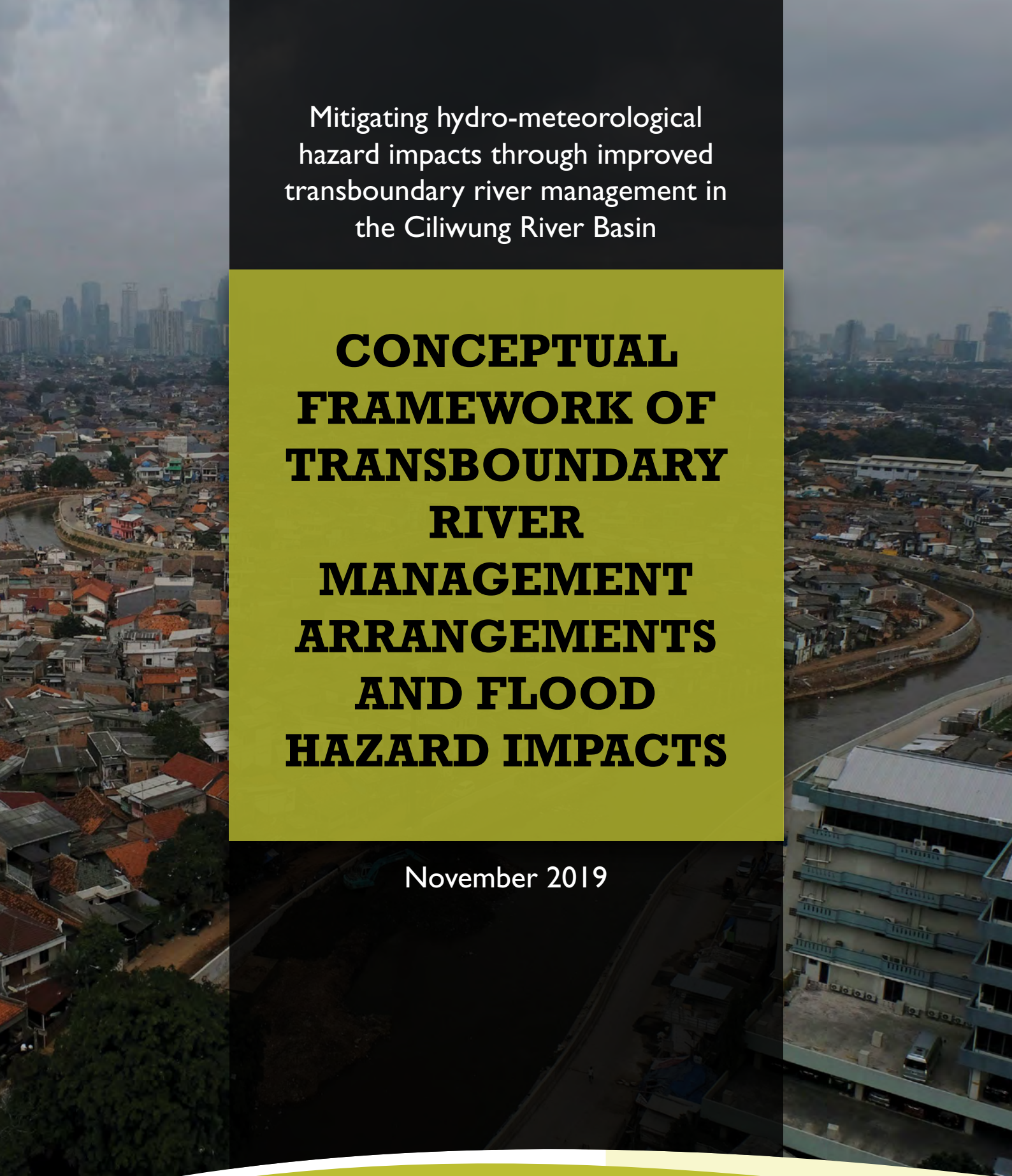

Mitigating hydro-meteorological hazard impacts through improved transboundary river management in the Ciliwung River Basin

CONCEPTUAL FRAMEWORK OF TRANSBOUNDARY RIVER MANAGEMENT ARRANGEMENTS AND FLOOD HAZARD IMPACTS

November 2019

University of HUDDERSFIELD
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About the Project

The project Mitigating Hydrometeorological Hazard Impacts Through Improved Transboundary River Management in the Ciliwung River Basin will examine how the current transboundary river management arrangements in the Ciliwung River Basin, Indonesia influence flood hazard impacts. The interdisciplinary project will bring together expertise in flood modelling, disaster risk reduction, urban planning, public policy, and behavioural science with the objective of identifying the environmental, socio-economic, political and organisational landscape associated with flood risk in the Ciliwung River Basin. The results will be used to inform improved transboundary river management arrangements for the Ciliwung Basin and provide a model for urban and peri-urban river basins elsewhere.

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- Major River Basin Authority for Ciliwung and Cisadane Watershed (BBWS)
- BAPPENDA in West Java and DKI Jakarta Provinces

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Contents

1. Introduction

This document presents a conceptual framework for the project ***Mitigating Hydrometeorological Hazard Impacts Through Improved Transboundary River Management in the Ciliwung River Basin, Indonesia.*** The model provides the starting point for the project with the purpose of presenting the relevant key concepts and to foster a shared interdisciplinary vision that will be used to underpin future project activities.

1.1. About the Project

The project ***Mitigating Hydrometeorological Hazard Impacts Through Improved Transboundary River Management in the Ciliwung River Basin*** will examine how the current transboundary river management arrangements in the Ciliwung River Basin, Indonesia influence flood hazard impacts. The interdisciplinary project will bring together expertise in flood modelling, disaster risk reduction, urban planning, public policy, and behavioural science with the objective of identifying the environmental, socio-economic, political and organisational landscape associated with flood risk in the Ciliwung River Basin. The results will be used to inform improved transboundary river management arrangements for the Ciliwung Basin and provide a model for urban and peri-urban river basins elsewhere.

Figure 1. The Ciliwung River snakes towards the centre of Jakarta, as viewed from Jatinegara district, 2016 (REUTERS/Alamy Stock Photo).

1.2. The Conceptual Framework

Concepts are ideas that are used to capture or represent the phenomenon being studied (Lewis-Beck ***et al***., 2004). Miles ***et al***. (2014) describe a conceptual framework as something that "explains either graphically or in narrative form, the main things to be studied – the key factors, variables or constructs – and the presumed interrelationships among them" (p. 20). Therefore, this conceptual framework aims to present the key concepts relevant to the project and to highlight any relationships between them. The document will define key terms, provide background and relate the concepts to the current status in the Ciliwung River Basin (where possible). The framework will provide basis and support for the projects future activities and will link the project to the existing body of literature.

To understand how to improve the management of a river system and to manage flood risk, it is important to first have a clear understanding of the hazardous processes and impacts as well as the interactions and dynamics at play (Simonovic, 2012; Zischg ***et al***., 2018). Therefore, this document focuses on three areas: it begins by setting out the (1.) drivers and (2.) impacts of flooding and then goes on to describe key concepts related to (3.) transboundary governance and river management. These three areas also support the different interdisciplinary elements of the project with flood risk drivers supporting the projects modelling activities and transboundary river management supporting investigations into governance of the river basin.

1.3. Methods

The concepts presented in this model were drawn from a review of the literature focused on the three main areas: flood risk drivers, flood impacts and transboundary governance and river management. For each concept identified throughout this document, firstly the general background, theory or the global view is presented for understanding. Each concept is then linked to the current situation in the Ciliwung River Basin where literature is available. In cases where no literature was available for the Ciliwung specifically, information was drawn from sources pertaining to the Jakarta area or Indonesia that could provide potentially relevant insights. Regarding information relating specifically to the Ciliwung Basin/Indonesia, the literature review was limited to the most recent documents available in order to present the current status.

Firstly, a review of flood risk drivers was conducted. Flood risk drivers were identified from an initial literature search using the following search terms (or terms in combination): e.g. 'flood risk'; 'drivers'; 'causes of [flooding]'. Once an initial list of drivers was identified a second search into each driver itself was carried out in order to gain greater depth. Each term was then searched in conjunction with the following terms: 'Ciliwung river'; 'Jakarta'; 'Indonesia' to identify any previous research conducted at the study location. The same method was applied to identify flood impacts, this time using relevant search terms e.g. 'flood impacts'; 'socio-economic'; 'environmental'; 'human'.

A review of literature relating to transboundary governance and river management was then conducted. Relevant search terms (and terms in combination) included e.g. 'river management', 'transboundary', 'governance', 'transboundary crisis management', 'flood risk management'. As there was little literature pertaining to transboundary river management in Indonesia, the search was broadened to issues relating to governance and disaster risk reduction in Indonesia which may have bearing.

The literature searches were conducted using online databases and search engines. The review included published journal and conference papers which were identified through the University of Huddersfield's library ('Summon') and Google Scholar portals, as well as reports published by organisations (e.g. World Meteorological Organisation) which were identified through online searches (Google).

Although the model sets out concepts relevant to the project in the outset, the model may be modified during the course of the project as new insights emerge.

1.4. Outline

The remainder of this document is structured as follows: Section 2 provides the background and rationale, Section 3 sets out the drivers of flood risk, Section 4 identifies some of the common impacts of flooding and Section 5 outlines concepts relating transboundary governance and river management.

2. Background and Rationale

This section provides definitions and background information on the primary themes used throughout this document. This includes, background to the flood hazard, flooding in the context of the Ciliwung River Basin and an introduction to integrated flood risk management.

2.1. The Flood Hazard

A flood can be defined as "A high water level along a river channel or on a coast that leads to inundation of land that is not normally submerged" (Thomas, 2016). There are several different types of floods, including fluvial (river), pluvial (surface), coastal, urban, flash and outburst (Rudari, 2017; Ambiental, 2019). Flooding itself is an outcome of multi-scalar interactions among climate, landscape physiography, river-valley morphology, and hydraulics (Van Appledorn ***et al.***, 2019) and as such is a part of the inherent variability of nature. But flooding is also closely linked to human activities, forming complex interactions between natural and social processes. The fundamental issue is that when a severe flood occurs in an area occupied by humans, it can result in disaster (Simonovic, 2012).

Floods have the highest frequency and widest geographical distribution of any natural hazard worldwide (Rudari, 2017). Despite efforts to manage flooding and reduce impacts,

trends show that there has been a steady rise in flooding experienced around the world. Extreme rainfall and other hydrological events have increased by more than 50% this decade and are now occurring at a rate four times higher than in 1980. This has been linked to changes in climate and increased exposure and vulnerability of populations (European Academies Science Advisory Council, 2018).

2.2. The Flood Issue in the Ciliwung River Basin

Indonesia, an island nation located between the Indian and Pacific oceans, is highly prone to natural hazards and is heavily impacted by flooding on a yearly basis. Indonesia is also one of the most populous countries worldwide, meaning large proportions of its population are exposed to flooding. Indonesia's capital city Jakarta is located on the coast in the north-west of the Indonesian island of Java. It is the largest city in Indonesia with an estimated population of over 30 million in the wider metropolitan area, making it one of the most populous cities worldwide (World Population Review, 2019). Located on the coast, with 13 rivers flowing into Greater Jakarta (Cheong, 2018) and with year-round exposure to heavy rain leads the city to be at risk of coastal, fluvial (river) and pluvial (surface) flooding. Jakarta has experienced flooding throughout its history, however several major floods have impacted the city in recent years, namely in 2002, 2007, 2013 and 2014, events which caused billions of dollars of economic damage and loss of lives. These severe flood events have highlighted the need, and increased the urgency for, more suitable methods to mitigate flood hazard impacts.

The Ciliwung River is one of 13 rivers that crosses through Jakarta (Cheong, 2018). From the river's source in Tugu Puncak, central Java, the river crosses two provinces and four municipal boundaries, including the capital city Jakarta, to where the river discharges into Jakarta Bay. It is the largest river running through Jakarta (Remondi ***et al.***, 2016) and its banks are one of the most highly populated in the city. As the river basin is not managed by one single authority, management of flood risk presents a set of complex problems (Sunarharum ***et al.***, 2014).

2.3. IWRM, IRBM and IFRM

Integrated Water Resource Management (IWRM), Integrated River Basin Management (IRBM) and Integrated Flood Risk Management (IFRM) are important concepts for understanding current thinking on how rivers and flooding should be managed. They can be seen as key management approaches or principles for good governance. The need for transboundary cooperation can be seen as a logical follow-on from these practices (Wiering ***et al.***, 2010), therefore a brief background to these integrated approaches is given here.

IWRM is an approach for achieving good water governance (Varis ***et al.***, 2014). It seeks to maximise the equitable use of water and balance competing uses without compromising sustainability and the environment (Varis ***et al.***, 2014). IWRM involves 'comprehensive, coordinated and systematic processes of planning, control, organisation, leadership and management within a basin' (UNISDR, 2018), therefore requires coordination across a range of institutions and stakeholders (Robins ***et al.***, 2017). IRBM can be understood as a subset of IWRM (van den Brandeler ***et al.***, 2019). Like IWRM, IRBM concerns the good management of water resources, but this time within the hydrologic boundaries of the river basin (Watson, 2004). The river basin is widely regarded as the largest relevant scale for the management of water (Rijke ***et al.***, 2012). Again, coordinated planning, development and management is required across the basin which calls for cooperation between actors within the basin (Watson, 2004). The successful management of water involves not only water-based actors but also those from non-water-based disciplines such as land planning which makes IWRM and IRBM multi-disciplinary, collaborative and complex (den Haan ***et al.***, 2019).

Linked to IWRM and IRBM is the subset of IFRM. Flood Risk Management (FRM) aims to reduce the likelihood and the impacts of flooding and can be defined as "holistic and continuous societal analysis, assessment and reduction of flood risk" (Schanze ***et al.***, 2006) p4. Traditionally, the management of flood risk has been focused on structural and engineered approaches to mitigate floods (for example, dikes, channel modifications and detention basins) and has often been conducted in a fragmented manner (WMO, 2009). However, the continued rise in flooding impacts overtime has indicated that fragmented approaches focused on structural mitigation alone are insufficient to tackle the problem, leading to a more integrated flood risk management (IFRM) approach. IFRM combines traditional structural flood management methods with non-structural management methods (e.g. early warning, land use planning). It also acknowledges that activities with a river basin are interconnected and interdependent (Serra-Llobet ***et al.***, 2016). In line with this, IFRM seeks to consider the catchment as a whole, take into account spatial and temporal interactions, and to engage all relevant stakeholders, acknowledging the inefficiencies of previous fragmented approaches (Hall ***et al.***, 2003; WMO, 2009).

The principles IFRM challenge the traditional approach to management where separate administrations manage their own affairs (World Bank, 2006). There are also many different stakeholders involved in the integrated approach, each with their own viewpoints to be considered, as well as resources, information flows and value systems to be balanced between them (Simonovic, 2012). Therefore, implementation of the integrated approach can be complex and has been found to be challenging in practice (Hall ***et al.***, 2003; Serra-Llobet ***et al.***, 2016). Although many studies have tried to identify common factors for integrated governance, there is still a lack of understanding on what arrangements are best and appropriate solutions are often context specific (Serra-Llobet ***et al.***, 2016). The complexity of the management of flood risk is only enhanced in the case of transboundary river basins. Rivers can traverse long distances from source to mouth crossing administrative borders between countries, regions and jurisdictions, multiplying interdependencies and the number of stakeholders involved.

2.4. Rationale

The Ciliwung River Basin is already experiencing frequent severe flooding events. Global trends suggest that the frequency of flooding may increase in the future, calling for improved ways of managing flood risk. The principles of IFRM suggest that this should be carried out is a holistic, basin-wide manner which requires a comprehensive understanding of drivers, impacts and management approaches in order to tackle this complex problem. This document is the first step in understanding these issues in the context of the Ciliwung River Basin.

Figure 2. Residents wade through flood waters after the capital city Jakarta was hit by severe floods in January 2020 (ZUMA Press, Inc./Alamy Stock Photo)

3. Flood Risk Drivers

The ability to manage flood risk depends on knowledge of hazardous processes and impacts (Zischg ***et al.***, 2018). This section outlines the key drivers of flood risk in order to better understand the processes that contribute to flooding in the Ciliwung River Basin.

3.1. Definition of Flood Risk

Risk is understood in different ways by different disciplines, however, in its basic form, risk can be defined as a function of probability and consequence, where probability is the chance of an event occurring and the consequence being the impact associated with the event (Equation 1) (Sayers ***et al.***, 2002; Simonovic, 2012).

$$Risk = Probability \times Consequence \qquad \text{Equation (1)}$$

UNISDR (2017) expand upon this, defining risk as a function of hazard, vulnerability, exposure and capacity. The elements are defined as follows:

- **Hazard:** a "dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage";
- **Exposure:** "people, property, systems, or other elements present in hazard zones that are thereby subject to potential losses";
- **Vulnerability:** "characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard";
- **Capacity:** the "combination of all the strengths, attributes and resources available within an organization, community or society to manage and reduce disaster risks and strengthen resilience. Capacity may include infrastructure, institutions, human knowledge and skills, and collective attributes such as social relationships, leadership and management".

Flood risk drivers therefore can be identified as factors leading to an increase in risk of floods i.e. factors which influence the probability and consequence, the hazard, exposure, vulnerability and capacity. Flood risk drivers can be manifold, they are dependent upon context and location, they can have physical or anthropogenic origins (or both) and be interrelated (Zischg ***et al.***, 2018). Recent floods in Jakarta have indicated both physical and socio-economic flood risk drivers are at play (Budiyono ***et al.***, 2016).

3.2. Physical Drivers

3.2.1. Climatological

There are several climatological factors which influence the flood hazard with precipitation being the most obvious. Precipitation may contribute to pluvial (surface water) flooding, where precipitation exceeds drainage capacity or fluvial (river) flooding, where precipitation increases river discharge to the point where capacity is breached.

Precipitation on a large scale is driven by climatological regimes. Jakarta is located within the equatorial band and experiences a tropical monsoon climate (type Am, Koppen Climate Classification) (Siswanto ***et al.***, 2015). Monsoonal climates are marked by seasonal changes in weather due to associated shifts in wind direction and exhibit distinct wet and dry seasons (O'Hare ***et al.***, 2013). In Jakarta, the peak wet season is conventionally December - February while the peak dry season occurs June – August. Due to high precipitation during the wet season, flooding is common during the period December to February (Tjasyono ***et al.***, 2008).

Other climatological factors can influence precipitation amounts. Orographic lift, due to the effects of air rising over high ground can create heavy precipitation in upland regions, such as the high mountains of central Java. Monsoon rains have been noted to be particularly heavy in the upper Ciliwung basin (Remondi ***et al.***, 2016), with annual rainfall amounts in the upper watershed exceeding 3000mm (Asdak ***et al.***, 2018). As this water enters drainage systems and river channels, high precipitation upstream may have implications downstream (Gruntfest and Handmer, 2001). In addition, high temperatures in the equatorial region create instability in the troposphere resulting in frequent convective precipitation all year round (not only during the wet season) (Narulita and Ningrum, 2018). Convective rainfall can be highly localised and although may be short lived, can bring very intense precipitation leading to high accumulations in a short period of time.

Figure 3. High rainfall in the upstream reaches of the Ciliwung caused flooding in the Bogor area, February 2018 (Adriana Adinandra/Alamy Stock Photo)

3.2.2. Extreme weather

Extreme weather events such as storms and cyclones can contribute to heavy rainfall and generate fluvial and pluvial flooding as described above, but may also present a driver for coastal flooding via storm surges. A storm surge is a rise in sea water above the expected astronomical tide. A storm surge may be generated by strong onshore winds and/or temporary increases in sea level due to low atmospheric pressure driven by the storm (NOAA, 2019). Storm surges have been noted along the Java coastline and may contribute to increased flood risk if in combination with spring tide conditions (Ningsih ***et al.***, 2011).

3.2.3. Climate change

'Climate change' refers to increases in global temperatures due to increases in heat-trapping gases in the atmosphere, but also encompasses a range of associated changes in climate phenomena such as sea level rise and extreme weather events (NASA, 2019). Global climate change may influence climatological factors which may impact flood frequency and severity in the future, this may include, changes in precipitation (frequency and intensity), windstorms, storm surges and sea level rise (Rudari, 2017).

Thermodynamic principles suggest that increasing temperatures will increase precipitation, as a warmer atmosphere can hold more moisture (Chang and Franczyk, 2008). Mean temperatures in Jakarta over the last century have increased by 1.6°C (Siswanto ***et al.***, 2015) and sea temperatures in the Java Sea have also shown a positive temperature rise, suggesting greater evaporation rates (Siswanto ***et al.***, 2015). There is evidence that precipitation events are becoming more extreme, with the heaviest 1% of all precipitation events exhibiting an increasing trend, which has been found to be strongest during the wet season (Siswanto ***et al.***, 2015).

Due to its influence on large scale global circulation patterns, climate change may also influence monsoonal rainfall. The IPCC report states that monsoon winds are likely to weaken, while monsoon precipitation is likely to intensify due to increases in atmospheric moisture globally. The likelihood of future increases in precipitation extremes related to the monsoon is identified to be very likely in Southeast Asia (>90% probability) (IPCC, 2013).

Rising sea levels with climate change may also contribute to increased coastal flooding. As global temperatures increase, loss of polar ice sheet mass and thermal expansion of ocean waters are the two main factors contributing to sea level rise (Nicholls and Cazenave, 2010). In the Jakarta Bay area, altimetry measurements have indicated that sea levels rose at a rate of approximately 6mm per year over the period 1993-2012 (Latief ***et al.***, 2018).

It is important to note that uncertainty remains regarding the impacts of climate change on flooding frequency and severity, which limits the possibility to assess the risk (Rudari, 2017). In Jakarta, although the observed record of flooding in Jakarta exhibits a positive trend, and recent years have seen more frequent severe floods, Siswanto ***et al.*** (2015) note that the precipitation events leading to the severe floods in 2014 were not very unusual, therefore there is currently insufficient evidence to attribute climate change to the apparent recent increases in flood events in Jakarta (Pidcock ***et al.***, 2017).

3.2.4. Geographic Location and Morphology

The geographic location of Jakarta is a key factor in its flood risk. Jakarta is located on a deltaic floodplain and the low-lying nature means the area is at risk of coastal flooding. Subsidence of the land due to compaction of alluvial soils further contributes to coastal flood risk. It is estimated that around 40% on Northern Jakarta lies below sea level (World Bank, 2011), with land subsidence rates around 1-15cm per year (depending on location) (Abidin ***et al.***, 2011). Land subsidence is also influenced by human activities, as such, is covered further in the following section on anthropogenic flood drivers.

There are 13 rivers crossing the Jakarta metropolitan area which adds to increased risk of fluvial flooding (Cheong, 2018). The morphology of the river basin and channel can influence the likelihood of overtopping and inundation. For example, basin characteristics determine rapidity of runoff influencing the speed at which water reaches the river channel and the speed in which peak flow is reached. Factors that influence runoff speed include stream network density, slope gradient and permeability of soils (Simonovic, 2012).

3.3. Anthropogenic Drivers

3.3.1. Agricultural land clearance

Human modification of the land surface can lead to increased flood risk. Deforestation and removal of vegetation are known to impact runoff by reducing interception, evapotranspiration, infiltration and water storage and increase erosion and siltation (Chang and Franczyk, 2008). Modification of hillslopes for agricultural production can changing flow paths, flow velocities, and water storage, and consequently flow connectivity and concentration times (Rogger ***et al.***, 2017). In the upper reaches of the Ciliwung River Basin land has been cleared for agriculture (primarily tea plantations) (Asdak ***et al.***, 2018). Studies have noted intensification of basin response and increases in peak flow and sediment load which have been attributed to land clearance in recent years (Ward ***et al.***, 2013; Remondi ***et al.***, 2016). Increased sediment load of the river upstream has contributed to increased sedimentation downstream (Marfai ***et al.***, 2015).

3.3.2. Population growth

The global population has increased exponentially over time. In particular, the population of urban areas and developing countries has grown rapidly. Global population is expected to continue to increase in the future, with the majority of growth concentrated in a few countries. Fifty percent of the population growth between 2017 and 2050 is expected to be concentrated in nine countries, Indonesia being the ninth (by expected contribution) (United Nations, 2017). In many cases, population growth in urban developing regions has exceeded the capacity of the state to manage associated development needs effectively (Cohen, 2006).

With growing populations there is a growing number exposed to flood risk. It has been estimated that approximately 21 million people are exposed to river floods alone worldwide and this could more than double to 54 million people in 2030 associated with socio-economic development and climate change (Luo ***et al.***, 2015).

3.3.3. Urbanisation

A growing population increases the demand for housing, services and infrastructure leading to land development and urbanisation. Urban expansion is placing urban areas at increased exposure to flooding. Guneralp ***et al.*** (2015) estimate that by 2030, 40% of total global urban land will be located in high frequency flood zones compared to 30% in 2000. Even without considering climate change, urban expansion is likely to contribute to increased flood risk in the future.

The way urban development is managed may also influence flood risk. Most countries around the globe have laws and regulations which in theory control land development, but in reality, such laws may not be properly enforced due to political, economic, capacity and/or resource constraints (Jha ***et al.***, 2012). In developing countries in particular, the rapidity of population growth has outstripped the capacity of states to meet demand. This has led to poorly planned and managed urbanisation and the development of informal settlements. For example, lack of proper consideration for land planning can mean developments spread to zones with greater flood risk, such as riverbanks and flood plains. Flood plains are often appealing

to developers as they provide fertile soils and flat land which is ideal for construction of industrial sites, however this puts high value assets at increased flood risk, an issue that is often overlooked in the face of economic gains (Zischg ***et al.***, 2018). In addition, the expansion of the built environment without proper consideration for drainage and allowance for permeable land surface can also increase flood risk (Jha ***et al.***, 2012).

The Jakarta urban area has undergone great expansion in recent decades. Between 1972 and 2012 is was estimated that the urban footprint of Jakarta increased more than 200 times (BPS Jakarta in Remondi ***et al.*** (2016)). However, this rapid urban development occurred faster than the development of plans to guide it (Sagala ***et al.***, 2013). Urban and spatial planning in Jakarta has been noted to be poor and there has been a lack of compliance with spatial planning and building regulations (Grady ***et al.***, 2016; Asdak ***et al.***, 2018). For example, planning restrictions mandate that a 15 metre setback should be implemented to allow space for the river, however, these restrictions have been widely violated and development has taken place on the river banks and flood plains up to the rivers edge (Sunarharum ***et al.***, 2014). In addition, the urban housing policy in Indonesia has also given the private sector the ability to build new residences with little government control (Texier, 2008). Each private developer has their own solution to drainage provision without coordinating with other developers, which may have negative impacts elsewhere (Sagala ***et al.***, 2013). Urbanisation both upstream and downstream, plus very low availability of open permeable green space in Jakarta has been noted to contribute to reduced infiltration and increased run off (Texier, 2008; Firman, 2009).

3.3.4. Social Vulnerability and Marginalisation

Cutter ***et al.*** (2004) identify social vulnerability as the product of social inequalities and place inequalities, thus is influenced by access to resources, political representation, social capital, social networks and socio-economic status. Those with higher social vulnerability are often most at risk of flooding (Brouwer ***et al.***, 2007).

Figure 4. A riverbank settlement on the banks of the Ciliwung River, Jakarta (Credit: the authors)

In Jakarta, urban development has pushed the urban poor from traditional kampungs (villages) into remaining marginalised space, such as the banks of rivers (Hellman, 2015). As a result, illegal settlements have developed along many of Jakarta's rivers, with the banks of the Ciliwung in particular being heavily populated. This places marginalised groups at greater risk of flooding. Texier (2008) notes that the Jakarta government often places blame on the riverbank settlers for increased flood impacts as these settlements have increasingly encroached on flood risk areas. As a result, there have been initiatives to relocate riverbank settlers to elsewhere. Riverbank settlers are sometimes reluctant to relocate because their livelihoods depend on for example, being centrally located or close to the river/coast (Hellman, 2015). Texier (2008) notes that it is socially and economically related processes within the city that have forced the vulnerable into hazard zones. In this sense socio-economic conditions drive vulnerability and exposure, thus present a significant driver for flood risk.

3.3.5. Land subsidence

Land subsidence is another factor that can increase food risk by lowering the land in relation to sea level and it can have both physical and anthropogenic drivers (Budiyono ***et al.***, 2016). Due to the situation of Jakarta on an alluvial flood plain, natural compaction of the soils has contributed to the land subsidence. This has been further compounded by the added weight of the city's built environment. In addition, the extraction of ground water for use by the population has accelerated the sinking (Budiyono ***et al.***, 2016). At present, approximately 40% of Jakarta is below sea level (World Bank, 2011). Studies have indicated that soil water extraction is one of the greatest contributing factors along with urban development (Abidin ***et al.***, 2011).

4. Flood Impacts

4.1. Definition

UNISDR (2017) define disaster impact as: "the total effect, including negative effects (e.g. economic losses) and positive effects (e.g. economic gains), of a hazardous event or a disaster. The term includes economic, human and environmental impacts, and may include death, injuries, disease and other negative effects on human physical, mental and social well-being." Following the UNISDR definition, this section highlights some of the human, economic and environmental impacts of flooding and some consequences of past flood events in Jakarta.

4.2. Human Impacts

Of all natural hazards, floods have impacted the most people in the 21st Century. In 2018, floods accounted for 24% of natural hazard related deaths (the second largest cause behind earthquakes) and 50% of the total number of people affected by natural hazards (CRED, 2018).

In Jakarta, the 2007 flood event was one of the most severe events experienced by the city and resulted in over 58 fatalities. Causes of these deaths include drowning, electrocution and hypothermia (Texier, 2008). The floods were also recorded to have secondary impacts on human health, for example after the 2007 flood event outbreaks of Dengue, Leptospirosis and Diarrhoea were recorded which are associated with poor water hygiene (OCHA (2007) ***in*** Texier (2008)).

Floods can also result in displacement of people from their place of residence. Residents impacted by floods often move to temporary accommodation if they are evacuated or relocate permanently their homes are damaged (Wijayanti ***et al.***, 2017). Major flooding in January 2013 is estimated to have displaced 40,000 people in total (BPBD (2013) ***in*** Wijayanti ***et al.*** (2017)). In particular, the informal settlements that line the riverbanks in Jakarta can be susceptible to flood damage which can result in displacement of these populations (Texier, 2008).

4.3. Economic Impacts

Flooding in urban environments can have major impacts on the economy through damages to buildings, utilities, housing, household assets and transport systems and can result in losses in industry, trade and employment (Jha ***et al.***, 2012). Economic impacts can be both direct (losses directly associated with the floods e.g. damage to infrastructure) and indirect (e.g. economic losses due to disruption of the production chain) (State of Queensland, 2011). While Jakarta suffers from floods on a regular basis, severe floods in recent years have demonstrated the significant economic damages that can be caused. The major floods in 2002, 2007, 2013 and 2014 have caused billions of dollars of economic damage. Estimated total losses incurred from the 2007 and 2013 severe flood events were 565 million USD (BAPPENAS (2007) in Wijayanti ***et al.*** (2017)) and 490 million USD (World Bank, 2016) respectively.

The greatest economic damages are associated with flooding in Jakarta's central business district (CBD). For example, Caljouw ***et al.*** (2005) note that during the 2002 floods, the flood gate of the Ciliwung was opened, directing water to the inner-city area, which brought economic activity to a standstill. Further flooding of the CBD in 2013 forced businesses and government agencies located there to close. Businesses

were further impacted due to disruption of the transport networks due to flood waters and gridlocked traffic (Vaswani, 2013).

Economic losses due to property damage are also great. The greatest proportion of losses during the 2007 flood event was suffered by the residential sector, accounting for 74% of losses (BAPPENAS (2007) in Wijayanti ***et al.*** (2017)). Floods have also been noted to have major impacts on the property market (Caljouw ***et al.***, 2005).

Economic impacts are also apparent at the household level and can impact heavily on peoples livelihoods, especially for those who work in the informal sector (Texier, 2008) and for those who rely on industries such as fishing. Floods impact on daily activities and prevent people accessing their place of work (Marfai ***et al.***, 2008).

Climate change is likely to increase economic damages from flooding globally. It is estimated that depending on the socio-economic scenario, with a 1.5-degree Celsius warming direct flood damage will increase by 160%-240%. As this degree warming rises, the impacts will only worsen (EU Science Hub, 2018). In Jakarta, Hallegatte ***et al.*** (2013) calculated that there could be over a 50% increase in average annual losses from coastal flooding compared to 2005 under a scenario of optimistic sea level rise and where current flood defence standards are maintained.

4.4. Environmental Impacts

Floods can have some positive impacts for the natural environment, for example providing nutrients to the environment and recharging ground water. However, floods can also degrade the natural environment, especially in areas where systems have already been degraded. Excess sediment loads can also have negative impacts on water quality (State of Queensland, 2011).

As Jakarta is an urban environment, floods have the most impacts on the built environment.

During the 2007 floods approximately 70% of Jakarta was inundated (Sagala ***et al.***, 2013). The highest flood level was 3.5m, measured in the area of Kampung Melayu causing significant damage to the built environment (Rahmayati ***et al.***, 2017). In a survey of households in west and south Jakarta, Wijayanti ***et al.*** (2017) found that on average homes were inundated to a height of 86cm, which lasted on average 98 hours during the January 2013 event.

Figure 5. Large parts of the capital city Jakarta were submerged under flood waters during the major 2002 flood event (REUTERS/Alamy Stock Photo)

5. Transboundary Governance and River Management

Rivers can span long distances from source to mouth and may traverse through different administrative areas, jurisdictions, regions, even countries (Bakker, 2009). A river which crosses more than one international border is termed 'transboundary' (UNEP-DHI and UNEP, 2016). From an integrated river management perspective, rivers are best managed at the basin level, therefore cooperation across borders is a necessary consequence (Wiering ***et al.***, 2010). However, the need to transcend borders to achieve basin wide management can present a set of complex governance issues (Bracken ***et al.***, 2016).

Rivers are interconnected systems and create a set of environmental, political and economic interdependencies between places (UNEP-DHI and UNEP, 2016). Actions taken in one location in the basin may have impacts elsewhere, which means the management of the river much more complex than for a static resource as environmental, political and economic considerations need to be balanced between actors (Kliot ***et al.***, 2001). Not only that, as the characteristics of administrative areas differ, the management of transboundary river basins requires coordination across different political, legal, institutional and technical settings (UNEP-DHI and UNEP, 2016).

Due to the interconnectedness of the river basin system, floods present a key issue of concern in the management of a transboundary river. As described in Section 3 there are a large number of flood drivers to be considered in flood management plans and river management itself is a complex problem that involves a wide number of stakeholders (Timmerman ***et al.***, 2017). Complexity is only added in transboundary flood management where the number of stakeholders and considerations are multiplied (Bakker, 2009).

5.1. Types of Boundaries

Bracken ***et al.*** (2016) define three types of 'borders' that are found in the practice of flood risk management that must be overcome in a transboundary setting, these are: 'physical', 'conceptual' and 'organisational'. Physical borders are those that denote geographic boundaries, political entities or jurisdictions and are found on multiple scales, from national to local. Organisational borders are the gaps between the many different organisations that are involved in the management of a river. These organisations may overlap, but may operate from different perspectives and have different priorities. Conceptual borders are the approaches and perspectives taken. This may in part be dictated by legislation, but the way this legislation is interpreted can vary. How these borders function impact on the way flood risk management is delivered.

Further elaborating on this, Wiering ***et al.*** (2010) identify three dominant approaches to transboundary management from the literature: 1) negotiation processes, 2) the regime perspective and 3) cognitive and discursive approaches. Negotiation processes focus on the distribution and redistribution of resources and interests. The regime approach shifts focus to the nature of institutions while cognitive and discursive approaches focus more on how the beliefs held by policy makers impact joint policy making (whether positively or negatively). The authors conclude that for successful cross-border cooperation, the three approaches must be combined and can be linked to the crossing of the borders defined by Bracken ***et al.*** (2016). In their understandings of transboundary management, both Wiering ***et al.*** (2010) and Bracken ***et al.*** (2016) highlight how it is not only borders between locations, but the differences between organisations and the ways they operate that must be overcome to achieve successful transboundary river management.

Although the Ciliwung river does not cross international borders, it does cross several administrative (physical) borders within Java. The river originates in the province of West Java and crosses through the municipalities of Bogor, Bogor Regency and Depok before entering the special province of Jakarta

(DKI Jakarta) and discharging into Jakarta Bay. There are different organisations within each jurisdiction, creating both organisational and conceptual borders. Thus, crossing physical, organisational and conceptual borders, the Ciliwung can be viewed as 'transboundary' and poses significant challenges to effective river management.

5.2. The Classical Temple

Savenije and van der Zaag (2000) present a conceptual framework for the sharing of transboundary waters. Their framework takes the form of a classical temple with three pillars: the technical (or operational) pillar, the political pillar and the institutional pillar. All three pillars are required to achieve the balanced sharing of waters, with integrated water resource management as the foundation. Although this framework is designed for the management of international waters, many of the same principles apply across borders within a state and will be used as the basis for understanding transboundary issues in the Ciliwung Basin, while holding the different types of boundaries (physical, organisational, conceptual) in mind.

5.3. Political Pillar

The political pillar contributes to the creation of an enabling environment for cross-border cooperation (Savenije and van der Zaag, 2000).

5.3.1. Leadership and Political will

Political will is often cited as a necessary component for creating an enabling environment for cooperation and a lack of political will can present a major barrier to transboundary management (Savenije and van der Zaag, 2000; Skoulikaris and Zafirakou, 2019). Political will can be a determinant of how much cooperation takes place and can either be used to improve or worsen relationships between jurisdictions. Differing political will across borders may present a coordination issue, although control is often seen to be steered towards the most powerful political actor (Zeitoun ***et al.***, 2013).

Changes in leadership can lead to changes in political will to cooperate, and also create changes in policies and systems that may impact risk governance. The will of leaders in particular can impact on the implementation of strategies. For example, in Jakarta Sagala ***et al.*** (2018) identify that leadership has been a central factor for the success of flood mitigation plans, with some Jakarta governors, such as Joko Widodo (2012-2014), pushing forward flood mitigation efforts, while others have not.

5.3.2. Capacity

Capacity building ensures that all parties have the adequate capacities to take cooperative action and helps to level the playing field so that coordination can take place, making capacity building an important aspect of the political pillar (Savenije and van der Zaag, 2000). UNEP-DHI and UNEP (2016) conducted a global survey of transboundary river basins and found that capacity building is still a work in progress in many transboundary basins around the globe. In Indonesia, Padawangi and Douglass (2015) identify that under decentralisation, some local governments have developed well, while others have not. This has led to varying capacities across administrative borders which may contribute to difficulties in transboundary coordination.

Similarly, political commitment to flood risk reduction depends on the ability of decision makers to provide vision, direction, material and non-material support (Jha ***et al.***, 2012). To create an enabling environment and provide sufficient support for flood risk reduction, governments require capacity to do so. The capacity

of political leaders can influence the effectiveness of flood mitigation policies and implementation. For example, leaders with an understanding of vulnerability and risk are better equipped to form effective policies and driver forward plans that are implementable (Sagala ***et al.***, 2018).

5.3.3. Sectoral fragmentation

In flood management alone there are many different sectors involved (e.g. planning and land use, agriculture and forestry, etc.) (Akhmouch and Calavreul, 2019). Integrated flood risk management stipulates that a variety of sectoral interests are dealt with in conjunction (Savenije and van der Zaag, 2000). However, more commonly government sectors take a 'siloed' approach, working independently from one another. Different government sectors have their own remits and competences in specific areas, and often define their objectives from their specific view point (Savenije and van der Zaag, 2000). The diverging interests of government sectors can be associated with issues such as institutional fragmentation, overlapping and unclear responsibilities.

In a transboundary case, government sectors operate within each jurisdiction. However, the priorities of an agriculture and forestry sector upstream may not mirror the priorities of the same sector downstream for example (Savenije and van der Zaag, 2000). The risk of flooding in different jurisdictions may be different, therefore may be a priority in one location but not in another. Diverging priorities can lead to unilateral working and further fragmentation, and can potentially lead to conflict without coordinated plans. Sectoral fragmentation has been identified within the Ciliwung River basin. For example, the municipalities of Bogor and Depok also have their own independent planning systems. These planning systems are not well integrated, leading to fragmentation and limited collaboration (Sunarharum ***et al.***, 2014; Asdak ***et al.***, 2018). It has been suggested that to improve sectoral integration across boundaries firstly sectoral goals need to be clarified, this allows incompatible interests and areas of synergy to be identified as a starting point for developing common management policies between upstream and downstream (UNECE, 2009; Ganoulis ***et al.***, 2011). Clear legal frameworks can help to implement coordination in a coherent manner and to clarify roles and responsibilities to help overcome fragmentation (Dewi and van Ast, 2017).

5.4. Legal/Institutional Pillar

In Savenije and van der Zaag's (2000) classical temple, the institutional pillar concerns the institutions involved and the legal instruments used to enable the sharing of transboundary water resources.

5.4.1. Legal frameworks

Across the globe legal instruments dictate the ways water resources are managed (Savenije and van der Zaag, 2000) and guide the governance of transboundary basins (UNEP-DHI and UNEP, 2016). This may include national laws, regulations, directives or international agreements and treaties (UNECE, 2009). Under the sovereignty principle each country has the right to make its own policies, legislation and strategies. The principle is often identified as an important legal consideration for transboundary river basin management, as it can lead to little or no continuity between laws across borders (Bakker, 2009). In the case of the Ciliwung, although the river does not cross state borders it crosses several jurisdictional borders within the country. Due to Indonesia's decentralised governance system, each local government has the ability to enact its own legal regulations, associated with the Indonesian law of regional autonomy (Law No. 23/2014) (Asdak ***et al.***, 2018) which may contribute to unilateral working and a lack of coordination.

The enforcement of law also needs to be considered, as a law that is not enforced is not effective. Indonesia exhibits a highly bureaucratic legal system, with many different legislative acts and regulations (Hellman ***et al.***, 2018). Taking flood management as an example, there are several different laws that need to be considered, including the Disaster Management Law (26/2007), the Water Law (07/2004) and the Spatial Planning Law (26/2007). However, several authors have identified that in reality, many laws are not implemented or enforced (Sagala ***et al.***, 2013; Ward ***et al.***, 2013; Hellman ***et al.***, 2018). For example, Grady ***et al.*** (2016) identify low levels of compliance with legislation relating to spatial planning and building codes which could impact on disaster risk.

A clear legal framework is suggested to be the basis for successful integrated management (Savenije and van der Zaag, 2000) and indeed, legal agreements between states often do form basis for international cooperative water management (Earle ***et al.***, 2010). However, in many cases transboundary agreements are still lacking. UNEP-DHI and UNEP (2016) found that a large proportion of the transboundary basins across the globe lacking common treaties, or if they do have them, they often lack the principles of customary law. They suggest that more effort is needed to negotiate and implement transboundary agreements. In Indonesia, although central government created regulation for the implementation of an inter-local-government partnership, it has been identified as too simplistic to tackle the complexity of coordinating local governments (Firman, 2014), and each local government able to decide on their own commitment towards coordination (Dewi and van Ast, 2017). Although legal frameworks are heralded as important for effective transboundary management, it should be noted that a lack of legal framework for cooperation does not necessarily mean cooperation does not take place, with some basins opting for more informal or voluntary agreements, which can also work if parties are committed to its implementation (UNECE, 2009).

BOX 1

THE EUROPEAN WATER FRAMEWORK DIRECTIVE: A LEGAL FRAMEWORK EXAMPLE

The EU Water Framework Directive (2000/60/EC) (WFD) presents an example of a legal framework that has been applied to encourage integrated river basin management in Europe. Although the Directive is for Europe specifically, the WFD brought a new approach to water management and is often considered an example of 'best practice' that could provide useful comprehension of how transboundary management could be incorporated into legislation for other places around the globe (Barreira and Kallis, 2004).

The Directive acknowledges that the river basin is the most appropriate scale for water management and sets out guidelines for improved river basin management in Europe. The WFD has several objectives relating to protecting aquatic ecosystems and the environment, sustainable use of water resources and in mitigating the effects of floods and droughts (Wilby *et al.*, 2006).

The Directive applies to river basins across Europe and for each river basin, a river basin management plan is required. The plans set out objectives for the river basins and how they are going to be reached. The plans cover the river basin's characteristics, a review of the impact of human activity on the status of waters in the basin, estimation of the effect of existing legislation and the remaining "gap" to meeting these objectives; plus a set of measures designed to fill the gap (European Commission, 2019).

To ensure progress is being made, the WFD sets out clear deadlines for when requirements should be met. The European Commission must also prepare reports on the implementation of the WFD which reviews progress and future plans which are presented to the European Parliament and Council. The WFD stipulates that river management plans should be updated on a regular basis as the dynamic nature of the river basins means the plans could become quickly outdated. The WFD also encourages the integration of climate change adaptation into management plans, however the focus is on water quality rather than flooding (Benson and Lorenzoni, 2017).

Although the WFD was a major legislative step in making water management more effective, some issues have been identified. It has been suggested that the WFD is somewhat vague and open to interpretation which has led to differences in approaches taken to its implementation (Vouvoulis *et al.*, 2017). Participation is also a key element of the WFD and the Directive requires that stakeholders are engaged in the development of the river management plans. On one hand, the WFD has been commended for highlighting participation as essential, but on the other, there is a great deal of room for interpretation on who should be engaged and how (Vouvoulis *et al.*, 2017).

5.4.2. Institutions and organisations

The organisational setting concerns the institutions and organisations that are involved in flood risk management at various levels (national, regional, local) and how they cooperate and relate to one another (UNECE, 2009). Key institutions in flood risk management may involve Governments (national – local levels), utilities, private businesses, community groups and insurance providers (Jha *et al.*, 2012). Flood risk management includes a complex set of actors and therefore cooperation and coordination between these actors is essential. In a transboundary situation, the number of organisations is multiplied. There are many different actors across scales, both vertically and horizontally, that must be considered in transboundary river management.

Horizontal integration

As rivers are connected from upstream to downstream, actions taken upstream may influence regions downstream and vice versa, therefore it is suggested that plans should take into consideration impacts on others sharing the watercourse (Bakker, 2009).

In 1999 Indonesia began a process of rapid decentralisation and this led to each local government having the power to enact regulations, develop its own plans and programmes and decide on their own priorities based on local interests (Asdak ***et al.***, 2018). Local governments are focused on generating local revenue which has resulted in intensive exploitation of location resources for economic gains (Firman, 2014). In many cases actions are conducted with little consideration for neighbouring areas (Padawangi and Douglass, 2015; Sagala ***et al.***, 2018). Local governments were of the opinion that there is no need to coordinate with neighbouring jurisdictions (Firman, 2014). In some cases, governors have been sceptical about cooperating with others for fear they would interfere in their own administration (Sagala ***et al.***, 2018). This lack of cooperation presents an issue for flood management in the basin, as it has been identified that activities such as urbanisation upstream impacts on flood risk downstream, however, as upstream and downstream reaches fall under different jurisdictions downstream has little say on upstream activities (Sagala ***et al.***, 2013). The decentralised administrative structure in Indonesia is widely considered to have hindered its ability to achieve an integrated, basin-wide management arrangement.

Vertical integration

The process of decentralisation in Indonesia distributed responsibilities from the central government to various levels of government. Decentralisation is often viewed positively for risk reduction governance as disasters are felt at the local level and local authorities and communities are usually the first responders during a disaster (Grady ***et al.***, 2016). However, decentralisation can tend to create fragmentation make delivery of coherent efforts more complex.

Responsibilities for flood management may be distributed across various levels of governance. For example, in a study conducted by the Organisation for Economic Co-operation and Development (OECD) (Akhmouch and Calavreul, 2019) flood anticipation was commonly the responsibility of the national or subnational level, while flood prevention/mitigation and response where commonly found at the local/ metropolitan level. If there is no coordination between government levels there may be inconsistences between national and local strategies. In Indonesia, Grady ***et al.*** (2016) identified a disconnect between policies at different levels. In particular, provinces lack strategic and operational plans for DRR which creates a policy disconnect with national level. Furthermore, for cooperation to take place, it is important that each organisation clearly understands who the other actors are and how responsibilities are distributed between them (Jha ***et al.***, 2012). In Greater Jakarta, a lack of clear responsibilities between local, provincial and central government authorities has been identified (Firman, 2014).

Although responsibility has been transferred to various levels of governance under decentralisation, it has been noted that a similar transfer of power and resources did not occur. In Indonesia the provincial level are found to have limited power which creates a gap between the national level through to the local levels (Grady ***et al.***, 2016). For example, the provincial disaster management office (BPBD) has the authority for implementation of DRR, but they have not received sufficient resources to act. A lack of funding, staffing and capacity has been found to hinder the work of BPBD at the provincial level (Srikadini ***et al.***, 2018). A lack of experienced staff working for BPBD has been associated to its reputation for being under resourced and high staff rotation rates (Grady ***et al.***, 2016). They also note that BPBD often rely on BNPB (national disaster management office) for funding, however this is often oriented towards emergency response rather than risk reduction which may impact on risk management efforts (Grady ***et al.***, 2016).

According to Dewi and van Ast (2017), there are several regulations in Indonesia that mandate relations between different levels of government, however they note that in practice, there is little coordination. For example, BKSP (Badan Kerja Sama Pembangunan Jabodetabekjur) is the inter-local government cooperation agency and consults with the central government on development matters. However, BKSP lack the authority to implement and enforce coordination, which means that in reality little coordination actually takes place (Padawangi and Douglass, 2015).

Savenije and van der Zaag (2000) suggest that too much delegation of power to local levels can if fact be counterproductive in the case of transboundary management and that in fact, as decisions made in a river

basin may impact the whole system, the appropriate level for this decision making should be the river basin level, not the local level. This is also in like with integrated flood risk management principles.

Coordinating institutions

In transboundary situations there can be a lack of suitable channels for communication between actors (Skoulikaris and Zafirakou, 2019) and due to the sheer number of stakeholders involved it can be unclear who is responsible for what and who should take the lead (Boin, 2019). As a result, river basin authorities are often proposed as a useful tool for achieving coordination as they can act as a platform for coordinating activities between different actors and for the sharing of information. However, where river basin management authorities exist they often face issues. As they often exist at odds with existing fragmented governance systems, they can end up with limited power to act. They also may lack sufficient capacities and resources to achieve their goals (Donzier, 2011; Akhmouch and Calavreul, 2019).

Participation

Stakeholder engagement in river management is important for the development of solutions that are sustainable and equitable and to ensure national decisions are compatible with local needs (Savenije and van der Zaag, 2000).

Governors of Jakarta have for the most part operated a top-down approach to governance which has not involved pubic participation. Although more recent governors have given more attention to participation (Sagala ***et al.***, 2018), recent flood management plans, such as those for the construction of the new seawall have been noted to still lack adequate participation of stakeholders in their design (Garschagen ***et al.***, 2018) and in general, citizens are excluded from decision making processes (Hellman ***et al.***, 2018). Socio-economic factors influence participation, including poverty, education, access to services, livelihood profile and cultural beliefs which may present potential barriers to successful engagement, in addition to political will (Savenije and van der Zaag, 2000; WMO, 2017).

5.5. Operational Pillar

5.5.1. Management approach

As noted in the UNISDR (2017) definition of risk, vulnerability and capacity are also important contributing factors to flood risk. It is now recognised that to reduced flood risk it is important to address factors that contribute to vulnerability and capacity as well as the hazard.

However, the approach to flood management in Jakarta has been criticised for focusing only on the management of the hazard with little consideration for underlying vulnerabilities (Texier, 2008; Garschagen ***et al.***, 2018). The Government has implemented structural mitigation measures on a wide scale, this has included dams, flood gates, polders and sea walls. However, poor management and maintenance of structural measures in some cases has resulted in reduced functionality. For example, Grady ***et al.*** (2016) identify that due to lack of maintenance of flood retention basins, some now operate at only 30% of their original capacity. There are further concerns that with increasing precipitation rates and sea level rise with climate change, existing engineered flood defences may no longer be sufficient to prevent flooding. If climate change is not considered in flood mitigation plans it could lead to increased flood risk in the future.

Figure 6. Concrete embankments and walls line the Ciliwung in an effort to protect residential areas from flooding during high water levels (Credit: the authors).

5.5.2. Technical cooperation

Data and information are crucial to effective integrated water resource and flood risk management. Integrated water management for example, requires data of different types and from different sources to be brought together. Data and information are required for each stage of the risk management cycle (UNECE, 2009), regarding both physical and social aspects (Girons Lopez, 2016) for a fully integrated approach. It is clear that for effective management a variety of data is required from many different actors.

However, borders can present blockages to the transfer of knowledge, ideas and technologies (Miller and Douglass, 2018) and a lack of suitable mechanisms for data exchange can pose a barrier to successful transboundary management (Skoulikaris and Zafirakou, 2019). For transboundary cases it can be difficult to identify firstly what information exists and what information is required, as information is held by different actors and may not necessarily transparent (Boin, 2019) which may lead to the duplication of data collection. Information may not be easily shared across borders due to use of technical concepts and different languages and terminologies (Boin, 2019). Actors may take different approaches to data collection and management, thus it can often prove difficult to effectively coordinate data sharing (Girons Lopez, 2016).

However, information sharing can also be a useful first step towards transboundary management, as cooperation of technical experts can help to start building trust (UNECE, 2009). Technical cooperation can be a useful tool, particularly when the political environment is not supportive, as it can help to build mutual trust and understanding between actors (van der Zaag and Savenije, 2000). The UNECE (2009) highlight several enabling factors for effective data sharing in transboundary environments. This includes clearly defined data needs, a common knowledge base and compatibility between data systems operated by different actors so that information from different sources can be brought together.

5.5.3. Climate Adaptation Plans

Transboundary cooperation for river management is particularly important in areas vulnerable to climate change as it contributes additional pressures and compounds existing challenges (Zeitoun ***et al.***, 2013). It is possible that cross-border conflicts could become a more frequent occurrence as existing arrangements may not be able to handle the strain of future climate change pressures (Gleick and Iceland, 2018). It also becomes more important that adaptation plans throughout the river basin are integrated to avoid mal-adaptive practice. Therefore, river management plans should consider the possible future effects of climate change for which technical cooperation with neighbouring regions is required. The uncertainty in climate change presents another issue, requiring management plans that are flexible to deal with the changes climate change may bring without leading to mal-adaptive practice (Zeitoun ***et al.***, 2013).

6. Conclusions

The aim of this study was to develop a conceptual framework that brings together the key concepts to be considered for the management of flooding in a transboundary river basin environment, with a particular focus on the Ciliwung River Basin, Indonesia. A diagrammatic summary of the framework is presented in Figure 7. The framework highlights that there are many aspects to be considered in the development of more effective river management plans for the reduction of flood impacts. Firstly, and most obviously, the drivers of flooding need to be addressed. The drivers of flooding can be considered here as 'external' and 'governable'. External drivers concern factors that contribute to flooding but cannot themselves be influenced by improved management. This includes climate and extreme weather, geography, morphology, natural land subsidence and population growth. Governable drivers can be influenced and potentially improved to reduce the likelihood of flooding and the severity of impacts. This includes the way flood management measures are implemented and maintained land modification, urbanisation, social vulnerability and climate change adaptation considerations. Coordinated action is required to address these factors holistically. There are then other factors which relate to the governance arrangements and approaches themselves. This includes coordination between sectors, institutions and governance levels and the integration of strategies. The effectiveness of management arrangements is also associated with supporting aspects, such as the availability of legal frameworks, political will, technical cooperation, enforcement and participation. These aspects can be used to coordinate activities and integrate approaches so that they are both effective and efficient. Through highlighting the key concepts relating to transboundary river governance and flood management, and the potential linkages between them, the framework provides a starting point for investigating how river governance influences flood hazard impacts and how transboundary river management plans may be made more effective in the future in the Ciliwung River Basin.

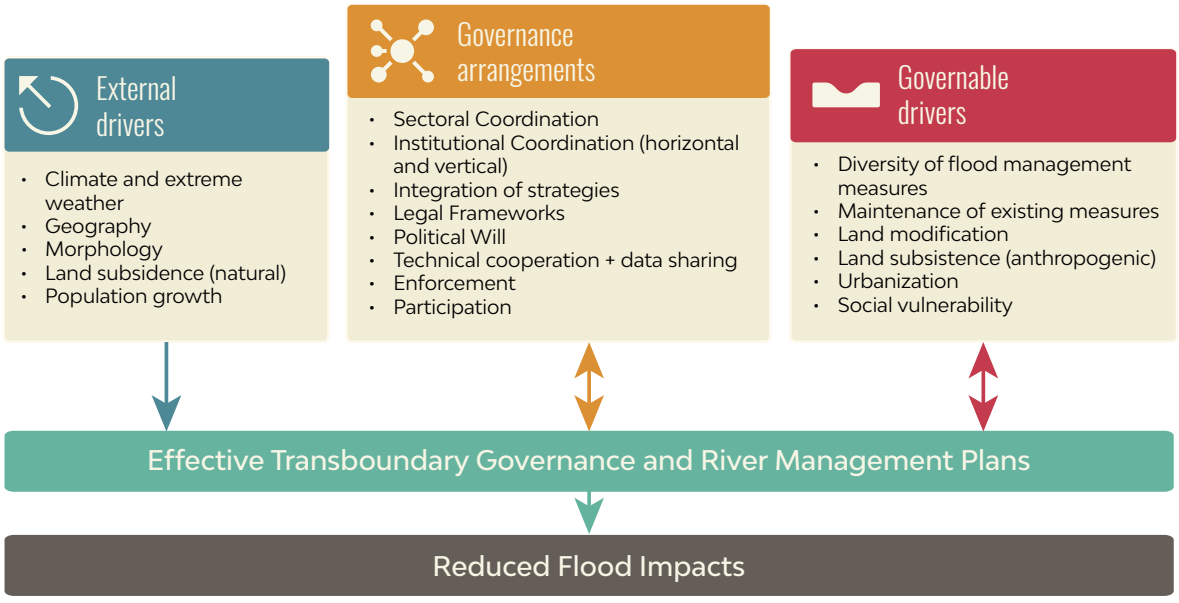

Figure 7. Conceptual framework for effective river governance and flood management plans with reference to the Ciliwung River, Indonesia.

References

Abidin, H. Z., Andreas, H., Gumilar, I., Fukuda, Y., Pohan, Y. E. & Deguchi, T. (2011) Land subsidence of Jakarta (Indonesia) and its relation with urban development. ***Natural Hazards***. 59, 1753.

Akhmouch, A. & Calavreul, D. (2019) Flood Governance: A Shared Responsability. An application of the OECD Principles on Water Governance to Flood Management.

Ambiental (2019) ***Types of flood and flooding impact*** [Online]. Ambiental. Available: https://www.ambiental.co.uk/types-of-flood-and-flooding-impact/ [Accessed 7 June 2019].

Asdak, C., Supian, S. & Subiyanto (2018) Watershed Management Strategies for Flood Mitigation: A Case Study of Jakarta's Flooding. ***Weather and Climate Extremes***. 21, (Sept 2018) 117-122.

Bakker, M. H. N. (2009) Transboundary River Floods and Institutional Capacity. ***Journal of the American Water Resources Association***. 45, (3) 553-566.

Barreira, A. & Kallis, G. (2004) The EU Water Framework Directive and public participation in transboundary river basin management. ***In:*** Timmerman, J. G. & Langaas, S. (eds.) ***Environmental Information in European Transboundary Water Management.*** London: IWA Publishing.

Benson, D. & Lorenzoni, I. (2017) Climate Change Adaptation, Flood Risks and Policy Coherence in Integrated Water Resources Management in England. ***Regional Environmental Change***. 17, (7) 1921-1932.

Boin, A. (2019) The Transboundary Crisis: Why are we unprepared and the road ahead. ***Journal of Contingencies and Crisis Management***. 27, (1) 94-99.

Bracken, L. J., Oughton, E. A., Donaldson, A., Cook, B., Forrester, J., Spray, C., Cinderby, S., Passmore, D. & Bissett, N. (2016) Flood risk management: an approach to managing cross border hazards. ***Natural Hazards***. 82, (Supplement 2) 217-240.

Brouwer, R., Akter, S., Brander, L. & Haque, E. (2007) Socioeconomic Vulnerability and Adaptation to Environmental Risk: A Case Study of Climate Change and Flooding in Bangladesh. ***Risk Analysis***. 27, (2) 313-326.

Budiyono, Y., Aerts, J. C. J. H., Tollenaar, D. & Ward, P. J. (2016) River flood risk in Jakata under scenarios of future change. ***Natural Hazards and Earth System Sciences***. 16, 757-774.

Caljouw, M., Nas, P. J. M. & Pratiwo (2005) Flooding in Jakarta. Towards a blue city with improved water management. ***Journal of the Humanities and Social Sciences of Southeast Asia and Oceania***. 161, (4).

Chang, H. & Franczyk, J. (2008) Climate Change, Land Use Change and Floods: Toward an Integrated Assessment. ***Geography Compass***. 2, (5) 1549-1579.

Cheong, A. (2018) ***A Retrospective view of floods in Jakarta*** [Online]. Online: JBA. Available: https://www.jbarisk.com/news-blogs/a-retrospective-view-of-floods-in-jakarta/ [Accessed 6 June 2019].

Cohen, B. (2006) Urbanization in developing countries: Current trends, future projections and key challenges for sustainability. ***Technology in Society***. 28, (1-2) 63-80.

CRED (2018) Disasters 2018: Year in Review. CRED Crunch. Available: https://www.cred.be/publications.

Cutter, S. L., Boruff, B. J. & Shirley, W. L. (2004) Social Vulnerability to Environmental Hazards. ***Social Science Quarterly***. 84, (2) 242-261.

den Haan, R. J., Fliervoet, J. M., cvan der Voort, M. C., Cortes Arevalo, V. J. & Hulscher, S. J. M. H. (2019) Understanding Actor Perspectives Regarding Challenges for Integrated River Basin Management. ***International Journal of River Basin Management.*** 17, (2) 229-242.

Dewi, B. R. K. & van Ast, J. A. (2017) Institutional Arrangements for Integrated Flood management of the Ciliwung-Cisadane River basin, Jakarta Metropolitan Area, Indonesia. ***In:*** Van Dijk, M. P., Edelenbos, J. & Van Rooujen, K. (eds.) ***Urban Governance in the Realm of Complexity.*** Rugby, UK: Practical Action Publishing.

Donzier, J.-F. (2011) Global Challenges and the European Paradigm: Towards Integrated Management of Transboundary River Basins over the World. ***In:*** Ganoulis, J., Aureli, A. & Fried, J. J. (eds.) ***Transboundary Water Resources Management: A Multidisciplinary Approach.*** 1 ed. Weinheim, Germany: John Wiley & Sons.

Earle, A., Jagerskog, A. & Ojendal, J. (2010) Introduction: Setting the Scene for Transboundary Water Management Approaches. ***In:*** Earle, A., Jagerskog, A. & Ojendal, J. (eds.) T***ransboundary Water Management: Principles and Practice.*** London / Washington DC: Earthscan.

EU Science Hub (2018) ***Rising danger of deadly river floods with global warming*** [Online]. Online: European Commission. Available: https://ec.europa.eu/jrc/en/news/rising-danger-deadly-river-floods-global-warming [Accessed 12 June 2019].

European Academies Science Advisory Council (2018) Extreme Weather Events in Europe. Statement. Available: https://easac.eu/fileadmin/PDF_s/reports_statements/Extreme_Weather/EASAC_Statement_Extreme_Weather_Events_March_2018_FINAL.pdf.

European Commission (2019) ***Introduction to the EU Water Framework Directive*** [Online]. Online: European Commission. Available: http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm [Accessed 12 June 2019].

Firman, T. (2009) The continuity and change in mega-urbanisation in Indonesia: a survey of Jakarta-Bandung Region (JBR) development. ***Habitat International.*** 33, 327-339.

Firman, T. (2014) Inter-local-government partnership for urban management in decentralizing Indonesia: from below or above? Kartamantul (Greater Yogyakarta) and Jabodetabek (greater Jakarta) compared. ***Space and Polity.*** 18, (3) 215-232.

Ganoulis, J., Aureli, A. & Fried, J. J. (2011) T***ransboundary Water Resources Management: A Multidisciplinary Approach.*** Weinheim, Germany, John Wiley & Sons.

Garschagen, M., Surtiari, G. A. K. & Harb, M. (2018) Is Jakarta's New Flood Risk Reduction Strategy Transformational? ***Sustainability.*** 10, (8) 2934.

Girons Lopez, M. (2016) Information Needs for Water Resource and Risk Management: Hydro-meteorological data value and non-traditional information. Digital Comprehensive Summaries of Uppsala Dissertations from the Faculty of Science and Technology 1419.

Gleick, P. & Iceland, C. (2018) Water, Security and Conflict. Issue Brief. Institute, W. R.

Grady, A., Gersonius, B. & Makarigakis, A. (2016) Taking Stock of Decentralised Disaster Risk Reduction in Indonesia. ***Natural Hazards and Earth System Sciences.*** 16, (9) 2145-2157.

Gruntfest, E. & Handmer, J. (2001) ***Coping with Flash Floods.*** Dordrecht, Kluwer Academic Publishers.

Guneralp, B., Guneralp, I. & Liu, Y. (2015) Changing global patterns of urban exposure to flood and drought hazards. ***Global Environmental Change.*** 31, (March 2015) 217-225.

Hall, J. W., Meadowcroft, I. C., Sayers, P. B. & Bramley, M. E. (2003) Integrated Flood Risk Management in England and Wales. ***Natural Hazards Review.*** 4, (3) 126.

Hallegatte, S., Green, C., Nicholls, R. J. & Corfee-Morlot, J. (2013) Future flood losses in major coastal cities. ***Nature Climate Change.*** 3, 802-806.

Hellman, J. (2015) Living with floods and coping with vulnerability. ***Disaster Prevention and Management.*** 24, (4) 468-483.

Hellman, J., Thynell, M. & van Voorst, R. (2018) ***Jakarta: Claiming Spaces and Rights in the City*** Routledge.

IPCC (2013) Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

Jha, A. K., Bloch, R. & Lamond, J. (2012) Cities and Flooding: A Guide to Integrated Urban Flood Risk Management for the 21st Century. Bank, T. W.

Kliot, N., Shmueli, D. & Shamir, U. (2001) Institutions for management of transboundary water resources: their nature, characteristics and shortcomings. ***Water Policy.*** 3, (3) 229-255.

Latief, H., Putri, M. R., Hanifah, F., Afifah, I. N., Fadli, M. & Ismoyo, O. (2018) Coastal Hazard Assessment in Northern part of Jakarta. ***7th International Conference on Building Resilience.*** Bankok, Thailand: Procedia Engineering.

Lewis-Beck, M., Bryman, A. & Liao, T. F. (2004) Conceptualization, Operationalization and Measurement. ***In:*** Lewis-Beck, M., Bryman, A. & Liao, T. F. (eds.) ***The SAGE Encyclopedia of Social Science Research Methods.*** Thousand Oaks, CA: Sage Publications Inc.

Luo, T., Maddocks, A., Iceland, C., Ward, P. & Winsemius, H. (2015) ***World's 15 Countries with the Most People Exposed to River Floods*** [Online]. wri.org: World Resources Institute. Available: https://www.wri.org/blog/2015/03/world-s-15-countries-most-people-exposed-river-floods [Accessed 11 July 2019].

Marfai, M. A., King, L., Sartohadi, J., Sudrajat, S., Rahayu Budiani, S. & Yulianto, F. (2008) The impact of tidal flooding on a coastal community in Semarang, Indonesia. ***Environmentalist.*** 28, 237-248.

Marfai, M. A., Sekaranom, A. B. & Ward, P. (2015) Community Responses and Adaptation Strategies Towards Flood Hazard in Jakarta, Indonesia ***Natural Hazards*** 75, (2) 1127-1144.

Miles, M. B., Huberman, A. M. & Saldana, J. (2014) ***Qualitative Data Analysis: A Methods Sourcebook.*** Los Angeles, Sage Publications Inc.

Miller, M. A. & Douglass, M. (2018) Crossing Borders: Governing the Globalising Urban Matrix of Compound Disasters in Asia and the Pacific. ***In:*** Miller, M. A., Douglass, M. & Garschagen, M. (eds.) ***Crossing Borders: Governing Environmental Disasters in a Global Urban Age in Asia and the Pacific.*** Singapore: Springer.

Narulita, I. & Ningrum, W. (2018) Extreme Flood Event Analysis in Indonesia Based on Rainfall Intensity and Recharge Capacity. ***IOP Conference Series: Earth and Environmental Science.*** 118, (1) 012045.

NASA (2019) ***What's in a name? Weather, global warming and climate change*** [Online]. Online: NASA. Available: https://climate.nasa.gov/resources/global-warming/ [Accessed 21 May 2019].

Nicholls, R. J. & Cazenave, A. (2010) Sea Level Rise and Its Impact on Coastal Zones. ***Science.*** 328, 1517-1520.

Ningsih, N. S., Suryo, W. & Anugrah, S. D. (2011) Study on Characteristics of Residual Water Level in Jakarta, Semarang and Surabaya Waters - Indonesia and its Relation to Storm Events in November 2007. ***International Journal of Basic and Applied Sciences.*** 11, (5) 31-37.

NOAA (2019) ***What is storm surge?*** [Online]. Online: National Oceanic and Atmospheric Administration. Available: https://oceanservice.noaa.gov/facts/stormsurge-stormtide.html [Accessed 6 June 2019].

O'Hare, G., Sweeney, J. & Wilby, R. (2013) ***Weather, Climate and Climate Change: Human Perspectives.*** New York, Routledge.

Padawangi, R. & Douglass, M. (2015) Water, Water Everywhere: Toward Participatory Solutions to Chronic Urban Flooding in Jakarta. ***Pacific Affairs.*** 88, (3) 517-550.

Pidcock, R., Pearce, R. & McSweeny, R. (2017) ***Mapped: How climate change affects extreme weather around the world*** [Online]. Online: Carbon Brief. Available: https://www.carbonbrief.org/mapped-how-climate-change-affects-extreme-weather-around-the-world [Accessed 21 May 2019].

Rahmayati, Y., Parnell, M. & Himmayani, V. (2017) Understanding Community-led Resilience: The Jakarta Floods Experience. ***Australian Journal of Emergency Management.*** 32, (4).

Remondi, F., Burlando, P. & Vollmer, D. (2016) Exploring the hydrological impact of increasing urbanisation on a tropical river catchment of the metropolitan Jakarta, Indonesia. ***Sustainable Cities and Society.*** 20, 210-221.

Rijke, J., van Herk, S., Zevenbergen, C. & Ashley, R. (2012) Room for the River: Delivering Integrated River Basin Management in the Netherlands. ***International Journal of River Basin Management.*** 10, (4) 369-382.

Robins, L., Burt, T. P., Bracken, L. J., Boardman, J. & Thompson, D. B. A. (2017) Making water policy work in the United Kingdom: A case study of practical approaches to strengthening complex, multi-tiered systems of water governance. ***Environmental Science and Policy.*** 71, (May 2017) 41-55.

Rogger, M., Agnoletti, M., Alaoui, A., Bathurst, J. C., Bodner, G., Borga, M., Chaplot, V., Gallart, F., Glatzel, G., Hall, J. W. & Holden, J. (2017) Land Use Change Impacts on Floods at the Catchment Scale: Challenges and Opportunities for Future Research. ***Water Resources Research.*** 53, (7) 5209-5219.

Rudari, R. (2017) Flood Hazard and Risk Assessment. Words into Action Guidelines: National Disaster Risk Assessment.

Sagala, S., Lassa, J., Yasaditama, H. & Hudalah, D. 2013. The Evolution of Risk and Vulnerability in Greater Jakarta: Contesting Government Policy in Dealing with a Megacity's Exposure to Flooding. An academic response to Jakarta Floods in January 2013. ***Issue 2 of IRGSC working paper series*** [Online]. [Accessed January 2013.

Sagala, S., Syahbid, M. & Wibisono, H. (2018) The Role of Leaders in Risk Governance in Jakarta. ***In:*** Hellman, J., Thynell, M. & Van Voorst, R. (eds.) ***Jakarta: Claiming Spaces and Rights in the City.*** 1 ed. London: Routledge.

Savenije, H. H. G. & van der Zaag, P. (2000) Conceptual Framework for the Management of Shared River Basins; with special reference to the SADC and EU. ***Water Policy.*** 2, (2000) 9-45.

Sayers, P. B., Hall, J. W. & Meadowcroft, I. C. (2002) Towards Risk-based Flood Hazard Management in the UK. ***Proceedings of the Institution of Civil Engineers - Civil Engineering.*** 150, (5) 36-42.

Schanze, J., Zeman, E. & Marsalek, J. (2006) ***Flood Risk Management: Hazards, Vulnerability and Mitigation Measures.*** Dordrecht, The Netherlands, Springer.

Serra-Llobet, A., Conrad, E. & Schaefer, K. (2016) Governing for Integrated Water and Flood Risk Management: Comparing Top-Downa dn Bottom-Up Approaches in Spain and California. ***Water.*** 8, (10) 445.

Simonovic, S. P. (2012) ***Floods in a Changing Climate: Risk Management.*** Cambridge and New York, Cambridge University Press.

Siswanto, van Oldenborgh, G. J., van der Schrier, G., Lenderink, G. & van den Hurk, B. (2015) Trends in High-daily Precipitation Events in Jakarta and the Flooding of January 2014. ***In:*** Stephanie C. Herring, Martin P. Hoerling, James P. Kossin, Thomas C. Peterson & Peter A. Stott (eds.) E***xplaining extreme evens of 2014 from a climate perspective.*** American Meteorological Society.

Skoulikaris, C. & Zafirakou, A. (2019) River Basin Management Plans as a Tool for Sustainable Transboundary River Basins' Management. ***Environmental Science and Pollution Research.*** 1-14.

Srikadini, A. G., Hilhorst, D. & van Voorst, R. (2018) Disaster Risk Governance in Indonesia and Myanmar: The Practice of Co-Governance. ***Politics and Governance***. 6, (3).

State of Queensland (2011) Understanding Floods: Qusestions & Answers. Government, Q.

Sunarharum, T. M., Sloan, M. & Susilawati, C. (2014) Re-framing planning decision-making: Increasing flood resilience in Jakarta. ***International Journal of Disaster Resilience in the Built Environment.*** 5, (3) 230-242.

Texier, P. (2008) Floods in Jakarta: when the extreme reveals daily structural constraints and mismanagement. ***Disaster Prevention and Management.*** 17, (3) 358-372.

Thomas, D. S. G. (2016) Flood. ***The Dictionary of Physical Geography.*** Fourth ed. Hoboken, NJ: John Wiley & Sons.

Timmerman, J., Matthews, J., Koeppel, S., Valensuela, D. & Vlaanderen, N. (2017) Improving governance in transboundary cooperation in water and climate change adaptation. ***Water Policy.*** 19, (6) 1014-1029.

Tjasyono, H. K. B., Gernowo, R., Sri Woro, B. H. & Ina, J. (2008) The Character of Rainfall in the Indonesian Monsoon. ***International Symposium on Equatorial Monsoon System.*** Yogyakarta, Indonesia.

UNECE (2009) Transboundary flood risk management: experiences from the UNECE region. Convention on the Protection and Use of Transboundary Water Courses and International Lakes. Nations, U.

UNEP-DHI & UNEP (2016) Transboundary River Basins: Status and Trends. Transboundary Waters Assessment Programme.

UNISDR (2017) ***Terminology on Disaster Risk Reduction*** [Online]. Online: UN Office for Disaster Risk Reduction. Available: https://www.unisdr.org/we/inform/terminology#letter-c [Accessed 20 May 2019].

UNISDR (2018) Implementation Guide for Addressing Water-related Disasters and Transboundary Cooperation: Integrating disaster risk management with water management and climate change adaptation. Words into Action Guidelines.

United Nations (2017) ***World population projected to reach 9.8 billion in 2050 and 11.2 billion in 2100*** [Online]. Online: United Nations Department of Economic and Social Affairs. [Accessed 4 June 2019].

Van Appledorn, M., Baker, M. E. & Miller, A. J. (2019) River-valley morphology, basin size, and flow-event magnitude interact to produce wide variation in flooding dynamics. ***Ecosphere.*** 10, (1).

van den Brandeler, F., Gupta, J. & Hordijk, M. (2019) Megacities and Rivers: Scalar Mismatches Between Urban Water Management and River Basin Management. ***Journal of Hydrology.*** 573, (June 2019) 1067-1074.

van der Zaag, P. & Savenije, H. H. G. (2000) Towards Improved Management of Shared River Basins: Lessons from the Maseru Conference. ***Water Policy.*** 2, (2000) 47-63.

Varis, O., Enckell, K. & Keskinen, M. (2014) Integrated Water Resources Management: Horizontal and Vertical Explorations and the 'Water in All Policies' Approach. ***International Journal of Water Resources Development.*** 30, (3) 433-444.

Vaswani, M. (2013) ***Indoensian capital Jakarta hit by deadly flooding*** [Online]. Online: BBC News. Available: https://www.bbc.co.uk/news/world-asia-21054769 [Accessed 6 June 2019].

Vouvoulis, N., Arpon, K. D. & Giakoumis, T. (2017) The EU Water Framework Directive: From great expectations to problems with implementation. ***Science of the Total Environment.*** 575, 358-366.

Ward, P. J., Pauw, W. P., van Buuren, M. W. & Marfai, M. A. (2013) Governance of flood risk management in a time of climate change: The cases of Jakarta and Rotterdam. ***Environmental Politics.*** 22, (3) 518-536.

Watson, N. (2004) Integrated River Basin Management: A Case for Collaboration. ***International Journal of River Basin Management.*** 2, (4) 243-257.

Wiering, M., Verwijmeren, J., Lulofs, K. & Feld, C. (2010) Experiences in Regional Cross Border Co-operation in River Management. Comparing Three Cases at the Dutch-German Border. ***Water Resources Management.*** 24, 2647-2672.

Wijayanti, P., Zhu, X., Hellegers, P., Budiyono, Y. & van Ierland, E. C. (2017) Estimation of River Flood Damages in Jakarta, Indonesia. ***Natural Hazards.*** 86, (3) 1059-1079.

Wilby, R., Orr, H., Hedger, M., Forrow, D. & Blackmore, M. (2006) Risks posed by climate change to the delivery of Water Framework Directive objectives in the UK. ***Environment international.*** 32, (8) 1043-1055.

WMO (2009) Integrated Flood Management. Concept Paper. Organization, W. M. Available: https://www.floodmanagement.info/publications//concept_paper_e.pdf.

WMO (2017) Community-based Flood Management. Integrated Flood Management Tools Series.

World Bank (2006) Integrated River Basin Management: From Concepts to Good Practice. An Introduction to Integrated River Basin Management.

World Bank (2011) Jakarta: Urban Challenges in a Changing Climate. Mayors Task Force on Climate Change, Disaster Risk and the Urban Poor.

World Bank (2016) ***Keping Indonesia's Capital Safer from Floods*** [Online]. Online: World Bank. Available: http://www.worldbank.org/en/news/feature/2016/01/08/keeping-indonesias-capital-safer-from-floods [Accessed 6 June 2019].

World Population Review (2019) ***Jakarta Population*** [Online]. Online. Available: http://worldpopulationreview.com/world-cities/jakarta-population/ [Accessed 6 June 2019].

Zeitoun, M., Goulden, M. & Tickner, D. (2013) Current and future challenges facing transboundary river basin management. ***Wiley Interdisciplinary Reviews: Climate change.*** 4, (5) 331-349.

Zischg, A. P., Hofer, P., Mosimann, M., Rothlisberger, V., Ramirez, J. A., Keiler, M. & Weingartner, R. (2018) Flood risk (d)evolution: Disentangling key drivers of flood risk change with a retro-model experiment. ***Science of the Total Environment.*** 639, 195-207.