning,



Fig. 3. (a). Calgary with Bow River during the 2013 flood. (b). Fort Lauderdale: proximity of water a key amenity. (c). São Tomé and Príncipe: fishery communities located on exposed shores. (d). Vietnam: floods a crucial geo-ecosystem service.

floodplain regulation, and building resilience into communities. The embankments along the Fraser River and its tributaries in the Lower Mainland have been constructed between 1968 and 1995 by the federal-provincial Fraser River Flood Control Program. They were intended to withstand the flood of record (dating back as far as 1894) with 0.6 m of freeboard. The 1894 flood was previously assessed as a 1: 200 per year flood but is now considered to likely have been a 1: 500 per year flood. A 1: 200 design flood applies for all areas along the Fraser river. Since 2003, the responsibility for flood management and floodplain regulation was shifted from the province to local governments, although the province remains involved in the infrastructure through the Dike Maintenance Act. The provincial River Forecast Center provides information on current water levels as well as 5- and 10-day predictions. Currently, the Fraser Basin Council, a non-profit organization comprising Federal, Provincial, Local and First Nations governments, considers an upgrade of the infrastructure in anticipation of sea-level rise and other climate-change related impacts, as well as an improvement of the resilience of the communities. For the funding of major infrastructural projects, local governments can apply to the Disaster Mitigation and Adaptation Fund (DMAF), which was launched by the federal government. The funding of the risk assessments, flood mapping, mitigation planning and small-scale mitigation works comes from the National Disaster Mitigation Program Funding, also established by federal government (in 2015), but administered by the province of British Columbia. Interestingly, the municipality of Richmond, a city surrounded by water from the Fraser River and the ocean, is the only taxing its citizens directly for flood protection. The extra funds are used to upgrade the flood defences and pumping stations. This municipality sticks out for its projects and taxation.

Fort Lauderdale's inhabitants primarily regard floods as a nuisance which comes with the location. The town has very few technical means to control the flood hazard, except raising its roads and other infrastructure and flood-proofing or raising properties: a strategy of constant repair and building back better. It implies that for property owners

buying insurance or accepting the recurrent losses is the only resort. As the majority of the area lies within the 100-year flood zone, buying insurance is obliged by the Flood Disaster Protection Act which the US passed in 1973. It requires participation in the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP) (FEMA, 2011). This calls for flood-proofing, has many exceptions from its policies, has a cap on its payments, and may ask very high rates in flood-prone areas; it hence favours the rich and excludes the poor. Still, it is not actuarially sound (GAO, 2007; Penning-Rowsell & Priest, 2014).

Sao Tome and Principe have three ministries with responsibilities for elements of flood risk management, under supervision of a National Council for the Prevention and Response to Disasters (CONPREC; established in 2011) which is supported by UNDP. It does, however, not have a formal flood risk management policy, nor an official plan, legal framework or budget available for flood risk management. In practice, focus lies strongly on disaster prevention and response, with a strong emphasis on building societal resilience through individual measures. The strategy does involve the protection of key infrastructure, e.g. by floodwalls along coastal and riverine roads, but the main idea is to keep the people out of harm's way, as the hazards are too intense to be controlled. Spatial planning is hence recognized as crucial but relocating land-owners from hazardous locations is found to be difficult; people said they were prepared to move, but not at their own costs. And not from locations with obvious advantages, such as the coast (for fishermen) or valleys (for farmers), to less favourable locations. Consequently, common practice is still that property owners (need to) take their own measures, mainly by building on stilts or on a concrete basement of sufficient height; the height not being prescribed but established locally by experience.

Because of regional differences in physiography **Vietnam** defined strategies for flood disaster mitigation and management for three distinct geographic areas (Van Staveren, 2007). For southern Vietnam the strategy reads: Living with floods and creating sustainable

Vulnerability reduction	Awareness and preparedness	Communicative	Education Flood risk maps/ information Evacuation planning Flood forecasting Flood warning/ alert (app) Radio/TV information channel Crisis management	
	Adaptation	Financial	Fines for damage- increasing behaviour Taxes related to vulnerability Subsidies for flood proofing etc.	
		Regulatory	Zoning (land use regulation) Building restrictions/ regulations Licencing (e.g. re. toxicants/chemicals) Regulating agricultural practices	
		Physical	Flood proofing	
Flood probability reduction	'Flood abatement' or flood alleviation	Regulatory	Wetlands conservation/rehabilitation Coastal wetland protection	
		Physical	Reforestation/ afforestation Conservation tillage Retention in upstream catchment Restoring meanders in brooks and rivers Retention in cities Connect rivers to existing lakes Detention areas/calamity polders Wave-damping vegetation Foreshore raising (wave dissipation) Wave breakers	
			Physical	Dams/reservoirs Embankment relocation/realignment Bypasses Removing hydraulic obstacles Floodplain lowering River bed widening Dredging rivers Coastal sand nourishment Storm surge barrier (closeable) Close dam/ barrier Embankments Mobile flood wall Flood wall
Reduction of exposure	Control of flood patterns	Physical	Mounds Ring dikes along villages/cities Floodway Compartmentalisation	
Other (recovery oriented)	Distribution of flood impacts	Financial	Damage compensation Governmental relief funds Insurances/ flood policies	

Fig. 4. Checklist of flood risk management interventions, allowing an analysis of strategies in different cases (freely adapted and re-ordered after De Bruijn et al., 2008 and FLOODsite, 2009). Nature-based interventions are shaded green and structural engineering interventions grey; intermediate greenish; and those without evident physical consequence not shaded. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

development. Historically, there was no rationale for full flood control in the Mekong Delta and people lived with floods for centuries. Since the end of the war in 1975, this strategy has gradually been changed and the flood defence infrastructure has been extended to protect the growing cities and in behalf of agricultural intensification (Van Staveren et al., 2018). This strategy has been reinforced by MARD Decision 101/QD-BNN-TT 2015 on the *Master Plan on Rice Production in the Autumn-winter Season in the Mekong Delta to 2020 with an outlook to 2030*. Consequently, the ancient system of low 'August dikes' which left room for high floods (Thanh et al., 2019), is now systematically being replaced by high flood defences, which completely prevent the annual floods (UNDP, 2017). This policy change is sometimes attributed to the dominance of a 'hydraulic bureaucracy' (Evers & Benedikter, 2009), with intricate linkages between government and the hydraulic construction sector and an intuitive preference for modern technology. This policy has, however, also stirred significant criticism because of the risk shifts it comes with. For the heightening of the embankments results in higher flood levels elsewhere (Käkönen, 2008), affecting cities like Can Tho, but especially rural areas. Moreover, the perceived better flood protection induces the so-called levee effect (White, 1945) of investing in protected areas and thus increasing the vulnerability to flooding (Käkönen, 2008). In the Mekong Delta Plan (MDP, 2013), which was endorsed by Vietnam's government as well as Development Partners in

December 2013, a shift in mindset emerged resulting in the adoption in Parliament in 2017 of several guiding principles for flood risk management, including: "to respect natural law and practical conditions, avoid violently interfering in the nature; select models of nature-based adaptation, environmentally sound, and sustainable development, on the basis of actively living with flood, brackish and salt water".

Despite all the differences, common to all cases was that the strategies were all quite comprehensive in the sense that combinations of many different measures and policy instruments were applied in which many actors were involved; and that the strategies had all constantly been adapted in response to experience in recent events, fashion and changing insights.

6. Results: The cases compared by indicators for the key socio-economic and cultural characteristics

Fig. 5 shows how the cases score on the 8 differentiating characteristics we proposed. The most obvious difference is that between the most developed countries and the least developed countries, especially on the first four characteristics. Canada and the US very much resemble the Netherlands as for state system (Rule of Law, Control of Corruption), institutions (Government Effectiveness), funds (GDP (PPP) per capita), and skills (Human Development Index and Global Innovation Index). Regarding these characteristics Vietnam takes an intermediate position, with a relatively high score for skills thanks to a high Innovation Index.

When we look at the 4 characteristics that rather reflect the cultural setting than the socio-economic context, there are remarkable

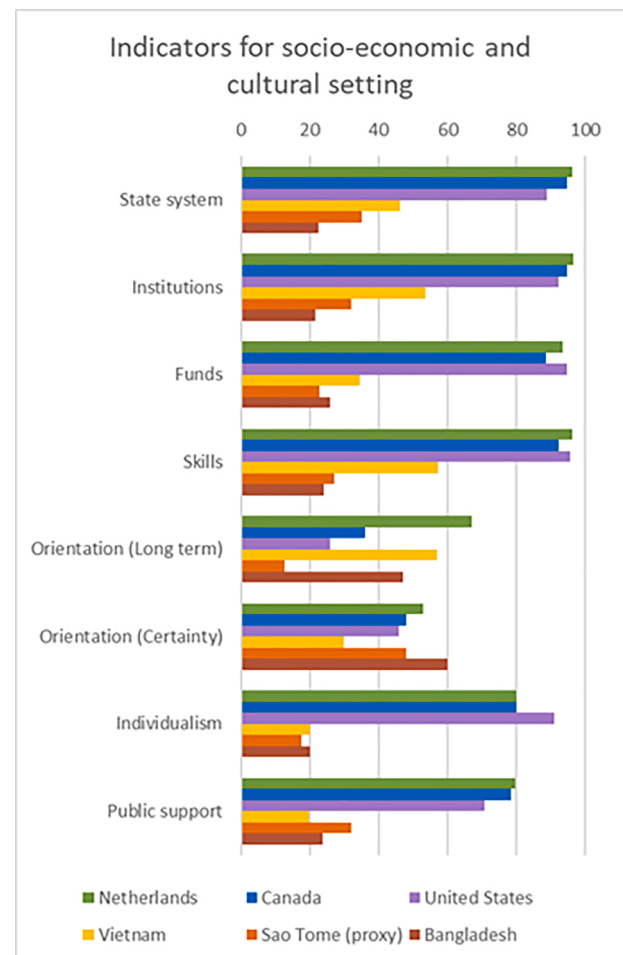


Fig. 5. Scores for the indicators for the 6 countries (2 of the 5 cases are in Canada; with Netherlands and Bangladesh as references).

differences as well as unexpected similarities. For example, the relatively long-term orientation of the Netherlands is almost equaled by Vietnam, which also develops a delta plan for its Mekong delta; the degree of uncertainty avoidance (Orientation 2) of the three richest countries is exceeded by Bangladesh and equaled by that of Sao Tome and Principe; and the expected largest degree of Individualism of the US is counterbalanced by higher scores for Public Support to government institutions in Canada and the Netherlands.

7. Is there any explanatory value in the identified socio-economic and cultural characteristics?

The characteristics related to socio-economic development, i.e. institutions, funds and skills, might explain a preference for highly technical and expensive structural interventions in the rich developed countries versus more local and low-cost interventions in the other cases. However, this difference proved not so marked in practice. This may be explained by the fact that the physical setting of the cases is so different, whilst also the risk level and the acceptance of risk differs. Vietnam's Mekong delta of course heavily relies on sound flood risk management for ages already, whereas Calgary has hardly any history of recent flooding and can easily recover from a flood, as evidenced by the aftermath of the 2013 flood. And Fort Lauderdale is located in such a disadvantageous physiographic setting that structural flood defence measures are bound to fail anyway. Also notable is that for the Vietnam case it was found that a strong lobby has been actively arguing for technical flood protection, whilst funding agencies also prefer to invest in structural measures, even when from a local and cultural perspective these are perhaps not the most preferable (cf. also Minkman, 2021).

As to the acceptance of risk, it is remarkable that the score for Uncertainty Avoidance (Orientation certainty) in Canada and the US is not much lower than that in the Netherlands; the score for long-termism (Orientation long-term) is, however, quite different. This could explain the relatively late development of comprehensive flood risk management policies in Canada and the US, although both countries seem to be increasingly aware of the need to respond to a changing climate and rising sea level. For the US case this is even essential for its chances of survival. At the same time, the US's preference for individual action is only marginally reflected by a different score on Individualism in comparison to Canada and the Netherlands. Perhaps this indicator does not so much reflect preferences about interventions as expected.

Vietnam's long-term orientation may be either considered a reflection of its dependency on sound flood risk management, or as an explanation for its policy. Here the question arises whether culture is partly the result of a physical setting, or whether culture explains how natural risk is perceived and hence the approach to flood risk management. Similarly, the short-termism of Sao Tome and Principe can equally be attributed to the still low socio-economic status of this young democracy, or alternatively be considered the explanation of an apparent acceptance of living with risk of the communities along the coast, which largely depend on fisheries and hence have no other option than to settle in hazardous places.

Where Vietnam and Sao Tome deviate strongly on long-term orientation, they also do on Public Support (Voice and Accountability), which would indicate that the Vietnamese people are being ruled rather than intensely participate in policy making, whereas the opposite seems true for Sao Tome. In Vietnam we indeed see that embankments are being installed or raised, even when the farmers prefer their rice fields to be flooded or where they suffer from the increased flood levels in the river as its discharge capacity is being reduced. It seems, thus, that not all stakeholders are being heard, certainly not those off-site but often not even those on-site.

All in all, we must admit that the characteristics we defined and the available indicators we used to qualify the socio-economic and cultural setting of each case proved less of an explanation of the current flood risk management policy than we expected. We already mentioned that

the physical risk situation may be so important that the influence of stage of development and culture may be too small to be noticeable, especially also due to the limited number and large variety of cases we investigated, each with comprehensive but also complex policies (but cf. Noll et al., 2020, who looked at one type of intervention only). Even more importantly, the in-depth descriptions of the cases showed that each case has a special history which is so rich that only by a very thorough investigation one can obtain sufficient insight in the possible why of (elements of) the current flood risk management strategy.

8. Findings and discussion

We argued that each flood risk situation calls for the design of a flood risk management policy tailored to the specific setting. We stated that not only the physical context and risk situation are relevant for the design of such a policy, but also the socio-economic and cultural context. We hypothesized that if that be true, we ought to be able to detect differences between current flood risk management policies between different cases, which could be explained by a characterization of this context. We then identified key characteristics to describe the socio-economic and cultural setting and selected indicators by which our cases could be compared.

We found that the policies in the cases show large differences, but that our presumed differentiating characteristics only explain these differences to a small extent. Perhaps the physical conditions are much more important than previously envisaged, or the number of cases is simply too small and their variety too large. Or our hypothesis is mistaken, which we rather not admit yet. After all, the World Bank and other funding agencies as well as OECD see a clear relationship between degree of development and being able to adequately manage flood risk. Whether this relationship is one way or the other, or both ways, is however yet to be seen; does development depend on sound (flood) risk management, or is it a prerequisite for well-established institutions, sufficient funding and the good skills that are needed to implement a comprehensive and effective flood risk management policy and its related interventions?

As for the experience with the 8 socio-economic and cultural characteristics we proposed, as well as with the globally available indicators, we still recommend anybody who is going to work abroad to have a look at them, just as a first acquaintance. Further, a sensitive and open attitude to the culture one is going to work in seems the best recommendation; not in order to simply accept or adopt its peculiarities, but to prevent an insufficiently humble attitude as to the local cultural setting which might result in ineffective advice on what to do or how to do it.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- E.A. Bogdan, *Perceptions and practices of flood risk management: a case study of flood risk governance in High River, Alberta*, University of Alberta, 2019. PhD thesis.
- P. Bubeck, H. Kreibich, E. Penning-Rowsell, W. Botzen, H. de Moel, F. Klijn, Explaining differences in flood management approaches in Europe and the USA – a comparative analysis, *J. Flood Risk Manage.* 10 (2017) (2017) 436–445, <https://doi.org/10.1111/jfr.12151>.
- De Bruijn, K.M., F. Klijn, C. McGahey, M. Mens & H. Wolfert (2008). Long-term strategies for flood risk management: scenario definition and strategic alternative design. FLOODsite report T14-08-01 (www.floodsite.net).
- C. Eijgenraam, R. Brekelmans, D. den Hertog, K. Roos, Optimal strategies for flood prevention, *Manage. Sci.* 63 (5) (2017) 1644–1656, <https://doi.org/10.1287/mnsc.2015.2395>.
- FEMA (2011). National Flood Insurance Program: Frequently asked questions, repetitive loss. (http://www.fema.gov/txt/rebuild/repetitive_loss_faqs.tx).
- FLOODsite (2009). Flood risk assessment and flood risk management. An introduction and guidance based on experiences and findings of FLOODsite (an EU-funded

- Integrated Project). Deltares | Delft Hydraulics, Delft, the Netherlands, ISBN 978 90 814067 1 0. E-publication www.floodsite.net, 140 pp.
- FLOODsite (2009b). Language of risk. Project definitions. 2nd ed. Report T32-04-01, www.floodsite.net.
- GAO (US Government Accountability Office) (2007). National Flood Insurance Program. FEMA's Management and Oversight of Payments for Insurance Company Services Should be Improved. GAO-07-1078. Washington.
- G. Hofstede, Culture's Consequences: Comparing Values, Behaviors, Institutions, and Organizations Across Nations, Second Edition, Sage Publications, Thousand Oaks CA, 2001.
- G. Hofstede, G.J. Hofstede, M. Minkov, Cultures and Organizations: Software of the Mind. Revised and Expanded, 3rd Edition., McGraw-Hill, 2010.
- Kaufmann, D., A. Kraay & M. Mastruzzi (2010). The Worldwide Governance Indicators: A Summary of Methodology, Data and Analytical Issues. World Bank Policy Research Working Paper No. 5430, Washington.
- M. Käkönen, Mekong delta at the crossroads: more control or adaptation? *AMBIO: J. Human Environ.* 37 (3) (2008) 205–212.
- F. Klijn, D. de Bruin, M. de Hoog, S. Jansen, D. Sijmons, Design quality of Room-for-the-River measures in the Netherlands: role and assessment of the Quality Team (Q-team), *Journal of River Basin Management* 11 (2013) 287–299, <https://doi.org/10.1080/15715124.2013.811418>.
- Klijn, F., H. Kreibich, H. de Moel & E. Penning-Rowell (2015). Adaptive Flood Risk Management Planning based on a Comprehensive Flood Risk Conceptualisation. Mitigation and Adaptation Strategies to Global Change (MITI) 20(2015)/6: 845–864, DOI: 10.1007/s11027-015-9638-z.
- J.M. Kind, Economically efficient flood protection standards for The Netherlands, *J. Flood Risk Manage.* 7 (2014) 103–117.
- Marchand, M., Trinh Thi Long & Sawarendro (2012). Adaptive Water Management for Delta Regions: Towards GREEN Water Defense in East Asia, Deltares-report 1205471-000, Delft.
- Mayer, I., H. van der Most & P. Bots (2002). Dam the river or go with the flow? Changing views on policy analysis in Dutch water management. 24th APPAM conference, November 7-9, 2002, Dallas, Texas.
- H. Middelkoop, M.B.A. van Asselt, S.A. Klooster van 't, et al., Perspectives on flood management in the Rhine and Meuse rivers, *River Research and Application* 20 (3) (2004) 327–342, <https://doi.org/10.1002/rra.782>.
- E. Minkman, P. Letitre, A. van Buuren, Reconstructing the impasse in the transfer of delta plans: evaluating the translation of Dutch water management strategies to Jakarta, Indonesia, *J. Environ. Plann. Manage.* 62 (9) (2019) 1562–1582, <https://doi.org/10.1080/09640568.2018.1527216>.
- E. Minkman, Building Bridges. Policy transfer and translation of the Dutch Delta Approach in South and Southeast Asia, Erasmus University, Rotterdam, 2021. PhD thesis.
- Noll, B. T. Filatova & A. Need (2020). How does culture affect individual adaptation to climate-driven floods? Proceedings of the FLOODrisk2020 conference, BME, Budapest.
- OECD, OECD Principles on Water Governance, OECD, Paris, 2015.
- OECD (2019). Applying the OECD principles on water governance to floods: a checklist for action. OECD Studies on Water, OECD Publishing, Paris.
- A. Offermans, P. Valkering, H. Vreugdenhil, N. Wijermans, M. Haasnoot, The Dutch dominant perspective on water; risks and opportunities involved, *J. Environ. Sci. Health, Part A* 48 (10) (2013) 1164–1177, <https://doi.org/10.1080/10934529.2013.776438>.
- E.C. Penning-Rowell, S.J. Priest, *Adaptation to Flood Risk: The Role of Insurance, Knowledge for Climate report*, Utrecht, 2014.
- P. Sayers, G. Galloway, E. Penning-Rowell, Li Yuanyuan, Shen Fuxin, Chen Yiwei, T. Le Wen Kang, Lei Wang Quesne, Yuhui Guan, Strategic flood management: ten 'golden rules' to guide a sound approach, *Int. J. River Basin Manage.* 13 (2) (2015) 137–151.
- Michael Schwarz, Michael Thompson. *Divided We Stand: Redefining Politics, Technology, and Social Choice*, University of Pennsylvania Press, 1990.
- M. Thompson, R. Ellis, A. Wildavsky, *Cultural Theory*, Westview Press, Boulder, 1990.
- Thompson, M. (2002). Understanding Environmental Values: A Cultural Theory Approach. Event paper, Carnegie Council on Ethics and International Affairs. Downloadable at Carnegie Council. <https://www.dustinstoltz.com/blog/2014/06/04/diagram-of-theory-douglas-and-wildavskys-gridgroup-typology-of-worldviews>.
- Sun-Ki Chai, Ming Liu, Min-Sun Kim, Cultural comparisons of beliefs and values: applying the grid-group approach to the world values survey, *Beliefs Values* 1 (2) (2009) 193–208.
- UN (United Nations General Assembly) (2015). Transforming our world: the 2030 Agenda for Sustainable Development. Resolution 70/1, adopted by the General Assembly on 25 September 2015.
- M.B.A. van Asselt van, H. Middelkoop, S.A. Klooster van 't, et al., Development of Flood Management Strategies for the Rhine and Meuse Basins in the Context of Integrated River Management, IRMA-SPONGE, Delft, 2001. IRMA-SPONGE project 3/NL/1/164 / 99 15 183 01 NRP project 958273.
- Van der Most H., Tanczos, I., De Bruijn, K.M. & Wagenaar, D. (2014). New, risk-based standards for flood protection in the Netherlands. Proceedings of the 6th international conference on flood management (ICFM6), September 2014, Sao Paulo, Brazil.
- M.F. Van Staveren, *Integrated Flood Management in the context of climate change, Vietnam. Evaluating the effects of Integrated Flood Management on flood risks in a climate change scenario*, Wageningen University, 2007. MSc Thesis.
- M.F. Van Staveren, J.P.M. van Tatenhove, J.F. Warner, The tenth dragon: controlled seasonal flooding in long-term policy plans for the Vietnamese Mekong delta, *J. Environ. Plan. Policy Manage.* 20 (3) (2018) 267–281, <https://doi.org/10.1080/1523908X.2017.1348287>.
- G.F. White. *Human adjustment to floods.*, The University of Chicago, Chicago, 1945. Research Paper no. 29.
- WMO/GWP Associated Programme on Flood Management, 2017. Selecting measures and designing strategies for integrated flood management: a guidance document. Policy and Tools Documents Series 1, version 1.0, World Meteorological Organization, Geneva, Switzerland.
- C. Zevenbergen, S. Alam Khan, J. van Alphen, C. Terwisscha van Scheltinga, W. Veerbeek, Adaptive delta management: a comparison between the Netherlands and Bangladesh Delta Program, *Int. J. River Basin Manage.* 16 (3) (2018) 299–305, <https://doi.org/10.1080/15715124.2018.1433185>.