Lund University
Department of Political Science

STVM23
Tutor: Rikard Bengtsson

Water Crisis Risk and the EU

A Quantitative Analysis of Global Water Crisis Risk and an Assessment of its Implications for EU Water Management Policy

Joe-Philipp Kassem

Abstract

Water is arguably the world's most valuable endangered resource, the management of which has been subject of contentious debate that in recent years has gained growing political, economic and media attention. This study intends to make use of that momentum by constructing a framework for quantifying global water crisis risk that is applied to assess both the EU's share of such risk and the success of EU water management policy in reducing it. Subsequently, high-risk areas in the EU are identified and policy suggestions for reducing their water crisis risk are provided. Finally, the insights from the previous steps are considered to discuss and provide a central reformulation of EU water management policy. The research design employs a statistical analysis to (1) quantify global water crisis risk, (2) assess the overlap between EU water crisis risk and EU water management policy implementation and (3) identify high-risk EU areas. The results indicate that: the EU holds a large share of global water crisis risk, there is considerable overlap between EU water crisis risk and EU water management policy implementation, and the high-risk EU areas face systematically different water crisis risk scenarios contingent upon their geographic location.

Keywords: *Water crisis risk, EU water management policy, Water Framework Directive (WFD), "Good status" goal, Water footprint*

Word count: 19794

List of Abbreviations

CV – Coefficient of Variation
EEA – European Environment Agency
EU – European Union
GRPS – Global Risk Perception Survey
OECD – Organisation for Economic Co-operation and Development
PoM – Programme of Measures
SD – Standard Deviation
SIWI – The Stockholm International Water Institute
UNFCCC - United Nations Framework Convention on Climate Change
USA – United States of America
WDI – World Development Indicators
WEF – World Economic Forum
WFD – Water Framework Directive
WHO – World Health Organisation
WISE – The Water Information System for Europe
WRI – World Resources Institute
WWC – World Water Council

Table of Contents

List of Tables and Figures

Tables

Figures

1 Introduction

“The principle of all things is water”, said the philosopher Tales of Miletus in approximately 590 BC (Abé et. al 2015, 9). Thousands of years later, in the cosy Swiss city of Davos Klosters, global leaders agreed that out of all thinkable risk scenarios that the world was currently facing, “water crises” (i.e. “a significant decline in the available quantity or quality of freshwater resulting in harmful effects on human health and/or economic activity”) would, if materialised, have the highest negative impact on our planet (WEF 2015a, 54). Yet, they somewhat reassuringly added, this was unlikely to happen any time sooner than within the next ten years and thus it appeared as though the world hat dodged a bullet (WEF 2015a, 14f.). However, as the year 2015 unfolded, a seemingly global decline in the available quantity and quality of freshwater gained worldwide political, economic and media attention: in Brazil, the pollution of the Rio Tietê sparked a long overdue debate on the country’s declining freshwater reserves and in California, a record drought threatened the world’s largest fruit and vegetable garden thus causing unprecedented price shocks across the globe. Moreover, in Spain, a water scarce country that exports the majority of its processed freshwater through water intense products such as strawberries, illegal water drilling skyrocketed. Finally, in Israel, the first active reversed osmosis water plant went into operation and thus, a small desert state gave the world further evidence that it considered access to water an imperative part of its raison d’état (Abé et. al 2015). However, as dramatic as these events and their subsequent media coverage may have been, they did not evoke any united response from global leaders. Instead, they fumbled for a common approach within the institutional contexts of the United Nations Framework Convention on Climate Change (UNFCCC), the Organisation for Economic Co-operation and Development (OECD), the World Economic Forum (WEF), the Stockholm International Water Institute (SIWI) and the World Water Council (WWC). Yet, the only tangible message that these forums seemed to repeatedly convey was that “business as usual” was no longer feasible (LPAA 2015, OECD 2012, 2012a, SIWI 2015, UN-Water 2014, WEF 2009, 2010, 2011, 2012a, 2015, SIWI 2015a, 2015b, Winpenny 2003, WWC 2015a, 2015b, 2015c). In fact, it seemed as though the world was experiencing an “invisible water crisis” that, although devastating if it were to materialise, was so diffuse that it was likely to continue, with responses occurring on an ad-hoc basis in reaction to events (WEF 2011, 180). More than that, it seemed as though not only politicians but also scientist failed to find any common ground in terms of addressing the unfolding global water crisis: some argued that water scarcity should be considered the “main causal model for a wide range of problems” whereas others identified an “understanding of the physical nature” of water as the only prudent basis for research in the field (Crow and Eckstein 2014, 774f.). Furthermore, even researchers within the respective approaches disagreed on how to accurately quantify water vulnerability, and thus “[n]o convergence towards common language, ideas, or metrics on freshwater resource sustainability has yet emerged ... that could help prioritize research questions, collate findings, or standardize metrics” (Srinivasan et. al 2012, 2). In sum, whereas the world agreed that water crises were posing a tangible risk, it agreed on little else. Most importantly, it did not agree on how to assess the probability or risk of such crises and thus, little was done to reduce their likeliness.

In the light of the above, this study aims to do three things: First, it establishes and applies a framework for quantifying global water crisis risk according to the WEF's definition of a "water crisis" (2015a, 54). From this, the share of such risk that originates within the European Union (EU) is identified and its level relative to that of global water crisis risk is assessed. Second, it conducts an EU wide assessment of the overlap between water crisis risk levels and EU water management policy implementation. Third, it identifies those areas within the EU for which water crisis risk levels are currently peaking and suggests policy approaches through which such risk can effectively be reduced. In addition to these aims, the results of this study are considered to discuss a reform of EU water management policy that will improve its ability to effectively reduce water crisis risk.

1.1 Structure of this Study

This investigation proceeds as follows: Chapter 2 provides the three research questions of this study that respectively correspond to the three aims presented in the previous section. Chapter 3 provides the methodology and research design of this study. The latter is split into three subchapters, one for each research question. Chapters 4, 5, and 6 respectively present the parts of the analysis and results that correspond to the three research questions of this study. Finally, Chapter 7 offers the conclusions drawn from the analysis and results of this study and, on that basis, suggests a reform of EU water management policy.

2 Research Questions

This chapter establishes the three research questions of this study and, for this purpose, proceeds in two steps: First, the three previously defined aims of this study are concretised so that their corresponding problem formulations are clearly defined. Second, given such concretisations, three research questions are formulated to respectively reflect the three aims. As a part of the second step, a comprehensive presentation of the geographic areas over which these research questions will be applied is provided.

2.1 From Aim to Research Question

The following paragraphs illustrate how the three aims of this study are transformed into concrete and clearly delimited problem areas that allow the formulation of three narrow research questions. The motivation for this approach, which combines broadly defined aims and narrowly defined research questions, follows this study's aspiration to produce sharp results that provide implications on a universal level (i.e. it is important that the analysis reflects the great complexity and statistical nature of water crisis risk assessment whereas it is equally important that its results easily can be placed into a larger context). Moreover, this approach helps to evade the problem, common in the field of water crisis risk assessment, of research questions that are either too general or too narrow to produce any comprehensive and easily accessible results (Sullivan 2011, 627ff.). Although some aspects of this study's research design out of necessity are addressed below, the reader is asked to bear with any temporary confusion that this produces. A full account of this study's research design is provided in the following chapter.

The first aim of this study underlines the necessity of establishing a framework that quantifies global water crisis risk on the basis of the WEF's definition of a "water crisis" (2015a, 54). Furthermore, this framework must enable a consideration of the EU's share of such risk in a way that allows it to be compared to its global counterpart. Thus, the first research question must depart from a quantification of the WEF's definition of water crises that, using a suitable unit of investigation (i.e. one that represents geographic areas), allows the construction of a source of information on which the following research questions and subsequently this entire study may be built. Essentially, the first research question must rest on the basis of a theoretically sound operationalisation of the WEF's definition of water crises.

The second aim of this study reflects the task of assessing how the distribution of water crisis risk within the EU overlaps with the implementation of EU water management policy. Essentially, this aim crystallises into a research question that must perform the dual task of both identifying a single measurable EU water management policy and, conducting a meaningful comparison of water crisis risk levels between areas where that policy has been implemented and areas where that policy has not been implemented. As is explained at length in Chapter 3 (research design), the chosen policy is the Water Framework Directive (WFD) "good status" goal (Directive 2000/60/EC §4).

The third aim of this study encompasses the identification of areas within the EU that represent the highest values among the previously established water crisis risk levels and the construction of a system by virtue of which policy suggestions for the reduction of such risk may be provided. Essentially, the third research question must include both a system for identifying the relevant high-risk EU areas and a theoretically reasoned mechanism for assigning these river basins a standardised policy approach for reducing water crisis risk. The mechanics of both these steps are provided in Chapter 3 (research design).

2.2 The Research Questions

Most questions consist of a "what" and a "where". For example, asking "how warm is it today" implies both a sense of an object of interest (temperature) and the delimitation of an area of relevance (i.e. a particular city or region). The research questions of this study are no different in this respect. Whereas the "what" element is water crisis risk, the "where" element, which is explicitly addressed here, is a number of sets of river basins (individual river basins are the unit of investigation and each set holds a particular combination of such units). These sets are all derived from the initial group of the world's 100 most populous river basins which, given the WEF's definition of a "water crisis", are those areas in the world in which such crises are likely to produce the most highly amplified harmful effects on "human health" and "economic activity" (2015a, 54). The sets of river basins are presented in Table 1: Set A and set B, both of which are considered by the first research question, respectively hold the world's 100 most populous river basins and, out of these river basins, those that are located within EU territory (set B is a strict subset of set A). Set C and set D, considered by the second research question, respectively hold those EU river basins that have implemented the WFD "good status" goal (set C is a subset of set B), and those that have not (set D is another subset of set B). Finally, set E, considered by the third research question, is established from the results produced by this study and holds those EU river basins that face the highest levels of water crisis risk (set E is a strict subset of set B).

Table 1: The sets of river basins considered by this study.

Set	**River basins**	**Relation**
Set A	World's 100 most populous river basins	
Set B	EU river basins	$B \subset A$
Set C	EU river basins – WFD "good status" goal is implemented	$C \subseteq B$
Set D	EU river basins – WFD "good status" goal is not implemented	$D \subseteq B$
Set E	EU river basins with the highest water crisis risk levels	$E \subset B$

Research Questions

1. How is the risk of water crisis, as defined by the WEF, distributed between the world's 100 most populous river basins (set A) and how does the average level of this risk in EU river basins (set B) compare to its global counterpart?

2. How is the risk of water crisis that is facing EU river basins distributed between such basins that have implement the WFD “good status” goal (set C) and such that have not (set D)?
3. Which EU river basins are facing the highest levels of water crisis risk (set E) and which policy approach is best suited to reduce such risk for each river basin individually?

3 Methodology and Research Design

The purpose of this chapter is to present this study's methodology and research design. Whereas the applied methodology reflects the general framework within which this investigation is best conducted, the applied research design represents the way in which the methodology is applied specifically to the research questions of this study. Below, this chapter presents: (1) the methodology as the most feasible framework for research in the field of this study and, (2) the research design as the blueprint for this investigation, constructed to allow a scientifically structured inquiry (i.e. it is what puts the science into political science).

3.1 Methodology

The following discussion of methodology is not intended to spark an independent all-encompassing debate on the general pros and cons of a particular mode of conducting an investigation in the field of political science. Instead, it serves two distinct purposes: First, it illustrates the conscious choices that have been made in the adoption of this particular study's methodological outlook. Second, it presents the results of those choices in the form of a detailed account of this study's methodological approach.

The methodology of this study is best though of as a framework that must provide a means of formulating and conducting a theory based quantitative analysis of global water crisis risk and, in turn, enable an assessment of its subsequent implications for EU water management policy. Thus, the methodological choices that this study is confronted with all ultimately reflect the identification of elements with which such a framework may be constructed in the most suitable way. Essentially, these choices consist of the questions of (1) how a particular theoretical understanding of water crisis risk may best be perceived on a global level and (2) how such an understanding may produce tangible insights or lessons for current water management policy. As follows from the presentation of this study's methodology that is provided below, the answer to these questions suggest a quantitative analysis that, following its theoretical basis, can produce systematic lessons for EU water management policy, as the most feasible way for conducting this investigation.

This study has a certain way of "doing" political science (Landman 2004, xix). Its methodology follows the fundamental objective that, more than just providing "information and evidence", this study must develop "methods and approaches which enable a clear understanding and indeed visualizations of relevant conditions" (Sullivan 2011, 629). In this light, the methodology's two key components are the development of theory (to create a framework that quantifies global water crisis risk) and the quantitative application of such theory for a number of distinct purposes (to create a statistical analysis of global water crisis risk and to use it to answer the research questions). Thus, this study's methodology essentially reflects the ambition of gathering quantitative information on a global level and, through the specific means provided by the research questions, to highlight policy implications that this information suggests on a river basin level (c.f. Esaiasson et. al 2007, 148ff.). In other words, the methodology is the guideline that turns this study into a tool for compiling a "basis of empirical information about the world" that is needed to produce, through the research questions, the desired insights beyond the mere results of the analysis (King et. al 1994, 7).

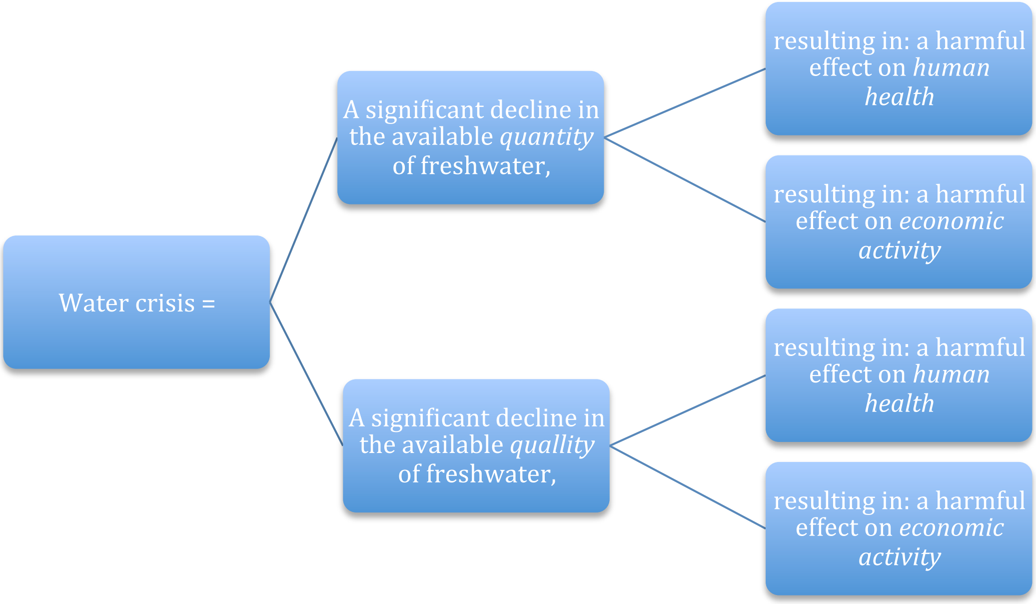
3.2 Research Design

This subchapter provides an account of how the previously considered methodology is applied to the three research questions of this study. Subsequently, the mechanics of the following analysis (chapters 4,5 and 6) are presented for each research question individually. It may however be fruitful for the reader to consider, prior to engaging with the presentation below, the fact that this investigation's primary link to existing research is found in its use of existing theoretical frameworks for the quantification of the WEF's definition of water crisis (chapter 3.2.1 below). It is rather the combined use of these frameworks and its application for informing EU water management policy that holds novelty value.

3.2.1 Quantifying the WEF's Definition of Water Crisis

To answer the first research question, this study must establish a quantifiable version of the WEF's definition of water crisis, that is: "A significant decline in the available quality and quantity of freshwater resulting in harmful effects on human health and/or economic activity" (WEF 2015a, 54). To do this, the parts of this definition that refer to measurable phenomena must be isolated. Then, these must be arranged according to the definition's internal order in a way that produces a structure that is useful for analysis (Figure 1).

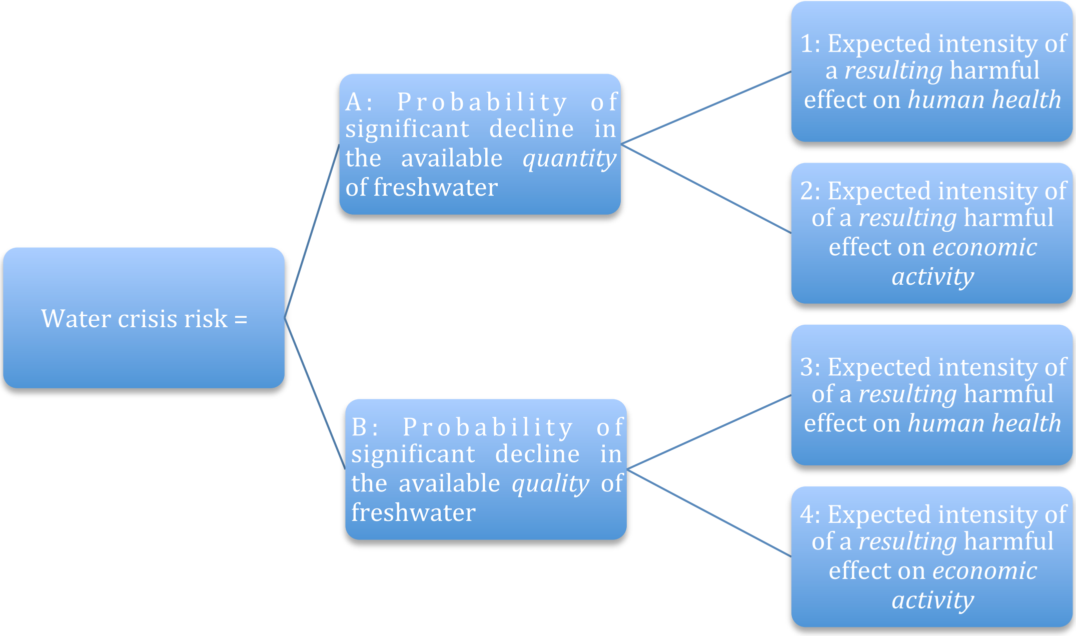
Figure 1: The WEF's definition of water crisis



Moving from left to right in the figure above, it is shown that water crisis (represented in its entirety by the first box) is an outcome that may be caused by four individual combinations of events. First (as represented by the next two boxes), a necessary precondition for a water crisis is either "a significant decline in the available quantity of freshwater" or "a significant decline in the available quality of freshwater". Second (as represented by the final four boxes), such a significant decline must result in either "a harmful effect on human health" or "a harmful effect on economic activity" in order for a water crisis to occur. Thus, water crisis is essentially an outcome that can be caused by four individual developments that are representative of four distinct characters of water crisis: The first combines "a significant decline in the available quantity of freshwater" with a "resulting harmful effect on human health". The second holds "a significant decline in the available quantity of freshwater" and a "resulting harmful effect on economic activity". The third combines "a significant decline in the available quality of freshwater" with a "resulting harmful effect on human health". Finally, the fourth holds "a significant decline in the available quality of freshwater" and a "resulting harmful effect on economic activity".

The above presents a first step towards the assessment of whether or not any given river basin is currently experiencing a water crisis pursuant to the WEF's definition. Yet, as this study is aspiring to measure the probability (i.e. risk) of such crises' occurrence, it is important to address how this framework may be quantified. This step, as illustrated below, is essentially concerned with the construction of a probability measure for all previously established elements of the WEF's definition of water crisis (Figure 2).

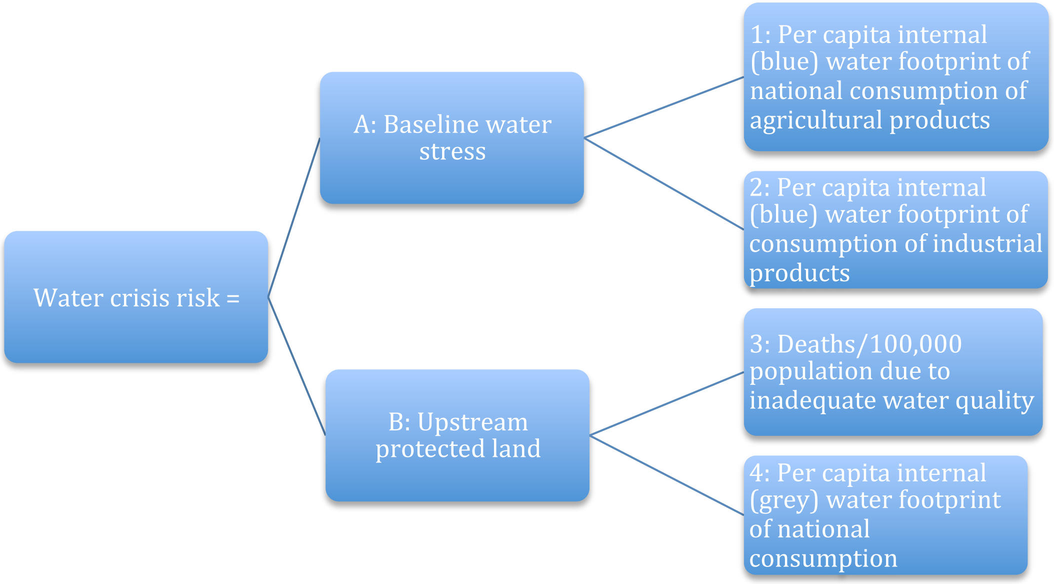
Figure 2: The WEF's definition of water crisis quantified (non-operationalised)



Moving from left to right in the figure above, the first box represents the measure of water crisis risk in its entirety. The next two boxes represent an assessment of how likely "a significant decline in the available quantity of freshwater" or "a significant decline in the available quality of freshwater" is to occur. Finally, given that such a decline materialises, the following four boxes represent an assessment of how intense the resulting "harmful effect on human health" or "harmful effect on economic activity" will be. It is important to note that water crisis risk assessment, following the structure provided above, is a consideration of both the probability of a significant decline and the expected intensity of a resulting harmful effect. Thus, for each of the previously identified four characters of water crisis, the assessment of water crisis risk pursuant to the WEF's definition must consider (1) how likely the relevant significant decline is to materialise, and (2) if it should materialise, how intense the relevant resulting harmful effect is likely to be.

The above however merely provides an "empty" probability measures that must be operationalised in order to actually provide a means of measuring the risk of water crisis on a river basin level. These operationalisations are illustrated below (Figure 3). Subsequently, in the following two subchapters, these operationalisations are in turn presented and motivated. Finally, in a third subchapter, the final statistical form of this study's analysis of global water crisis risk is provided and it is thereby shown how river basins' specific water crisis risk levels are assessed for each of the four characters of water crisis.

Figure 3: The WEF's definition of water crisis quantified (operationalised)



Significant Declines – Baseline Water Stress and Upstream Protected Land

To operationalise the individual probabilities of a significant decline in the quantity or quality of available freshwater, this study uses the World Resources Institute's (WRI) datasets of "baseline water stress" and "upstream protected land" respectively (Figure 3: box A and B respectively). These are constructed and compiled on a river basin level as part of the WRI's Aqueduct Water Risk Atlas project (Gassert et. al 2013). In the following two paragraphs, these operationalisations are presented and motivated.

The baseline water stress dataset offers a suitable measure of the probability, for any given river basin, of a significant decline in the available quantity of freshwater. It measures the degree of competition for surface water among water users by considering the "total annual withdrawals ... expressed as a percent of the total annual available flow" and is calculated by dividing the 2010 water withdrawals (agricultural and industrial respectively), on a river basin level, with the mean available blue water in that river basin from 1950 to 2008 (Gassert et. al 2013, 8). The scores that this produces are continuous between zero and five (where five indicates the highest possible percentage of withdrawals out of the available water flow). In essence, the baseline water stress dataset provides a way of indicating overuse that, in itself, is a major contributor towards a potential significant decline in the available quantity of freshwater (Gassert et. al 2013, 8). Thus, this dataset represents a useful operationalisation of the probability of a significant decline in the available quantity of freshwater. Finally, it should be noted that the baseline water stress dataset's agricultural and industrial values are both used in this study: the former in connection to a resulting harmful effect on human health (Figure 3: box 1) and the latter in connection to a resulting harmful effect on economic activity (Figure 3: box 2). The logic behind this is explained in the following subchapter that considers the harmful effects.

The upstream protected land dataset provides a suitable measure of the probability of a significant decline in the available quality of freshwater because it considers "the percentage of total water supply that originates from protected ecosystems" (Gassert et. al 2013, 16). It is calculated as the percentage of a river basin's total blue water that originates in protected areas and effectively measures "the health of freshwater ecosystems" (Gassert et. al 2013, 16). Thus, functioning as an indicator of severe downstream impacts, this dataset can be used for the interpretation of the probability of a significant decline in the available quality of freshwater (c.f. Gassert et. al 2013, 16). It is expressed as a discrete variable that can assume the value of any integer between zero and five (where five equals the lowest possible percentage of surface water originating from protected areas).

Harmful Effects – Food Crisis, Decline of Industrial Production, Spread of Infectious Disease and Major Biodiversity Loss

To operationalise the individual intensity measures of the resulting harmful effects on human health and economic activity respectively (Figure 3: boxes 1-4), this study uses four datasets that have been selected according to the following three conditions (as is individually shown in the subsequent paragraphs): First, all operationalisations of resulting harmful effects measure the intensity of an underlying phenomenon that is indeed harmful to either human health or economic activity (these phenomena are food crisis, decline of industrial production, spread of infectious disease and major biodiversity loss). Second, all such phenomena are likely to be produced by a significant decline in either available quantity or quality of freshwater. Finally, to avoid random selection among the many potential operationalisations that fulfil the first two requirements, all operationalisations refer to phenomena that have been identified as "interconnected" to the risk of water crisis by the WEF's Global Risk Perception Survey (GRPS) (WEF 2015a, 3). In the following paragraphs, each operationalisation is presented and motivated.

The dataset of "internal (blue) water footprint of consumption of agricultural products" (Figure 3: box 1), compiled by Mekonnen and Hoekstra, provides a suitable measure of the expected intensity, given a significant decline in the available quantity of freshwater, of a resulting harmful effect on human health (2011a). It measures countries' dependence on domestic water sources for the production of food for their national population and thus allows an assessment of how intense, given a materialised significant decline in the available quantity of freshwater, a "food crisis" is likely to be (c.f. Mekonnen and Hoekstra 2011, 11f.). A food crisis constitutes an intuitive harmful effect on human health as "[a]ccess to appropriate quantities and quality of food and nutrition becomes inadequate, unaffordable or unreliable on a major scale" (WEF 2015a, 54). Such a scenario has been identified as "interconnected" to the risk of water crisis by the WEF GRPS (WEF 2015a, 4). However, this dataset (as any water footprint raw data) provides only an absolute account of the amount of domestic water that countries use to feed their population (i.e. it provides a country's total water footprint for that particular purpose). Naturally, this says little about the sustainability of a particular size of water footprint (Hoekstra et. al 2011, 3). To overcome this obstacle, this study modifies the Mekonnen and Hoekstra dataset into per capita form. Thus, it becomes possible to compare the expected intensities of potential food crises that river basins of particular countries, in the event of a significant decline in the available quantity of freshwater, are likely to experience. This per capita transformation is constructed by dividing the country specific internal water footprints with the 2015 global population data from the World Bank's World Development Indicators (WDI) (World Bank 2016). The same transformation has been applied to the two following water footprint datasets that are considered by this study.

The dataset of per capita "internal (blue) water footprint of consumption of industrial products" (Figure 3: box 2), compiled by Mekonnen and Hoekstra, provides a suitable measure of the expected intensity, given a significant decline in the available quantity of freshwater, of a harmful effect on economic activity (2011a). This dataset measures countries' dependence on domestic water sources for the production of industrial products that are consumed by their national population. Thus, it allows an assessment of how intense, provided a significant decline in the available quantity of freshwater, a decline of industrial production is likely to be (c.f. Mekonnen and Hoekstra 2011, 11f.). A decline of industrial production is an obvious harmful effect on economic activity because a large share of such activity consists of industrial production. Yet, it is not explicitly mentioned by the WEF GRPS as a risk scenario that is interconnected to that of water crises. However, this study (as its only derogation from the previously identified requirements that operationalisations of harmful effects must meet) proceeds with the use of this particular dataset. This step is motivated by the fact that the GRPS identifies many economic risks as individual subcategories, all of which are considered "interconnected" to the risk scenario of water crisis. Thus, by extension, it is nothing more than a stylistic error to treat a decline of industrial production as interconnected to the risk of water crisis in its own right (c.f. 2015a, 4).

The World Health Organisation's (WHO) dataset on "deaths per 100,000 population due to inadequate water quality" (Figure 3: box 3) provides a suitable measure of the expected intensity, given a significant decline in the available quality of freshwater, of a harmful effect on human health (WHO 2016). For this purpose, the dataset is used as a proxy for assessing countries' resistance to the spread of water related disease. This is possible as the data set, by extension, allows an assessment of how intense, given a significant decline in the available quality of freshwater, a "rapid and massive spread of infectious disease" is likely to be (WEF 2015a, 4). The logic behind this is that countries with a currently high death toll due to inadequate water quality are likely to suffer more from a further decrease of water quality than countries with a currently low death toll. The spread of infectious disease is a harmful effect on human health as “[b]acteria, viruses, parasites or fungi cause uncontrolled spread of infectious disease leading to widespread fatalities” (ibid.). Furthermore, such a spread of infectious disease is, by the WEF GRPS, deemed “interconnected” to the risk scenario of water crisis (2015a, 4). The causal mechanism between a significant decline in the available quality of freshwater and the spread of infectious disease is the simple fact that water quality is a determinant of water-related disease (WHO 2016). Finally, this dataset only considers low and medium income countries, which generally are the only countries for which water quality related disease poses a considerable problem (WHO 2016).

The dataset of per capita “internal (grey) water footprint of national consumption” (Figure 3: box 4), that is compiled by Mekonnen and Hoekstra, provides a suitable measure of the expected intensity, given a significant decline in the available quality of freshwater, of a harmful effect on economic activity (2011a). It measures countries’ relative degree of pollution based on the “volume of freshwater that is required to assimilate the load of pollutants based on existing ambient water quality standards” and thus allows an assessment of how intense, given a significant decline in the available quality of freshwater, a major biodiversity loss is likely to be (c.f. Mekonnen and Hoekstra 2011, 11 and WEF 2015a, 53). The logic behind this approach is that a significant decline in the available quality of freshwater is likely to cause more harm in highly polluted river basins than in non-polluted river basins. A major biodiversity loss is detrimental to economic activity as it causes “[i]rreversible consequences for the environment resulting in severely depleted resources for ... industries” (WEF 2015a, 53). It is causally linked to a significant decline in the available quality of freshwater because good water quality is a precondition for a high level of biodiversity. Finally, a major biodiversity loss has been identified as “interconnected” to the risk scenario of water crisis by the WEF GRPS (2015a, 4).

The Final Form of the Statistical Analysis of Water Crisis Risk Levels

As a final step towards a quantifiable version of the WEF’s definition of water crisis, this subchapter shows how the framework presented above (Figure 3), given the data behind the operationalisations, is turned into a statistical analysis of water crisis risk across the world’s 100 most populous river basins. For this purpose, four statistical relationships are presented (Figure 4), each of which corresponds to one of the four characters of water crisis that previously have been presented. Each of these statistical relationships is illustrated by a scatterplot that, for each character of water crisis respectively, plots the values obtained for the relevant operationalisations (as x and y-variables). Whereas the values, obtained from the assessment of the probability of a significant decline in the available quantity or quality of freshwater, are plotted as y-variables, the values, obtained from the assessment of expected intensity of the resulting harmful effects on human health and economic activity respectively, are plotted as x-variables.

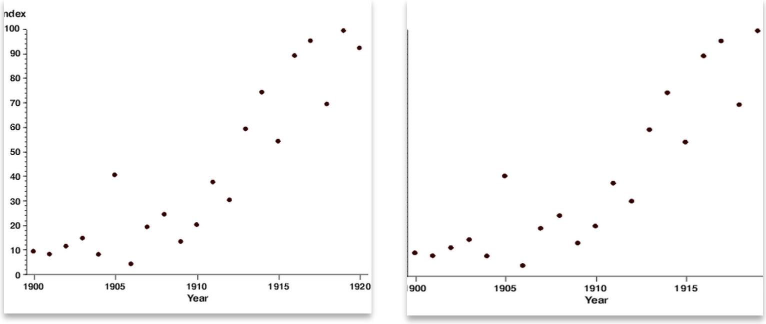
It is important to note that this study proposes no absolute threshold in terms of a coordinate value beyond which, for any given scatterplot, a river basin is considered to suffer from a certain level of water crisis risk. Instead, this study takes a relative approach by which, once all river basins have been plotted in a scatterplot, the relative risk of water crisis between the different river basins can be observed. Then, those river basins that face an above-average value for both variables are thought of as facing a high level of water crisis risk. This approach yet again underlines the fact that only a combined consideration of both variables, for any given scatterplot, reflects the full concept of water crisis risk for a given character of water crisis.

Moreover, this study considers three statistical measures to illustrate, beyond insights gained from the scatterplots, water crisis risk levels for each character of water crisis. These are the mean value of water crisis risk, the standard deviation (SD) of such risk, and the coefficient of variation (CV) of such risk. The CV is a normalised version of standard deviation that allows the comparison of dispersion over sets of different ranges. Finally, each character of water crisis is assessed, given the above, once on a global level and once on a EU level. This provides the basis for the comparison of water crisis risk levels between global and EU river basins. Below, Figure 4 illustrates an exemplification of the final statistical form of the analysis of global water crisis risk that is conducted by this study.

Figure 4: Statistical assessment of the four character of water crisis (C1-C4).

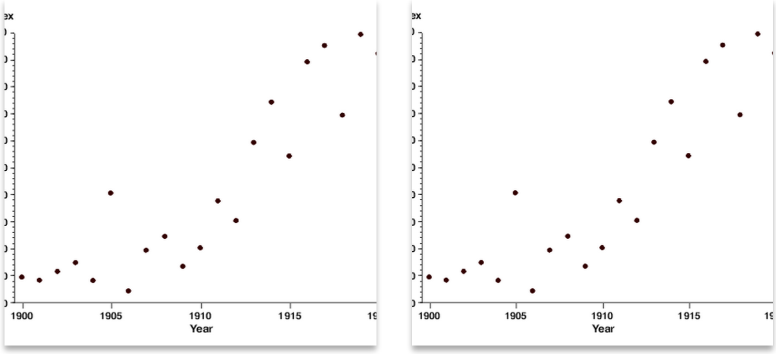
C1- Baseline water stress / internal (blue) water footprint of agricultural production

C2- Baseline water stress/ internal (blue) water footprint of industrial production



C3- Upstram protecet land/ deaths per 100´ due to inadequate water quality

C4- Upstram protected land / internal (grey) water footprint of national consumption



3.2.2 Water Crisis Risk Levels and WFD "Good Status" Goal Implementation

To answer the second research question, this study must develop a way of assessing how water crisis risk that is currently facing EU river basins is distributed between such river basins that have implemented the WFD "good status" goal and such river basins that have not (Directive 2000/60/EC, 4(a)). Given the water crisis risk levels of EU river basins, established in the previous step of this study, this chapter proceeds in three distinct steps to show how such risk overlaps with WFD "good status" goal implementation: First, an assessment of WFD "good status" goal implementation across EU river basins is conducted. Second, water crisis risk levels are considered, for each character of water crisis individually, for both those river basins that have implemented the WFD "good status" goal and those river basins that have not. Third, the pattern that emerges from the established distribution of water crisis risk and WFD "good status" goal implementation is interpreted. Whereas these steps are addressed respectively in subchapter two, three and four, the first subchapter provides an account of why the WFD's "good status" goal should even be considered as part of an analysis of water crisis risk in the EU. It thus provides an account of the WFD "good status" goal's nature and motivates as well as explains its central position in this study.

The WFD "Good Status" Goal

The WFD is a very comprehensive policy that essentially reflects the belief that "water is not a commercial product like any other" but rather "a heritage which must be protected, defended and treated as such" (Directive 2000/60/EC, L327/1). Among its many tools for turning this ambition into tangible actions is the "good status" goal. Having passed implementation deadline for all EU river basins in late 2015, this quality benchmark has both an ecological and a chemical definition, and is applied with varying implications over surface waters, groundwater and protected areas (Directive 2000/60/EC, §4 and European Commission Publications Office 2010, 2). This study focuses on the ecological "good status" goal for surface waters (which hereafter is referred to simply as the WFD "good status" goal) that was established to "prevent the deterioration of the status of all bodies of surface water" with the "aim of achieving good ecological potential" (Directive 2000/60/EC, 4(a)(iii)). The central reason for including the WFD "good status" goal in this study is that it essentially is a policy that seeks to reduce the likeliness of exactly those developments that the WEF defines as a "water crisis" (c.f. Directive 2000/60/EC, §4(a) and WEF 2015a, 54). The connection between the WFD "good status" goal and the WEF's definition of water crises becomes abundantly clear when considering the overlap between the WFD's "Programme of Measures" (PoM) (i.e. actions to meet predefined results that Member States' implementation of the WFD must produce) and the WEF's definition of water crisis: First, the WFD "good status" goal PoM measure for control of water abstraction matches the notion of reducing the risk of a significant decline in the available quantity of freshwater (c.f Directive 2000/60/EC, §11(e) and WEF 2015a, 54). Second, the WFD "good status" goal PoM measure for promoting sustainable water use matches the aim of reducing the risk of a significant decline in the available quality of freshwater (c.f Directive 2000/60/EC, §11(c) and WEF 2015a, 54).

Subsequently, it is reasonable to expect that, for any given EU river basin, the level of water crisis risk implies something about the degree of WFD "good status" goal implementation. Formalising this notion, two hypotheses are formulated to guide this study: (H1) EU river basins for which the WFD "good status" goal has been implemented are likely to show a lower average water crisis risk level than river basins for which the WFD "good status" goal has not been implemented, and (H2) EU river basins for which the WFD "good status" goal has been implemented are likely to show a higher average water crisis risk level than river basins for which the WFD "good status" goal has not been implemented. The first hypothesis focuses on the WFD "good status" goal's aim to reduce water crisis risk, assuming that implementation is likely to overlap with low levels of risk. The second hypothesis departs from the notion that the WFD "good status" goal has been strategically implemented, in a more or less objectively accurate fashion, on the basis of Member States' prioritisation of water management policy.

Measuring Implementation

Pursuant to the WFD, EU Member States have to provide reports on their overall implementation progress to The Water Information System for Europe (WISE) that is run as a partnership between the European Commission and the European Environmental Agency (EEA) (EEA 2012, 16). The prescribed content and structure of such reports is outlined in the "WFD Reporting Guidance", the main function of which is to "provide Member States with guidance on how the various aspects of the WFD should be reported to the European Commission" (WFD Reporting Guidance 2015, 8). Among other things, these reports provide data on the implementation progress of the WFD "good status" goal that is monitored according to a classification scheme for surface water that includes five categories: high, good, moderate, poor and bad (EEA 2012a). High status means "no or very low human pressure", good status means "a slight deviation from this status", moderate status means "a moderate deviation from this status, and so on (European Commission Publications Office 2010, 2). Given this classification scheme, a river basin has implemented the WFD "good status" goal when 100% of its surface water holds an at least good status (i.e. good or high status)(ibid.).

The primary notion of this study is that the assessment of EU river basins' implementation progress should be conducted on the basis of a division of such river basins into groups: one for those that have implemented the WFD "good status" goal and one for those that have not. However, given the implementation criterion that 100% of a river basin's surface water need to be of at least "good status", this exercise proves little useful due to EU river basins' generally poor record of implementation (EEA 2012a). Thus, for the intents and purposes of this study, any EU river basin for which implementation data shows that (1) at least 50% of its surface water, (2) hold an at least good status, will be considered to have implemented the WFD "good status" goal. Hence, all relevant EU river basins will be divided into either the "Top 50%" group of river basins or the "Bottom 50%" group of river basins, based on their success or failure to implement the WFD "good status" goal. Naturally, using a 50% rather than a 100% threshold is a setback for the intended results of this study. Yet, in the light of the European Commission's prediction that the WFD "good status" goal, by its 2015 deadline, would only be implemented in approximately half of all EU river basins, it rather serves as further evidence of lagging implementation (European Commission 2012, 3). Another drawback for this part of the study is that the data through which WFD "good status" goal implementation is assessed was submitted to the European Commission in 2012. Thus, the initial notion of providing an assessment of WFD "good status" implementation shortly after its 2015 deadline is not achieved (the latest Member State reports have yet to be published by the EEA).

Statistical Insights: Water Crisis Risk Levels and WFD "Good Status" Goal Implementation

Given both the statistical analysis of EU water crisis risk levels (as previously outlined in chapter 3.2.1) and the account of WFD “good status” goal implementation across EU river basins (as provided above), it is possible to analyse the overlap between the two. This is done through a statistical assessment of water crisis risk levels (mean, SD and CV for all four characters of water crisis) that is conducted for both the “Top 50%” and the “Bottom 50%” group of river basins. Most importantly, this identifies the group of river basins that has the higher average level of water crisis risk and thus, it can be assessed which of the two previously provided hypotheses should be accepted.

The process of accepting or rejecting the hypotheses is conducted for each character of water crisis individually. More specifically, each character of water crisis is broken down into its two variables (x and y) and the hypotheses are accepted, on the basis of the corresponding statistical assessment, for each such variable individually. Only if the same hypothesis is accepted for both variables of a particular character of water crisis will that hypothesis be accepted for the entire character of water crisis. Based on this final step, it is shown for each character of water crisis, whether river basins for which the WFD “good status” goal has been implemented face a higher or lower average risk of water crisis than river basins for which the WFD “good status” goal has not been implemented.

Finally, a central issue has to be considered in the light of the statistical assessment outlined above: whereas the data behind the established water crisis risk levels is compiled on the basis of river basins defined by the WRI, the reports on WFD “good status” goal implementation are naturally provided on the basis of river basins that have been defined for the WFD. Yet, matching WRI river basins’ territory, as defined in the WRI’s Aqueduct Water Risk Atlas online tool, with WFD river basins’ territory, as defined in country-specific accompanying documents to the third European Commission report on WFD implementation, shows that these correspond, with only one exception, to exactly the same geographic areas (WRI 2016, European Commission 2012a). Provided this neat fit, water crisis risk levels and WFD “good status” goal implementation can directly be compared for any given river basin. However, to avoid the confusion that likely would result from the use of river basin names provided by either the WRI or WFD, this study assigns new names to all relevant river basins (Appendix E). These names consists of a country code (the country within which the river basins is located) and, if several river basins are located within the same country, a single digit to identify that particular river basin.

Interpreting the pattern

Given the results from the previous steps, this study suggests how the established overlap between average water crisis risk levels and WFD “good status” goal implementation should be interpreted. This is done on the basis of the hypothesis (as established above) that the results of this study support. From this, it is considered whether the results gives rise to any geographic pattern in terms of areas in which an overlap between water crisis risk levels and WFD “good status” goal implementation does or does not exist.

3.2.3 **Critical EU River Basins**

To answer the third research question, this study proceeds in two steps: First, a definition of the highest scoring ("critical") EU river basins in terms of water crisis risk levels is proposed and then applied to identify all such river basins that meet the requirements of this definition. Subsequently, two standardised policy approaches for reducing water crisis risk are established and, one of these, following the governing mechanism described below, is applied to each "critical" river basin. Second, the results of the previous step are illustrated on a map of the EU, providing the geographic distribution of "critical" river basins and their corresponding character of water crisis as well as their suggested policy approach. A detailed account of the mechanics behind both steps is provided in the following two subchapters.

Identifying Critical EU River Basins and Suggesting Policy Approaches

In the light of this study's previous analysis of water crisis risk levels (as outlined in chapter 3.2.1), a "critical" river basin is defined as a river basin that is facing an above-EU-average water crisis risk level for a given character of water crisis. More specifically, any such river basin must show above-EU-average values for both variables (x and y) that have been measured for that particular character of water crisis. Thus, a "critical" river basin is one that faces both an above-EU-average probability of experiencing a significant decline in the available quantity or quality of freshwater and an above-EU-average expected intensity resulting harmful effect on human health or economic activity. Through an application of this definition to the results previously produced from the analysis of water crisis risk levels, a list of all "critical" river basins is presented for each character of water crisis individually.

Subsequently, for each "critical" river basins, one out of two standardised policy approaches for reducing the probability of a water crisis is proposed. These policy approaches represent two distinct considerations: First, concerning "critical" river basins for which the WFD "good status" goal has been implemented (i.e. that belong to the "Top 50%" group of river basins), the scope of the WFD "good status" goal must be expanded in order to further reduce the probability of a significant decline in either quantity or quality of available freshwater. This may be achieved by extending the elements of the WFD "good status" goal that, given a particular character of water crisis, reduce the y-variable value, that is, that decrease either baseline water stress (agricultural or industrial) or increase upstream protected land. This essentially means that, for the first and second character of water crisis, such an extension focuses on the measure, within the WFD "good status" goal PoM, for water abstraction control (Directive 2000/60/EC, §11(e)). Moreover, for the third and fourth character of water crisis, such an extension would focus on the measure, within the PoM, for sustainable water use (Directive 2000/60/EC, §11(c)). Second, concerning "critical" river basins for which the WFD "good status" goal has not been implemented (i.e. that belong to the "Bottom 50%" group of river basins), focus should be given to actually implementing the WFD "good status" goal in order to reduce the probability of a water crisis. Through the application of this governing mechanism, a policy approach that reduces the probability of a water crisis is provided for each "critical" river basin.

Interpreting The Results

To provide an intuitive and accessible interpretation of this chapter's results, all identified "critical" river basins and their corresponding character of water crisis as well as suggested policy approach are plotted on a map of the EU. From this, any systematic geographically determined variation on these two points is illustrated. Furthermore, this allows an assessment of whether the earlier established results concerning the interpretation of the overlap between water crisis risk levels and WFD "good status" goal implementation (as outlined in chapter 3.2.2) remain accurate even when considering "critical" river basins only.

4 Analysis and Results: The Distribution of Water Crisis Risk across Global and EU River Basins

This chapter presents the parts of the analysis and results that are produced by the first research question, that is:

> How is the risk of water crisis, as defined by the WEF, distributed between the world's 100 most populous river basins (set A) and how does the average level of this risk in EU river basins (set B) compare to its global counterpart?

The analysis that answers this question emanates from the application of a quantifiable version of the WEF's definition of water crises, which allows an assessment of water crisis risk levels across the world's 100 most populous river basins. On this basis, structured into the first four subchapters that follow below, the distribution of water crisis risk is individually assessed for each of the four previously established characters of water crisis. Each subchapter consists of the following: First, for the global level, the statistical analysis of water crisis risk levels is presented in a scatterplot and some preliminary interpretations are made based on a visual assessment of clusters and outliers among the river basins. Second, a corresponding table of statistical measures formalises the assessment of mean value coordinates and dispersion along both variables, allowing further interpretations of the established water crisis risk distribution. Third, the first two steps are then repeated on a EU level.

In addition to this, the fifth subchapter that follows below addresses the emerging pattern of differences and similarities in the distribution of water crisis risk, for all four character of water crisis, between global and EU river basins. For this purpose, the by then previously established results of this chapter are plotted against each other. This provides a way of directly comparing global and EU-level water crisis risk levels. Among other things, this step gives the subsequent parts of this study a corresponding sense of urgency as it indicates how much of a "EU problem" global water crisis risk really is.

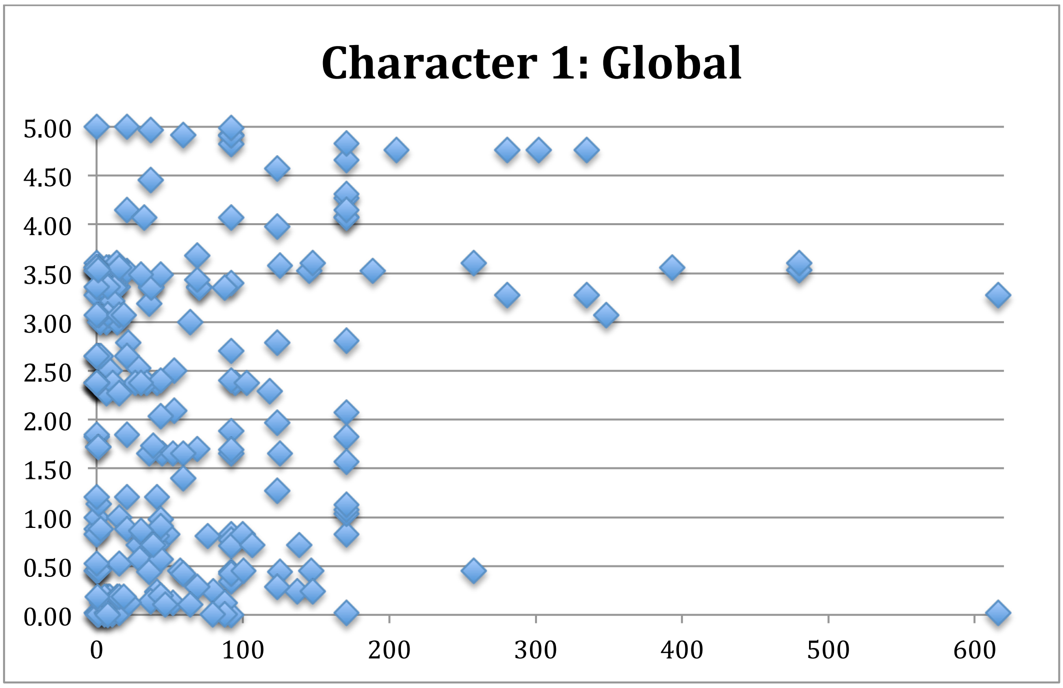
The reader should note that the following logic applies to all scatterplots that are provided in this chapter: First, the higher up a dot is located (y-axis), the higher the probability of a significant decline in the available quantity (or quality) of freshwater in the river basin that it represents. Second, for that river basin, the further to the right the dot that represents it is located (x-axis), the higher the expected intensity, given such a significant decline, of the relevant resulting harmful effect on human health (or economic activity). Thus, combining these two notions, the risk of water crisis is particularly acute for those river basins represented by dots in the top-right quadrant of a scatterplot. Finally, Appendices A-D provide a full list of all raw data, thus allowing the identification of individual river basins in the scatterplots by virtue of their coordinate value.

Furthermore, the following logic applies to all considered statistical measures of water crisis risk that are presented below: First, the average value of the y-variable represents the average statistical probability of a significant decline in the available quantity (C1 and C2) or quality (C3 and C4) of freshwater. Second, the average value of the x-variable represents the average statistically expected intensity, given a corresponding significant decline in the available quantity or quality of freshwater, of a harmful effect on human health (C1 and C3) or economic activity (C2 and C4). For any given character of water crisis, these two values together form the coordinate of average water crisis risk that may be placed in the framework of each corresponding scatterplot. Finally, the measure of dispersion (CV) shows, for all variables of all character of water crisis, the extent to which the recorded average values may be thought of as representative of the actual values recorded for all river basins individually (as seen in the scatterplots).

4.1 The First Character of Water Crisis

This subchapter assesses water crisis risk levels within the first character of water crisis and thus, in the following figures and tables, the levels of agricultural baseline water stress (y-variable) and the per capita internal (blue) water footprint of consumption of agricultural products (x-variable) are considered.

Figure 5: Scatterplot of water crisis risk for Character 1 [Global]



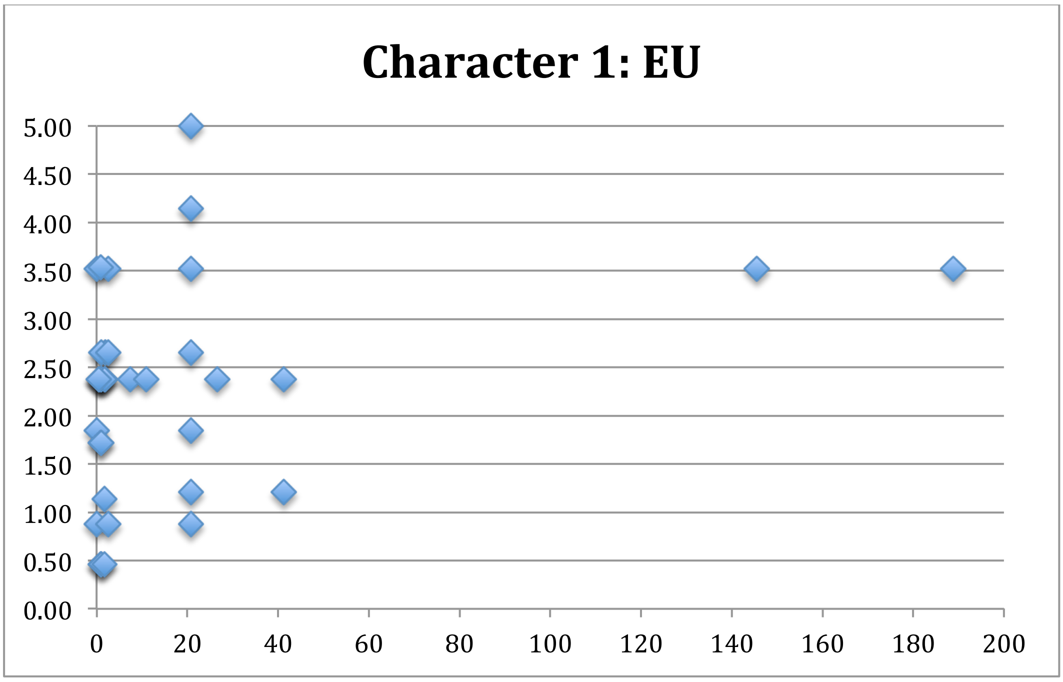
This scatterplot shows two distinct clusters. Located at the approximate coordinates of (0,0.00) and (0,3.25), these highlight the fact that most river basins face an either low or medium probability of a significant decline in the available quantity of freshwater, whereas both of these groups, should such a decline materialise, face a food crisis of relatively low intensity. Moreover, the scatterplot shows that there is a small group of river basins that, in the coordinate-area of (250-600,3.00-5.00), is facing a relatively high probability of a significant decline in the available quantity of freshwater as well as, given that such a decline materialises, a food crisis of relatively high intensity. The most obvious two members of this group are found at coordinates (479.8,3.53) and (479.8,3.60) respectively, representing the Qom (Namak Lake) and Tigris & Euphrates river basins in Iran.

Table 2: Statistical measures for Character 1 [Global]

Measure	**Baseline water stress (agricultural)**	**Per capita internal (blue) water footprint of consumption of agricultural products**
Mean	2,1	66,9
SD	1,4	96,6
CV	68%	144%

The statistical measures show that the coordinate representing the mean level of risk along both axes is found at (66.9,2.1). If placed in the scatterplot as origin of an imagined quadrant grid, all river basins that are located in the bottom-left quadrant from this point hold a below average risk of water crisis (i.e. they hold a below average value along both variables) whereas the opposite is true for those located in the upper-right quadrant. This indicates that the spread of risk among above-average risk river basins is much higher than it is for their below average-risk counterparts (this follows from a purely visual assessment of the scatterplot). Furthermore, for the values along the y-axis, the standard deviation (1,4) from the mean (2,1) produces a coefficient of variation of 68%, meaning that the spread of values along this axis is significantly lower than the spread observed for the x-axis (114%). Naturally, this effect is intensified by a number of high-value outliers on the x-axis, notably the Amudaryo and Hairud river basins in Turkmenistan at coordinates (615,0.02) and (615,3.27) respectively.

Figure 6: Scatterplot of water crisis risk for Character 1 [EU]



This scatterplot shows that the EU distribution of water crisis risk, in resemblance of its global counterpart, shows clusters around coordinates (0,0.75) and (0,2.50). Thus, many EU river basins face an either relatively low or medium probability of experiencing a significant decline in the available quantity of freshwater, whereas both of these groups, should such a decline materialise, face a food crisis of relatively low intensity. However, a number of river basins (range 20-40 on the x-axis), although showing a highly dispersed probability of experiencing a significant decline in the available quantity of freshwater, are facing potential food crises of a higher intensity. Moreover, there are two river basins that face a relatively high probability of a significant decline in the available quantity of freshwater and, provided such a decline, a food crisis of relatively high intensity. These are found at coordinates (145,3.52) and (188,3.52), representing the Tejo river basins in Portugal and Spain respectively.

Table 3: Statistical measures for Character 1 [EU]

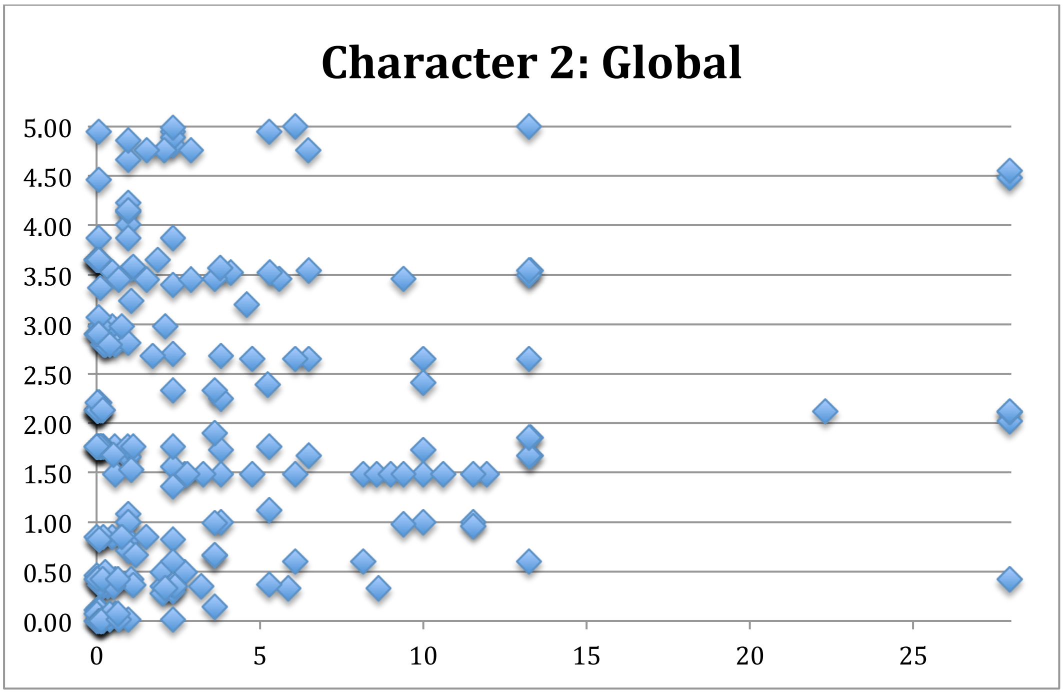
Measure	**Baseline water stress (agricultural)**	**Per capita internal (blue) water footprint of consumption of agricultural products**
Mean	2,2	17,6
SD	1,1	38,9
CV	48%	221%

The statistical measures on a EU level show that the coordinate of average water crisis risk is located at (17.6,2.2). From this point, the quadrant concept again shows that the relative spread of risk among river basins holding an above-average risk level (top-right quadrant) is higher than its equivalent among below-average risk river basins (bottom-left quadrant). Furthermore, for the values along the y-axis, the standard deviation (1,1) from the mean (2,2) produces a coefficient of variation of 48%, meaning that the spread of values along this axis is significantly lower than the spread observed for the x-axis (221%). In this case, this large difference is partially explained by the extreme x-axis values of the Tejo river basins in Portugal (145) and Spain (188).

4.2 The Second Character of Water Crisis

This subchapter assesses water crisis risk levels within the second character of water crisis and thus, in the following figures and tables, the levels of industrial baseline water stress (y-axis) and the per capita internal (blue) water footprint of consumption of industrial products (x-axis) are considered.

Figure 7: Scatterplot of water crisis risk for Character 2 [Global]



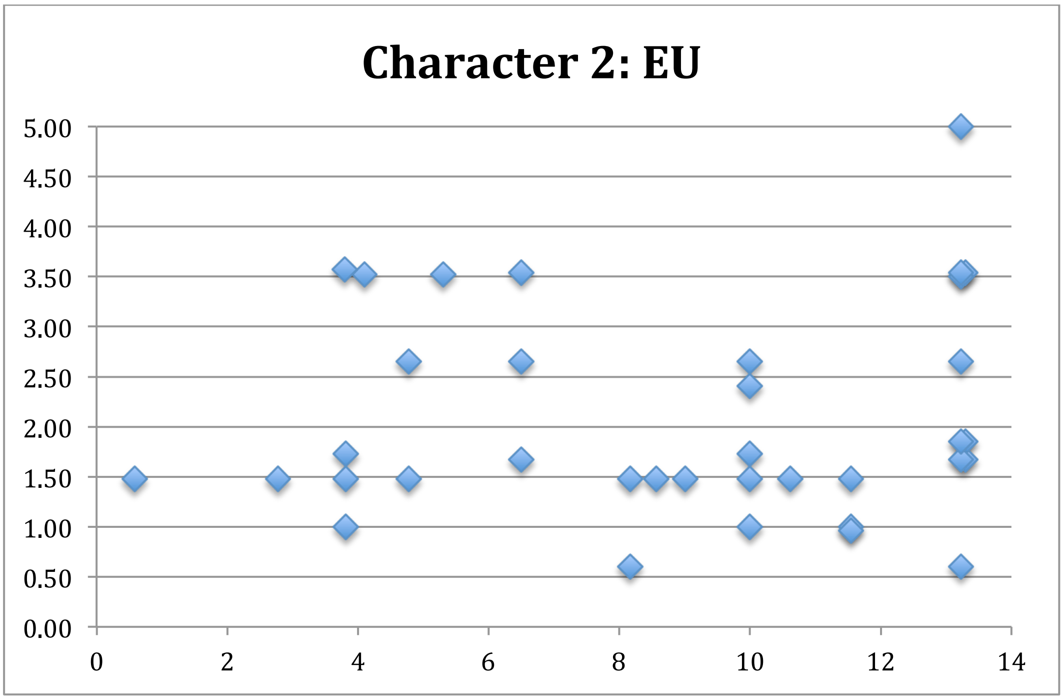
This scatterplot shows two clusters. These are found around the coordinates (0,0.50) and (0,3.00), respectively indicating a relatively low and medium risk of a significant decline in the available quantity of freshwater, in combination with, given that such a decline materialises, a relatively low intensity decline of industrial production. Furthermore, the scatterplot shows that there is a small group of river basins in the approximate coordinate range of (13-28,2.50-5.00) within which river basins are facing a relatively high probability of a significant decline in the available quantity of freshwater as well as, given such a decline, a relatively high intensity decline of industrial production. The two members of this group that stand out the most are, at coordinates (27.96, 4.48) and (27.96, 4.55) respectively, the Columbia River and Delaware River river basins in the United States of America (USA).

Table 4: Statistical measures for Character 2 [Global]

Measures	**Baseline water stress (industrial)**	**Per capita internal (blue) water footprint of consumption of industrial products**
Mean	1,9	3,3
SD	1,4	5,4
CV	72%	166%

The statistical measures above show that the coordinate of average water crisis risk is found at (3.3,1.9). Applying the quadrant concept shows that the dispersion of water crisis risk levels among river basins holding an above-average water crisis risk level is higher than its equivalent among below-average water crisis risk river basins. Furthermore, considering the y-axis, the ratio of the standard deviation (1,9) to the mean (1,4) produces a coefficient of variation of 72% which, in comparison to its counterpart for the x-axis (166%), shows that values are relatively less dispersed around the mean.

Figure 8: Scatterplot of water crisis risk for Character 2 [EU]



This scatterplot shows that the EU distribution of water crisis risk is clustered around three distinct coordinate ranges. Along the x-axis, these are 0-6, 6-12 and 12-14. For these ranges, the probability of a significant decline in the available quantity of freshwater is evenly spread whereas the intensity of a resulting decline of industrial production, depending on which range a particular river basins belongs to (from left to right along the x-axis), is relatively low, medium or high. Finally, the obvious outlier along both axes is found at coordinate (13.23,5.00) that represents the Rhone river basins in France.

Table 5: Statistical measures for Character 2 [EU]

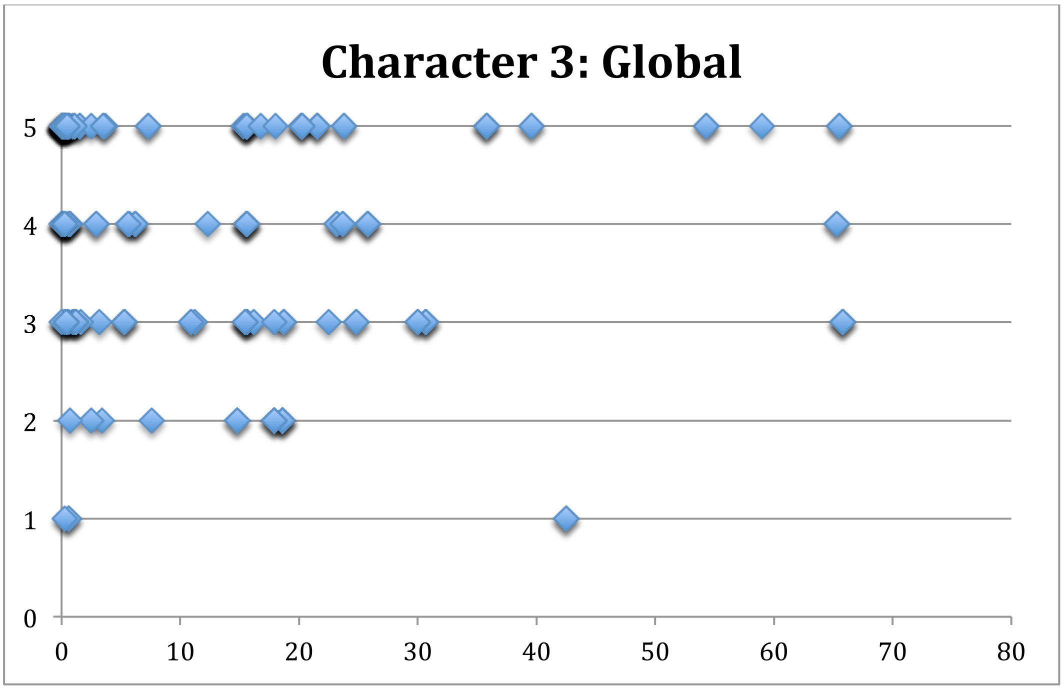
Measures	**Baseline water stress (industrial)**	**Per capita internal (blue) water footprint of consumption of industrial products**
Mean	2,0	8,8
SD	1,0	3,8
CV	50%	43%

The statistical measures on a EU level show that the average value of water crisis risk is found at coordinate (8.8,2.0). From an application of the quadrant concept (top-right quadrant holds above-average risk along both axes and bottom-left quadrant holds the opposite), it can be seen that the dispersion of water crisis risk for below and above average risk river basins respectively is relatively similar. Moreover, for the y-axis, the ratio of standard deviation (1,0) to mean (2,0) produces a coefficient of variation of 50% that, in comparison to its counterpart for the x-axis (43%), is slightly higher. This means that EU river basins are slightly more dispersed in terms of their probability of experiencing a significant decline in the available quantity of freshwater than in terms of their expected intensity, given that such a decline materialises, of an industrial decline.

4.3 The Third Character of Water Crisis

This subchapter assesses water crisis risk levels within the third character of water crisis and thus, in the following figures and tables, the levels of upstream protected land (y-axis) and the deaths per 100 000 population due to inadequate water quality (x-axis) are considered.

Figure 9: Scatterplot of water crisis risk for Character 3 [Global]



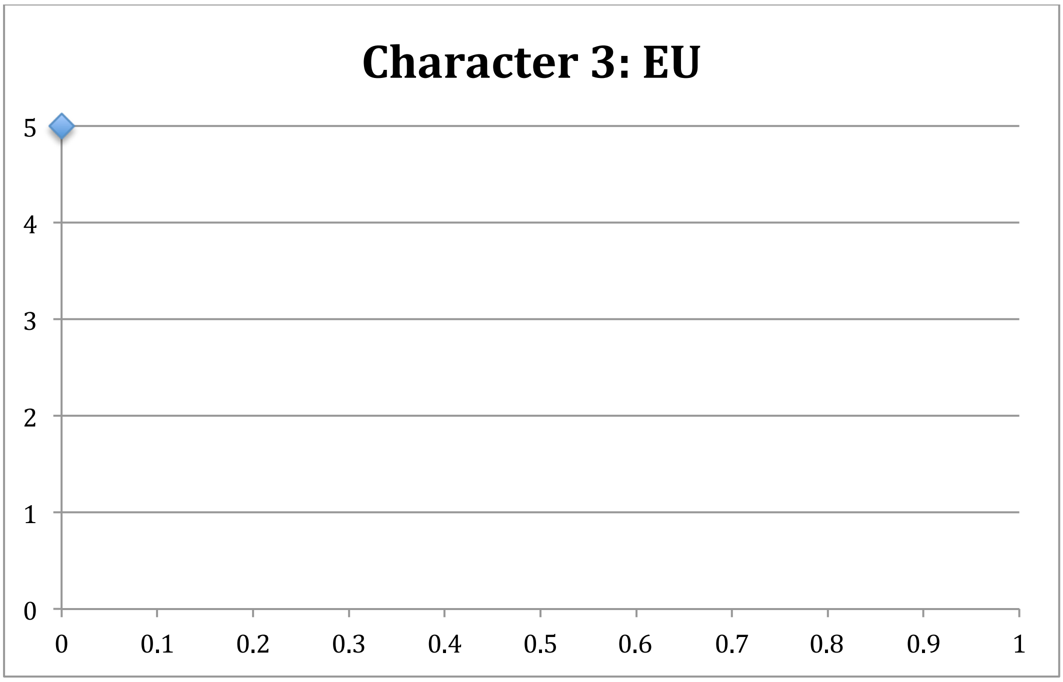
This scatterplot shows a clustering of water crisis risk in river basins that are found towards the upper-left quadrant of the scatterplot. Within the approximate coordinate range (0-30,3-5), these river basins face a relatively high probability of a significant decline in the available quality of freshwater and, given such a decline, a relatively low intensity spread of infectious disease. Furthermore, the scatterplot shows a group of three river basins that each faces both a relatively high probability of experiencing a significant decline in the available quality of freshwater and, given that such a decline materialises, a relatively high intensity spread of infectious disease. These are, at coordinates (54.3,5), (59,5) and (65.5,5) respectively, the Lake Chad (Chad), Shebelle (Somalia) and Congo (Angola) river basins.

Table 6: Statistical measures for Character 3 [Global]

Measures	**Upstream protected land**	**Deaths per 100 000 population due to inadequate water quality**
Mean	3,9	12,4
SD	1,1	3,9
CV	28%	31%

The statistical measures provided above show that the coordinate of average water crisis risk is located at (12.4,3.9). Thus, using the quadrant concept reveals that the spread of risk is considerably higher among the above-average water crisis risk river basins than among their below-average water crisis risk counterparts. Furthermore, the y-axis ratio of standard deviation (1,1) to mean (3,9) produces a coefficient of variation of 28% that, in comparison to its x-axis counterpart (31%), shows that values are almost equally spread along both variables.

Figure 10: Scatterplot of water crisis risk for Character 3 [EU]

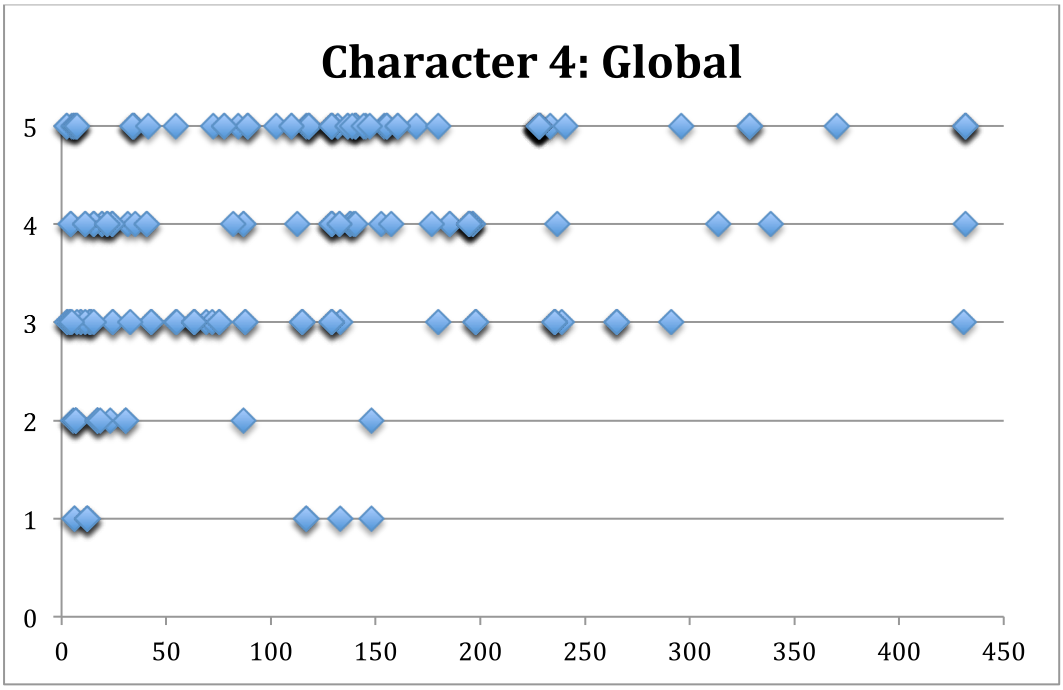


This scatterplot seemingly indicates that water crisis risk within the third character of water crisis virtually does not exist within the EU. However, it rather underlines a lack of data (Romania is the only EU country included in the WHO dataset) than an actual assessment of water crisis risk across the EU (WHO 2016a). Yet, as the recorded water crisis risk level for the Romanian Danube river basin (RO1) shows a minimum value for the expected intensity of the spread of infectious disease (x-axis), it is reasonable to assume that the third character of water crisis is an unlikely risk scenario within the EU. The fact that the WHO dataset only includes countries in which death due to inadequate water quality is a tangible reality further supports this conclusion (ibid.).

4.4 The Fourth Character of Water Crisis

This subchapter assesses water crisis risk levels within the fourth character of water crisis and thus, in the following figures and tables, the levels of upstream protected land (y-axis) and the per capita internal (grey) water footprint of national consumption (x-axis) are considered.

Figure 11: Scatterplot of water crisis risk for Character 4 [Global]



This scatterplot shows a clustering of river basins towards the upper-left quadrant of the scatterplot, indicating that a majority of global river basins hold a relatively high probability of a significant decline in the available quality of freshwater and, given that such a decline materialises, a relatively low intensity biodiversity loss. Furthermore, there is a group of river basins that shows both a relatively high probability of a significant decline in the available quality of freshwater and, should such a decline materialise, a high intensity biodiversity loss. At coordinate (431.88, 5) these are (all plotted at the same value) the Colorado River (Pacific Ocean), Columbia River, Delaware River, Mississippi River, Rio Grande (Bravo) and St. Lawrence river basins in the USA.

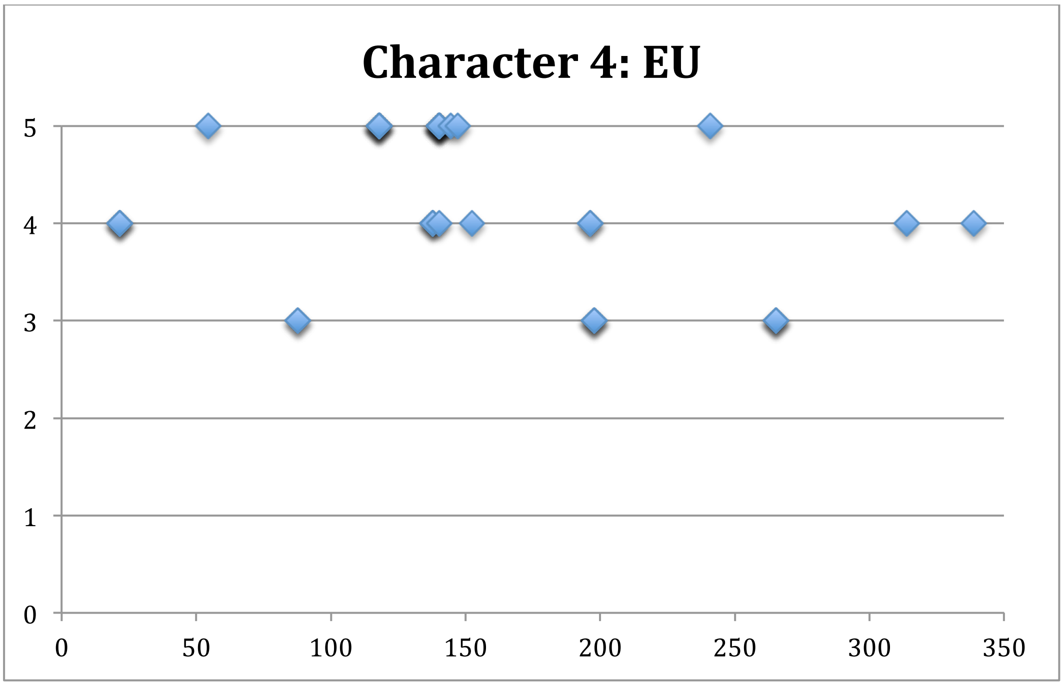
Table 7: Statistical measures for Character 4 [Global]

Measures	**Upstream protected land**	**Per capita internal (grey) water footprint of national consumption**
Mean	3,9	115,3
SD	1,1	103
CV	28%	89%

The statistical measures on a global level show that the coordinate of average water crisis risk is found at (115.3,3.9). Using the quadrant concept reveals that the above-average risk river basins (in the top-right quadrant from the average value) face a higher dispersion of water crisis risk than the below-average risk river basins (bottom-left quadrant from the average value). Furthermore, considering the y-axis, the ratio of the standard deviation (1,1) to the mean (3,9) produces a coefficient of variation of

28% that, in comparison to its counterpart for the x-axis (89%), shows that values along the y-axis are considerably less dispersed than their x-axis counterparts.

Figure 12: Scatterplot of water crisis risk for Character 4 [EU]



This scatterplot shows that the EU distribution of water crisis risk is clustered around the coordinate range (100-200,3-4). This means that EU river basins generally face a relatively high probability of experiencing a significant decline in the available quality of freshwater and, given that such a decline materialises, are likely to experience a biodiversity loss of relatively high intensity. Furthermore, two river basins show a particularly high probability of experiencing a significant decline in the available quality of freshwater and, given such a decline, are likely to experience a relatively high intensity loss of biodiversity. At coordinates (313.88, 4) and (338.85, 4) respectively, these are the Danube river basins in Hungary and Slovenia.

Table 8: Statistical measures for Character 4 [EU]

Measures	**Upstream protected land**	**Per capita internal (grey) water footprint of national consumption**
Mean	4,2	153,9
SD	0,79	73
CV	18%	47%

The statistical measures on a EU level show that the coordinate of average water crisis risk is located at (153.9,4.2). Using the quadrant concept shows that the dispersion of risk among river basins holding an above-average water crisis risk level (top-right quadrant) is much lower than its equivalent among below average-risk river basins (bottom-left quadrant). Moreover, for the y-axis, the ratio of the standard deviation (0,79) to the mean (4,2) produces a coefficient of variation of 17% that, in comparison to its counterpart for the x-axis (47%), indicates a much lower dispersion of values.

4.5 Comparing Global and EU Water Crisis Risk Levels

This subchapter provides a summary of all statistical measures that have been individually considered in the previous steps and, based on this, allows a comparison of how the average level and dispersion of water crisis risk, for each character of water crisis individually, compares between global and EU river basins.

In the following paragraphs, after an introductory presentation and interpretation of the results provided below (Table 9), each character of water crisis is in turn considered. Given that the results for the third character of water crisis (chapter 4.3) allow no such comparison, this particular character of water crisis is not treated here and hence will not be considered in the remainder of this study. Thus, any reference to "the characters of water crisis" will, from this point on, refer only to the first, second and fourth character of water crisis. Finally, in the table provided below, the emboldened figures highlight, for the measure of average water crisis risk within each variable of each character of water crisis respectively, the group of river basins for which the highest value has been established (either global or EU river basins).

Table 9: Comparison of global and EU water crisis risk (C1-C4).

Group	Statistical measure	C1[x]	C1[y]	C2[x]	C2[y]	C3[x]	C3[y]	C4[x]	C4[y]
Global river basins	Mean	**66,9**	2,1	3,3	1,9	12,4	3,9	115,3	3,9
	SD	96,6	1,4	5,4	1,4	3,9	1,1	103	1,1
	CV	144%	68%	166%	72%	31%	28%	89%	28%
EU river basins	Mean	17,6	**2,2**	**8,8**	**2,0**	-	-	**153,9**	**4,2**
	SD	38,9	1,1	3,8	1,0	-	-	73	0,79
	CV	221%	48%	43%	50%	-	-	47%	18%

Table 9 presents a summary of the previously conducted assessment of water crisis risk levels across the world's 100 most populous river basins, the aim of which is to clearly plot such water crisis risk that originates within the EU against its global counterpart. First, the comparison of y-variable values highlights an assessment of whether a significant decline in the available quantity (for C1 and C2) or quality (for C4) of freshwater is statistically more likely to occur in a global or a EU context. Furthermore, the comparison x-variable values highlights an assessment of whether, given the corresponding significant decline in the available quantity or quality of freshwater, the resulting harmful effects on human health (C1) or economic activity (C2 and C4) are statistically likely to be more intense in a global or a EU context. Finally, the measure of dispersion (CV) shows, for all variables of all character of water crisis, the extent to which the average water crisis risk levels considered in the previous two steps can be thought of as representative of the absolute values for each river basins in the global and EU group of river basins respectively. Thus, they provide the comparison of average water crisis risk levels between global and EU river basins with a sense of accuracy.

For the first character of water crisis, Table 9 shows that EU river basins face an only marginally higher probability than global river basins, of experiencing a significant decline in the available quantity of freshwater (C1[y]). It is also shown that the dispersion of such probability is considerably higher for the global group of river basins. Moreover, Table 9 provides that, given a significant decline in the available quantity of freshwater, the average expected intensity of a resulting food crisis is much higher for the global than the EU group of river basins (C1[x]). Yet, for the dispersion of such expected intensity, the opposite is the case.

Considering the second character of water crisis, Table 9 again shows that EU river basins face an only marginally higher probability than global river basins, of experiencing a significant decline in the available quantity of freshwater (C2[y]). The dispersion of this probability is yet again somewhat higher for the global group of river basins. Moreover, Table 9 shows that, given a significant decline in the available quantity of freshwater, the average expected intensity of a decline of industrial production is much higher for the EU group of river basins (C2[x]). Finally, the dispersion of such expected intensity is more than four times higher for the group of global river basins.

For the fourth character of water crisis, Table 9 provides that EU river basins face a somewhat higher probability than their global counterparts, of experiencing a significant decline in the available quality of freshwater (C4[y]). Yet, the dispersion of such probability is slightly higher for the group of global river basins. Moreover, Table 9 shows that, given a significant decline in the available quality of freshwater, the average expected intensity of a major biodiversity loss is much higher for the group of EU river basins (C4[y]). Finally, the dispersion of such expected intensity is considerably higher among the group of global river basins.

5 Analysis and Results: Water Crisis Risk Levels and WFD “Good Status” Goal Implementation

This chapter provides the parts of the analysis and results that answer the second research question, that is:

> How is the risk of water crisis that is facing EU river basins distributed between such basins that have implement the WFD “good status” goal (set C) and such that have not (set D)?

As provided in the research design of this study (chapter 3.2.2), this chapter is comprised out of a number of steps. These steps are in turn considered throughout the following four subchapters: the first subchapter presents an account of WFD “good status” goal implementation across all EU river basins considered by this study. Subsequently, the second subchapter presents the statistical assessment of the overlap between water crisis risk levels (as established in the previous chapter) and WFD “good status” goal implementation. In the third subchapter, the pattern established in the previous step is assessed in order to determine which one of the two previously defined hypotheses this study should accept. Finally, the fourth subchapter provides an interpretation of the results established in this chapter.

5.1 WFD “Good Status” Goal Implementation

For all EU river basins considered by this study, the two following figures show the respective percentage of surface water that is of high, good, moderate, poor, bad and unknown status (EEA 2012a). All river basins that show an at least good status for at least 50% of their surface water are subsequently considered to have implemented the WFD “good status” goal (i.e. they are assigned to the “Top 50%” group). Conversely, all remaining river basins are assigned to the group of river basins that have not implemented the WFD “good status” goal (the “Bottom 50%” group). All raw data behind the following figures and the subsequent grouping of river basins (Table 10) is provided in Appendix F.

Figure 13: WFD "good status" goal implementation for EU river basins (part 1).

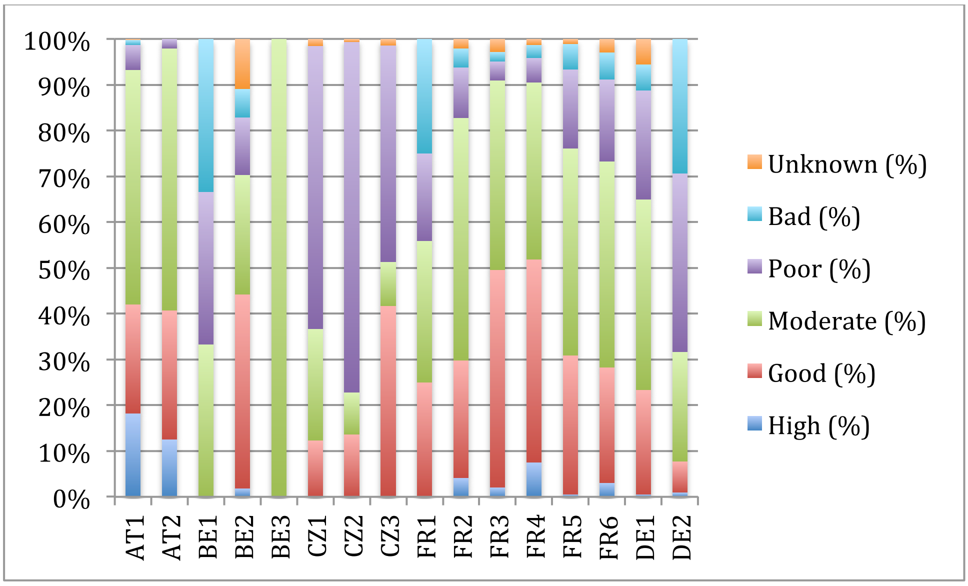


Figure 14: WFD "good status" goal implementation for EU river basins (part 2).

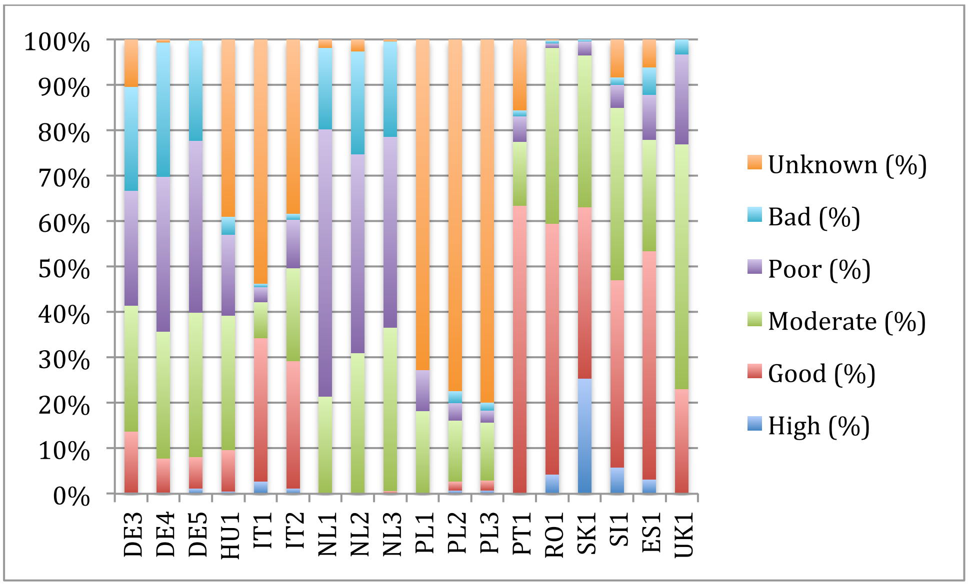


Table 10: The two groups of EU river basins.

Group	**River Basins**
Top 50%	PT1, SK1, RO1, ES1, FR4
Bottom 50%	FR3, SI1, BE2, AT1, CZ3, AT2, IT1, FR5, FR2, IT2, FR6, FR1, DE1, UK1, CZ2, DE3, CZ1, HU1, DE5, DE2, DE4, PL3, PL2, NL3, BE3, BE1, NL1, NL2, PL1

At this point, the considerable share of "unknown" status surface water in the HU, IT and PL river basins should be considered (Figure 14). For these river basins, the respective percentage of total surface water that is of "unknown" status is so large that, depending on its actual status, these particular river basins should potentially have been assigned to the "Top 50%" group of river basins rather than the "Bottom 50%" group. Naturally, this may have an impact on the statistical analysis conducted below. Yet, this potential flaw has to be seen in the light of two things. First, it is not possible to mend due to the lack of data. Second, only six out of thirty-four river basins hold an uncertainty of this size. Thus, the potential impact of this issue on the subsequent statistical analysis remains limited.

5.2 Adding Water Crisis Risk Levels

This subchapter provides the results of the statistical assessment of the overlap between water crisis risk levels and WFD "good status" goal implementation. Statistical measures of water crisis risk (mean, SD and CV) representative of all three characters of water crisis are considered to assess the average level and dispersion of such risk for both the "Top 50%" group and the "Bottom 50%" group of EU river basins (Table 11). In the table below, the emboldened figures identify the group of river basins ("Top 50%" or "Bottom 50%") for which, given a particular variable within a character of water crisis, the higher value has been established.

Table 11: Water crisis risk levels and WFD "good status" goal implementation.

Group	Statistical measure	C1[x]	C1[y]	C2[x]	C2[y]	C4[x]	C4[y]
Top 50%	Mean	**78,5**	**2,6**	6,7	**2,1**	**162,5**	**4,8**
	SD	82,5	0,9	4,1	1,3	43,7	0,4
	CV	105%	37%	61%	62%	26%	9%
Bottom 50%	Mean	7,5	2,11	**9,3**	1,9	152,9	4,1
	SD	11,9	1,0	3,4	0,8	81,4	0,8
	CV	157%	47%	36%	44%	53%	19%

The results of the statistical assessment that are presented above allow a number of insights about the overlap between water crisis risk levels and WFD "good status" goal implementation. In the following paragraphs, these insights are individually considered for each of the three character of water crisis (C1, C2 and C4).

For the first character of water crisis, Table 11 shows that the average probability of a significant decline in the available quantity of freshwater (C1[y]) is higher for the "Top 50%" group of river of basins than for the "Bottom 50%" group. It is also shown that the dispersion of such probability is higher for the "Bottom 50%" group of river basins than for the "Top 50%" group. Moreover, given a significant decline in the available quantity of freshwater, the average expected intensity of a food crisis (C1[x]) is much higher for the "Top 50%" group of river basins than for the "Bottom 50%" group. Finally, the dispersion of such expected intensity is higher for the "Bottom 50%" group of river basins.

Considering the second character of water crisis, Table 11 provides that the average probability of a significant decline in the available quantity of freshwater (C2[y]) is slightly higher for the "Top 50%" group of river basins than for the "Bottom 50%" group. It is also shown that the dispersion of such probability is considerably higher among the "Top 50%" group of river basins. Furthermore, Table

11 shows that, if a significant decline in the available quantity of freshwater was to materialise, the average expected intensity of a decline of industrial production will be much higher in the "Bottom 50%" group of river basins than in the "Top 50%" group (C2[x]). Finally, the dispersion of such expected intensity is much higher for the "Top 50%" group of river basins.

For the fourth character of water crisis, Table 11 shows that the average probability of a significant decline in the available quality of freshwater (C4[y]) is considerably higher for the "Top 50%" group of river basins than for the "Bottom 50%" group. It also shows that the dispersion of such probability is considerably higher in the "Bottom 50%" group of river basins. Furthermore, Table 11 shows that, in the event of a materialised significant decline in the available quality of freshwater, the average expected intensity of a major biodiversity loss (C2[x]) is considerably higher in the "Top 50%" group of river basins than in the "Bottom 50%" group. Finally, the dispersion of such expected intensity is considerably higher for the "Bottom 50%" group of river basins.

5.3 Assessing the Strength of the two Hypotheses

In the light of the results presented in Table 11 (of the previous section), this subchapter determines which one of the two previously established hypotheses this study should accept: (H1) EU river basins for which the WFD "good status" goal has been implemented are likely to show a lower average water crisis risk level than river basins for which the WFD "good status" goal has not been implemented, or (H2) EU river basins for which the WFD "good status" goal has been implemented are likely to show a higher average water crisis risk level than river basins for which the WFD "good status" goal has not been implemented. In Table 12, the two hypotheses are evaluated for all three characters of water crisis: for every character of water crisis, each variable ([x] and [y]) is individually assessed in terms of the ratio that is produced by the average water crisis risk levels (as provided in Table 11 of the previous section) of the "Top 50%" and the "Bottom 50%" group of river basins. If that ratio is larger than one, H2 is accepted for the particular variable. Conversely, if that ratio is smaller than one, H1 is accepted for the particular variable. Finally, for each character of water crisis, if both variables ([x] and [y]) support the same hypothesis, that hypothesis is accepted for the corresponding character of water crisis in its entirety. In the following paragraphs, the results shown in Table 12 are in turn considered for each character of water crisis (C1-C4).

Table 12: Assessment of the hypotheses.

Character of water crisis	**Variable**	**Ratio**	**H1**	**H2**	**Accepted**
C1	C1[x]	>1	False	True	H2
	C1[y]	>1	False	True	
C2	C2[x]	<1	True	False	-
	C2[y]	>1	False	True	
C4	C4[x]	>1	False	True	H2
	C4[y]	>1	False	True	

For the first character of water crisis (C1), Table 12 shows that dividing the previously established average levels of water crisis risk of the “Top 50%” and the “Bottom 50%” group of river basins, for both variables individually (C1[x] and C1[y]), produces a ratio that is larger than one. This shows that the average water crisis risk level for the first character of water crisis is higher among the “Top 50%” group than the “Bottom 50%” group of river basins. Thus, for both variables (C1[x] and C1[y]), the second hypothesis is accepted. Subsequently, the second hypothesis is accepted for the first character of water crisis in its entirety, meaning that: a significant decline in the available quantity of freshwater is more likely to occur, and once it occurs, more likely to produce a high-intensity food crisis, in river basins for which the WFD “good status” goal has been implemented than in river basins for which the WFD “good status” goal has not been implemented.

For the second character of water crisis (C2), Table 12 shows that a division of the average levels of water crisis risk of the “Top 50%” group and the “Bottom 50%” group of river basins produces opposing results for the two relevant variables (C2[x] and C2[y]). Whereas the C2[x] ratio is smaller than one, the C2[y] ratio is larger than one. Thus, the first hypothesis is accepted for the former variable and the second hypothesis is accepted for the latter variable, making it impossible to accept any hypothesis for the second character of water crisis in its entirety. The results thus show that: (1) a significant decline in the available quantity of freshwater is more likely to occur in river basins for which the WFD “good status” goal has been implemented than in river basins for which the WFD “good status” goal has not been implemented and (2) given such a decline, a high-intensity decline of industrial production is less likely to occur in river basins for which the WFD “good status” goal has been implemented than in river basins for which the WFD “good status” goal has not been implemented.

For the fourth character of water crisis (C4), Table 12 provides that that a division of the previously established average levels of water crisis risk of the “Top 50%” and the “Bottom 50%” group of river basins, for both variables individually (C4[x] and C4[y]), yields a ratio that is larger than one. Thus, the average water crisis risk level for the fourth character of water crisis is higher for the “Top 50%” group than the “Bottom 50%” group of river basins. Subsequently, for both variables (C4[x] and C4[y]), the second hypothesis is accepted. Thereby, the second hypothesis is accepted for the fourth character of water crisis in its entirety. This means that a significant decline in the available quality of freshwater is more likely to occur, and once it occurs, more likely to produce a high-intensity major biodiversity loss, in river basins for which the WFD “good status” goal has been implemented than in river basins for which the WFD “good status” goal has not been implemented.

In sum, the above by and large provides that water crisis risk levels overlap with WFD “good status” goal implementation (thereby supporting the second hypothesis). The only exception from this pattern is found within the framework of the second character of water crisis. There it is shown that, provided a significant decline in the available quantity of freshwater, the average intensity of a decline of industrial production (C2[x]) will be higher in river basins for which the WFD “good status” goal has not been implemented than in river basins for which it has been implemented.

5.4 Interpreting the Results

This subchapter provides an interpretation of the results established in the previous section of this chapter. Essentially, it is shown below that the considerable overlap between water crisis risk levels and WFD "good status" goal implementation is a result of Member States' strategic implementation of the WFD "good status" goal. Furthermore, it is established that this mode of implementation has produced a north/south divide in the distribution of WFD "good status" goal implementation across the EU. Finally, it is shown how the previously established exception from the overlap between water crisis risk levels and WFD "good status" goal implementation is manifested within the framework of this north/south divide.

Many factors may be considered explanatory of the overlap between water crisis risk levels and WFD "good status" goal implementation. Yet, a suitable point of departure for explaining why such overlap actually exists, is the notion of strategic implementation. In fact, the results provided above show that Member States have had a rather accurate understanding of water crisis risk levels' distribution as they have managed to implement the WFD "good status" goal, by and large, for river basins in which water crisis risk levels are high. Yet, the central issue at stake here is how Member States have been able to do this. Whereas such decisions are naturally made on the basis of expert assessments, this study argues that the pattern of WFD "good status" goal implementation reflects a larger underlying issue. To address this issue, consider the river basins that belong to the "Top 50%" group and the "Bottom 50%" group of river basins in terms of their geographic location. This reveals that (as can be seen in Table 10 and in Appendix E) all river basins in the "Top 50%" group are located in the south of the EU whereas all river basins of the "Bottom 50%" group are located in the north (the dividing line is close to the 50th parallel north). Thus, water crisis risk levels' overlap with WFD "good status" goal implementation can essentially be thought of as a geographic distribution of water crisis risk between the north and the south of the EU. This distribution, knowingly or not, has been matched by Member States' WFD "good status" goal implementation. Most likely, that is because such implementation has been independently conducted by the Member States, which acted according to the notion that water risk management is a priority issue mainly in regions that suffer from clearly visible symptoms of water scarcity, which in a European context naturally is more accurate for southern than northern Member States (WEF 2010, 1). Thus, translating the "Top 50%" group of river basins into southern EU river basins and the "Bottom 50%" group of river basins into northern EU river basins, forms the following interpretation: Whereas the WFD "good status" goal has been implemented for southern EU river basins, which by and large face a higher level of water crisis risk, the WFD "good status" goal has not been implemented for northern EU river basins, which by and large face lower levels of water crisis risk. However, there is one large problem with this mode of strategic implementation that most likely has not occurred to Member States: it does not pick up on the fact that, given a significant decline in the available quantity of freshwater (within the second character of water crisis), the average expected intensity of a decline of industrial production is much higher in the north than in the south of the EU. This essentially shows that Member States' strategic implementation of the WFD "good status" goal, provided this geographic interpretation of water crisis risk levels, leaves a major vulnerability in the north of the EU.

Provided the identification of this mismatch in the overlap between water crisis risk levels and WFD "good status" implementation, this study now turns to a more detailed consideration of the overlap’s nature. This is done by considering, rather than average water crisis risk levels, the absolute risk levels of those EU river basins that currently are the most likely to experience a water crisis.

6 Analysis and Results: “Critical” EU River Basins

This chapter provides the parts of the analysis and results that answer the third research question, that is:

> Which EU river basins are facing the highest levels of water crisis risk (set E) and which policy approach is best suited to reduce such risk for each river basin individually?

As provided in the research design of this study (chapter 3.2.3), this chapter initially proceeds in two steps, each of which in turn is considered by the two following subchapters: First, all “critical” (i.e. highest scoring in terms of water crisis risk) EU river basins are identified for each character of water crisis. Subsequently, each “critical” river basin is assigned one out of two standardised policy approaches for reducing the probability of a water crisis. Second, to provide an interpretation of the results from the previous step, all “critical” river basins are plotted on a map of the EU. From this, three geographic regions (Northern, Central and Southern) are derived, each of which holds a particular combination of river basins’ respective character of water crisis and suggested policy approach. From this, it is assessed whether Member States’ strategic implementation of the WFD “good status” goal (as established in the previous chapter) matches the distribution of “critical” water crisis risk across the EU. In a third and final subchapter, the results of the previous steps are interpreted with a focus on their implications for the future.

6.1 “Critical” River Basins and Suggested Policy Approaches

The tables below present all “critical” river basins that have been identified for each character of water crisis respectively. It is shown that these river basins meet the requirement of holding above-EU-average values for both variables ([x] and [y]) of their corresponding character of water crisis. Furthermore, the following tables provide the suggested policy approach for each “critical” river basin on the basis of its respective success with WFD “good status” goal implementation (i.e. the policy approach is suggested depending on a particular “critical” river basin’s belonging to either the “Top 50%” group or the “Bottom 50%” group of river basins).

Table 13: “Critical” EU river basins (Character 1)

River basin	C1[x]	C1[y]	Group	Policy approach
PT1	145.4	3.5	Top 50%	Expand WFD scope
RO1	26.6	2.3	Top 50%	Expand WFD scope
ES1	188.7	3.5	Top 50%	Expand WFD scope
FR2	20.7	4.1	Bottom 50%	Implement WFD
FR3	20.7	3.5	Bottom 50%	Implement WFD

FR5	20.7	2.6	Bottom 50%	Implement WFD
IT1	41.1	2.3	Bottom 50%	Implement WFD
Mean (EU)	17.6	2.2		

The table above (Table 13) shows all "critical" river basins within the framework of the first character of water crisis. As such, these river basins face both an above-EU-average probability of a significant decline in the available quantity of freshwater and, given such a decline, an above-EU-average expected intensity food crisis. Among these "critical" river basins, the FR2 (Loire river France) river basin is the most likely to experience a significant decline in the available quantity of freshwater whereas the PT1 (Tejo river in Portugal) and ES1 (Tejo river in Spain) river basins are facing, in the event of a significant decline in the available quantity of freshwater, the by far highest expected intensity food crisis.

Furthermore, the suggested policy approaches for these "critical" river basins provide that the PT1, RO1, and ES1 river basins, all of which belong to the "Top 50%" group of river basins, should focus on expanding the WFD "good status" goal's scope to further reduce the probability of experiencing a water crisis. Given the context of the first character of water crisis, this aim of reducing the value of the C1[y] variable implies that steps need to be taken to further reduce agricultural baseline water stress, that is, the competition among agricultural actors for surface water, through an increased control of water abstraction. This essentially means an increase in the WFD "good status" goal PoM measure for control of surface water abstraction (Directive 2000/60/EC, §11(e)). Conversely, the remaining FR2, FR3, FR5, and IT1 river basins, all part of the "Bottom 50%" group of river basins, should focus on implementing the WFD "good status" goal in order to reduce their respective probability of experiencing a water crisis.

Table 14: "Critical" EU river basins (Character 2)

River basin	**C2[x]**	**C2[y]**	**Group**	**Policy approach**
FR2	13.2	3.5	Bottom 50%	Implement WFD
FR3	13.2	3.5	Bottom 50%	Implement WFD
FR5	13.2	2.6	Bottom 50%	Implement WFD
BE2	13.3	3.5	Bottom 50%	Implement WFD
DE3	10	2.6	Bottom 50%	Implement WFD
DE4	10	2.4	Bottom 50%	Implement WFD
Mean (EU)	8.8	2.0		

The table above (Table 14) shows all EU river basins that are "critical" within the context of the second character of water crisis. These river basins face both an above-EU-average probability of a significant decline in the available quantity of freshwater and, given such a decline, an above-EU-average expected intensity decline of industrial production. Among these "critical" river basins, the FR2 (Loire river France), FR3 (Meuse river France) and BE2 (Meuse river Belgium) river basins are the most likely to experience a significant decline in the available quantity of freshwater (C2[y]). Moreover, the BE2 river basin is, in the event of such a decline, facing the highest expected intensity decline of industrial production.

Furthermore, consideration of the suggested policy approaches for these "critical" river basins shows that, since these all belong to the "Bottom 50%" group of river basins, they should focus on implementing the WFD "good status" goal in order to reduce their respective probability of experiencing a water crisis.

Table 15: "Critical" EU river basins (Character 4)

River basin	C4[x]	C4[y]	Group	Policy approach
RO1	240.7	5	Top 50%	Expand WFD scope
Mean (EU)	153.9	4.2		

It is shown above (Table 15) that given the context of the fourth character of water crisis, the RO1 (Danube river Romania) river basin is the only instance of a "critical" river basin. As such, it is facing both an above-EU-average probability of experiencing a significant decline in the available quality of freshwater, and given such a decline, an above-EU-average expected intensity biodiversity loss. It should be noted that it scores a maximum (five) for the C4[y] variable, which underlines this river basin's high probability of experiencing a water crisis.

Furthermore, the suggested policy approach for the RO1 river basin, which belongs to the "Top 50%" group of river basins, is an expansion of the WFD "good status" goal's scope, aimed at reducing the C4[y] variable value. This implies an extension of the WFD "good status" goal PoM measure for ensuring sustainable water use (Directive 2000/60/EC, §11(c)). Finally, as this character of water crisis only shows one "critical" river basin it is not considered in the following parts of this chapter and thus, removed from the remainder of this study.

6.2 A Geographic Interpretation of the Results

This subchapter provides a geographic interpretation of the results presented in the previous section of this chapter. For this purpose, all identified "critical" river basins are plotted on a map of the EU, identifying their corresponding character of water crisis and their suggested policy approach. Subsequently, three EU geographic regions (Northern, Central and Southern) are identified. For each such region, a particular combination of "critical" river basins' character of water crisis and their suggested policy approach is presented. From this, it is assessed whether Member States' strategic implementation of the WFD "good status" goal (as established in the previous chapter) matches the distribution of "critical" water crisis risk across the EU.

6.2.1 The Northern/Central/Southern Region Divide

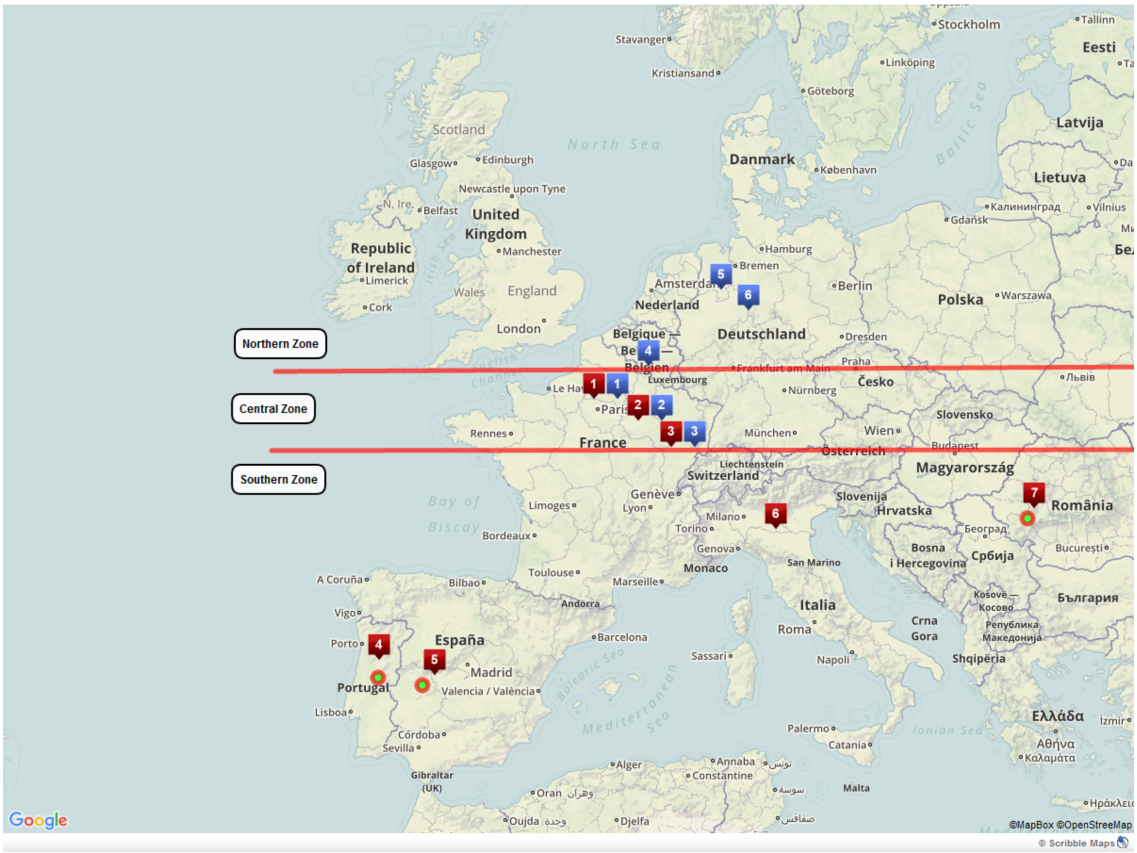
Table 16 provides all "critical" river basins that have been identified for the three geographic regions of the EU respectively (Northern, Central and Southern). It is furthermore shown that each of these regions holds a particular combination of "critical" river basins' respective character of water crisis as well as their respective suggested policy approach: First, the Central region's "critical" river basins are critical in the context of both the first and second character of water crisis. Moreover, they are all suggested to implement the WFD "good status" goal in order to reduce water crisis risk. Second, the Northern region's "critical" river basins are critical in the context of the second character of water crisis. Furthermore, they too are all suggested to implement the WFD "good status" goal in order to reduce water crisis risk. Third, the Southern region's "critical" river basins are critical in the context of the first character of water crisis. Moreover, they are (with exception of the IT1 river basin) suggested to extend the scope of the WFD "good status" goal to reduce their respective probability of experiencing a water crisis.

Table 16: "Critical" EU river basins and the three regions.

Geographic regions	**River basin**	**C1 (red)**	**C2 (blue)**	**Policy approach**
Central region	FR2, (1)	Critical	Critical	Implement WFD
	FR3, (2)	Critical	Critical	Implement WFD
	FR5, (3)	Critical	Critical	Implement WFD
Northern region	BE2, (4)		Critical	Implement WFD
	DE3, (5)		Critical	Implement WFD
	DE4, (6)		Critical	Implement WFD
Southern region	PT1, (4)	Critical		Expand WFD scope
	ES1, (5)	Critical		Expand WFD scope
	IT1, (6)	Critical		Implement WFD
	RO1, (7)	Critical		Increase WFD scope

The results provided in Table 16 (above) are illustrated in Figure 15 (below) that provides a map of the EU. On this map, the horizontal lines delimit the Central, Northern, and Southern region. For each such region, the corresponding "critical" river basins are marked by coloured squares: if red, these identify a river basin as "critical" in the context of the first character of water crisis and, if blue, they identify a river basin as "critical" in the context of the second character of water crisis. Thus, the Central region's "critical" river basins are respectively marked by both a red and blue square, whereas the Northern region's "critical" river basins are marked by a blue square and the Southern region's "critical" river basins are marked by a red square. Moreover, the "critical" river basins' respective suggested policy approach for reducing water crisis risk is indicated only for those "critical" river basins for which an expansion of the WFD "good status" goal's scope has been suggested. These river basins (ES1, PT1 and RO1) are marked by a red circle with green filling.

Figure 15: Map of “critical” EU river basins in the three EU regions.



6.2.2 “Critical” River Basins and WFD “Good Status” Goal Implementation

This subchapter assesses whether the distribution of “critical” river basins provided above (Figure 15) matches Member States’ strategic implementation of the WFD “good status” goal that (as established in the previous chapter) has favoured southern EU river basins over their northern counterparts.

First, representing the considerably shorter and simpler answer, the above establishes that only three out of ten “critical” river basins belong to the group of “critical” river basins for which an extension in the WFD “good status” goal’s scope is suggested to reduce water crisis risk (marked by red circles with green filling). This establishes that only 30% of all “critical” river basins are in fact such river basins for which the WFD “good status” goal has been implemented. Thus, although this study has earlier established that average water crisis risk levels by and large match Member States’ strategic implementation of the WFD “good status” goal, the opposite is evidently the case when considering only “critical” river basins. For these, no south bias can be observed in their distribution across the EU. In fact, only four out of ten “critical” river basins are located in the Southern region.

Second, representing the more nuanced and thus complex answer, the above provides opposing biases in the distribution of “critical” river basins, one for each of the two characters of water crisis. The Central region’s “critical” river basins, all located in France, are “critical” in terms of both the first and second character of water crisis. However, the Northern region’s “critical” river basins, located in Belgium and Germany, are critical only in the context of the second character of water crisis whereas the Southern region’s “critical” river basins, located in Portugal, Spain, Italy and Romania, are critical only in the context of the first character of water crisis. This indicates that whereas Member States' strategic implementation of the WFD "good status" goal is south biased, such bias in terms of "critical" river basins' distribution only exists for the first character of water crisis.

Although the above highlights a considerable mismatch between the distribution of "critical" river basins across the EU and Member States' strategic implementation of the WFD "good status" goal, it also underlines the following question: Which "critical" river basins do in fact pose the greater water crisis risk, those for which the WFD "good status" goal already has been implemented (because water crisis risk is high albeit such implementation) or those for which the WFD "good status" goal yet has to be implemented (because these high-risk river basins are not at all addressed by Member States' strategic implementation of the WFD "good status" goal)? In the framework of Figure 15, this question essentially asks whether it is possible that the "critical" river basins of the Northern and Central regions may be facing a fate similar to that of the Southern region's "critical" river basins, that is, high levels of water crisis risk even after WFD "good status" goal implementation. This consideration is addressed in the following section of this chapter.

6.3 The Northern and Central Regions' "Critical" River Basins

This subchapter considers the likeliness with which WFD "good status" goal implementation, for any given "critical" river basin in the Northern or Central region, may fail to significantly reduce water crisis risk, thus causing a situation similar to that of the "critical" river basins in the Southern region. This inquiry underlines the concept of causality, as it is essentially assessed what effect WFD "good status" goal implementation will have on the respective levels of water crisis risk for "critical" river basins in the Northern and Central region.

To assess this causality, it is first and foremost important to consider the incredible breadth of the WFD "good status" goal's definition. It entails "the abundance of aquatic flora and fish fauna, the availability of nutrients, and aspects like salinity, temperature and pollution by chemical pollutants" as well as morphological features, such as "quantity, water flow, water depths and structures of the river beds" (EU Publications Office 2010, 2). In other words, there is a broad spectrum of isolated measures that allow an increase, for any given river basin, in the share of at least "good status" surface water. The central question is whether such a measure, in its outcome, necessarily will coincide with a decrease in water crisis risk. In essence, the question is whether implementation of the WFD "good status" goal, for any given "critical" river basin in the Northern or Central region, is likely to cause a decrease of agricultural or industrial baseline water stress respectively.

This question must be answered in the light of the assumption (as established in chapter 3.2.2) that the WFD "good status" goal essentially is a policy that seeks to reduce the likeliness of exactly those developments that the WEF defines as a water crisis (c.f. Directive 2000/60/EC, §4(a) and WEF 2015a, 54). However, whereas the previous steps of this study, in relation to the first and second character of water crisis, have seen this link in the "control of water abstraction" measure that is part of the WFD PoM (Directive 2000/60/EC, §11(e)), a broader perspective must now be applied. There are other measures within the PoM that likely have little or no effect on water crisis risk. Thus, to understand how likely WFD "good status" implementation is to reduce water crisis risk for a particular river basin, it must be considered through which exact measures (within the PoM) such a step is going to be conducted. Essentially this requires the assessment of whether the relevant measure is an increase in the control of surface water abstraction, for which the concept of a causal decrease in water crisis risk has been established, or any other action within the PoM, for which no effect on water crisis risk is likely to occur.

To exemplify this approach and thus provide an understanding of whether the "critical" river basins in the Northern and Central region may be approaching a fate similar to that of their counterparts in the Southern region, this study departs from the results of the PoM assessment that was issued by the European Commission in 2015 (DG Environment 2015a). In this way, an assessment of the underlying measures (within the PoM) of WFD "good status" implementation for "critical" river basins in France (Central region), Belgium and Germany (Northern region) becomes possible. Subsequently, from this data, it is assessed whether such measures in the future are going to include the "control of water abstraction" measure and thereby, if they are going to reduce water crisis risk. The logic behind this is the fact that every measure in the PoM represents a certain share of the overall progress towards implementing the WFD "good status" goal (DG Environment 2015). Thus, if a particular Member State already has fully carried out the "control of water abstraction" measure, then future progress towards WFD "good status" goal implementation is not likely to reduce water crisis risk in its river basins.

The results of this assessment show that whereas France and Belgium are currently in an on-going phase of implementing the "control of water abstraction" measure, Germany has already completed implementation of this measure (WRC 2015, 12 and WRC 2015a, 12 and WRC 2015b, 13). Thus, whereas it remains difficult to say exactly how much of a decrease in water crisis risk future WFD "good status" goal implementation is going to produce, it can be established that some decrease likely will occur in France and Belgium, whereas no decrease is likely to manifest in Germany. This indicates that the "critical" river basins of the Central and Northern region are quite likely approaching a fate similar to that of the "critical" river basins of the Southern region, that is, a critical level of water crisis risk even after WFD "good status" goal implementation.

7 Conclusions

This chapter proceeds in two steps. First, the results of this study are summarised. Second, following the previous step, a reform of the WFD "good status" goal is suggested by which its capacity of effectively reducing water crisis risk in the EU will be significantly strengthened.

7.1 Summary of Results

This study set out to: First, assess the risk of water crisis, as defined by the WEF, across the world's 100 most populous river basins and, furthermore, provide a comparison of such risk's average level between global and EU river basins. Second, conduct a comparison of average water crisis risk levels between EU river basins that have implement the WFD "good status" goal and EU river basins that have not implemented the WFD "good status" goal. Third, identify the EU river basins that face the highest (i.e. "critical") levels of water crisis risk and to provide each such river basin with a suggested policy approach for reducing that risk.

For the first point, this study has established and applied a framework for quantifying water crisis risk, according to the WEF's definition of water crises, for the world's 100 most populous river basins. The results produced by the application of this framework (chapter 4) form a statistical analysis that is presented in the shape of scatterplots and the assessment of statistical measures. Each scatterplot provides, given one out of the four established characters of water crisis, a visual representation of global and EU river basins' respective water crisis risk. Furthermore, the statistical measures formalise these insights as mean value coordinates as well as the dispersion of risk values are provided in order to give a full picture of global and EU water crisis risk. For this point of the study, the comparison of global and EU river basins' water crisis risk levels provide the following insights (corresponding to the four characters of water crisis): (1) For the first character of water crisis, it has been established that EU river basins are more likely than their global counterparts to experience a significant decline in the available quantity of freshwater, but that such a significant decline, if materialised, is more likely to result in a food crisis in a global context as opposed to an EU context, (2) For the second character of water crisis, it has been shown that EU river basins are more likely than global river basins to experience a significant decline in the available quantity of freshwater and that such a significant decline, if materialised, is more likely to produce a decline of industrial production in an EU context as opposed to a global context, (3) For the third character of water crisis it has been shown that due to a lack of data, no meaningful comparison of EU and global river basins can be conducted. This is likely due to the infinitely small risk that a significant decline in the available quality of freshwater, in an EU context, will result in a spread of infectious disease, (4) For the fourth character of water crisis, it has been established that EU river basins are more likely than global river basins to experience a significant decline in the available quality of freshwater and that, given such a decline, a major biodiversity loss is more likely in an EU context as opposed to a global context. In sum, as one of this study's most alarming conclusions, it has been shown that the statistical risk of water crisis, for nearly all characters of water crisis, is higher in the EU subset of river basins as compared to the full set of global river basins.

For the second point, this study has established a statistical assessment (chapter 5) of the overlap between EU water crisis risk levels and EU water management policy implementation, that is, implementation of the WFD “good status” goal. For this, the previously established water crisis risk levels of EU river basins were considered in the light of the degree to which the WFD “good status” goal has been implemented for these river basins. This was achieved by grouping EU river basins according to either their success (“Top 50%” group) or failure (“Bottom 50%” group) in implementing the WFD “good status” goal. Subsequently, it was considered which group of river basins shows the higher average water crisis risk levels, in order to accept one of the following two hypotheses: (H1) EU river basins for which the WFD “good status” goal has been implemented are likely to show a lower water crisis risk level than river basins for which the WFD “good status” goal has not been implemented, or (H2) EU river basins for which the WFD “good status” goal has been implemented are likely to show a higher water crisis risk level than river basins for which the WFD “good status” goal has not been implemented. These hypotheses were considered for each character of water crisis individually and applied to both variables of each such character of water crisis, meaning that a hypothesis has only been fully accepted if both variables of a particular character of water crisis support it (chapter 5.3). The results of the above show that: (1) For the first character of water crisis, river basins for which the WFD “good status” goal has been implemented are both more likely to experience a significant decline in the quantity of available freshwater and, given such a decline, more likely to experience a food crisis, than river basins for which the WFD “good status” goal has not been implemented. Thus the second hypothesis has been accepted for the first character of water crisis, (2) For the second character of water crisis, river basins for which the WFD “good status” goal has been implemented are more likely to experience a significant decline in the quantity of available freshwater than river basins for which the WFD “good status” goal has not been implemented. However, provided the materialisation of such a decline, river basins for which the WFD “good status” goal has been implemented are less likely to experience a resulting decline of industrial production than river basins for which the WFD “good status” goal has not been implemented. Thus, provided the inconclusive results, no hypothesis was accepted for the second character of water crisis, (3) For the fourth character of water crisis, river basins for which the WFD “good status” goal has been implemented are both more likely to experience a significant decline in the quality of available freshwater and more likely to, given such a decline, experience a major biodiversity loss, than river basins for which the WFD “good status” goal has not been implemented. Thus the second hypothesis has been accepted for the fourth character of water crisis. Finally, the established statistical overlap between EU river basins’ water crisis risk levels and their corresponding WFD “good status” goal implementation were subsequently interpreted as a result of Member States’ strategic implementation of the WFD “good status” goal, which favours southern EU river basins over their northern counterparts. As its most important result, this point of the study shows that whereas this strategic implementation largely overlaps with the established average water crisis risk levels, it completely fails to address the risk of an industrial decline that, within the context of the second character of water crisis, given a significant decline in the available quantity of freshwater, is much higher in river basins for which the WFD “good status” goal has not been implemented as opposed to such river basins for which it has been implemented (i.e. it is higher in the north than in the south of the EU).

For the third point, this study has identified the EU river basins that currently are facing the highest levels of water crisis risk (chapter 6). For this purpose, the previously established water crisis risk levels of EU river basins were consulted, for each character of water crisis individually, to identify such river basins whose water crisis risk level, for both variables of a particular character of water crisis, show an above-EU-average value (i.e. "critical" river basins) (chapter 6.1). For all such "critical" river basins, one out of two standardised policy approaches for reducing water crisis risk was suggested on the basis of each river basins' implementation of the WFD "good status" goal: for river basins for which the WFD "good status" goal has been implemented, an expansion of the policy's scope was suggested whereas, for river basins for which the WFD "good status" goal has not been implemented, it was suggested that focus should be given to the implementation of the policy. Subsequently, the results of the above were geographically interpreted: "Critical" river basins were plotted on a map of the EU, showing that both their corresponding character of water crisis and their corresponding suggested policy approach vary systematically across three regions of the EU (the Central, Northern and Southern region)(chapter 6.2). From this, it was established that: (1) "Critical" river basins in the Central region, provided a significant decline in the available quantity of freshwater, are likely to experience both a food crisis and a decline of industrial production, (2) "Critical" river basins in the Northern region, provided a significant decline in the available quantity of freshwater, are likely to experience only a decline of industrial production and, (3) "Critical" river basins in the Southern region, provided a significant decline in the available quantity of freshwater, are likely to experience only a food crisis. Furthermore, it was shown that only "critical" river basins in the Southern region (all but the IT1 river basin) have implemented the WFD "good status" goal and thereby have been suggested to expand the policy's scope to reduce the probability of experiencing a significant decline in the available quantity of freshwater. Conversely, it was also shown that all remaining "critical" river basins (Central and Southern region) have been suggested to implement the WFD "good status" goal to reduce their water crisis risk levels. However, as a final step (chapter 6.3) the results for this point indicate that WFD "good status" goal implementation will likely not be enough to sufficiently reduce the water crisis risk levels of "critical" river basins in the Central and Northern regions. Thus, as its most important result, this point indicates that although "critical" river basins' corresponding character of water crisis varies systematically across the EU, the WFD "good status" goal is not a sufficient tool for reducing water crisis risk levels for any such character of water crisis in any region of the EU. It is primarily in the light of this final insight that the following subchapter suggests a reform of the WFD "good status" goal.

7.2 Reforming the WFD "Good Status" Goal

In the light of the summary of results provided above and with special attention to the insight that water crisis risk levels of the "critical" river basins are not likely to be sufficiently reduced through the implementation of the WFD "good status" goal, this study now suggests a reform of the WFD "good status" goal. This reform explicitly addresses the problems that the WFD "good status" goal's "one size fits all" approach is causing as "critical" river basins have emerged for which water crisis risk levels are (in the Southern region) and likely will be (in the Central and Northern region) far too high even after implementation of the policy. In essence, the problem that this underlines is that the current form of the WFD "good status" goal does not take into account (1) the geographically systematic variation in "critical" river basins' corresponding character of water crisis across the EU and, (2) the relative degree of implementation of the "control of water abstraction" measure that, under the WFD "good status" goal's PoM, works to reduce the probability of a significant decline in the quantity of available freshwater (Directive 2000/60/EC §11(e)). In other words, this reform addresses the fact that instead of allowing one approach for fixing all problems, the WFD "good status" goal currently (given the focus of this study) represents one approach for fixing none of the problems.

The reform that this study suggests essentially turns the universal "one size fits all" WFD "good status" goal into a flexible policy that is responsive to river basins' respective level and character of water crisis risk. By conducting, prior to implementation efforts, an assessment of each such river basin's level of water crisis risk, it can be established how high the relative need of "control of water abstraction" is in each particular case, thus showing the relative importance of the corresponding measure in the WFD "good status" goal's PoM (Directive 2000/60/EC §11(e)). The same applies to the measure of the PoM that safeguards sustainable water quality (Directive 2000/60/EC §11(c)), although this study only deemed one river basin to be "critical" as regards a significant decline in the available quality of freshwater (this may however change in the future). Essentially, what this reform would achieve is a picture, for all EU river basins, of where and to what extent the WFD "good status" goal is needed to reduce water crisis risk. Such an approach would focus its power on those areas where it is needed rather than, as is currently done, wrongly assuming that its universal standards are high enough to combat water crisis risk across the entire EU.

Finally, attempting to frame the results of this study as an argument for a renationalisation of environmental policy in the EU would be hugely misguided. Any potential gains of Member States from returning water management policy to the national arena would likely be outweighed by the difficulty of aligning 28 different environmental policies to effectively address the issue of water crisis risk on a EU, and in fact global level. Essentially, as brilliantly put by Jacques Cousteau: "However fragmented the world, however intense the national rivalries, it is an inexorable fact that we become more interdependent every day...The sea, the great unifier, is man's only hope. Now, as never before, an old phrase has literal meaning: We are all in the same boat" (National Geographic 1981).

8 References

Abé, Nicola, Jens Glüsing, Felix Lill, Michaela Schiessel, Samiha Shafy and Helene Zuber. 2015. "Bis zum letzten Tropfen". *Der Spiegel* Nr 33, 9-16.

Crow, Ben and Yoram Eckstein. 2014. "Discussion – An exchange between Ben Crow and Yoram Eckstein on the global water crisis". *Water International*. 39:5, 774-784. Available from (downloaded 2015-12-08): http://aquadoc.typepad.com/files/debate_water_crisis.pdf

Cousteau, Jacques. 1981. National Geographic. Vol 159: No 5 (May).

DG Environment. 2015a. "WFD Implementation Reports – Member State specific in-depth assessment on the WFD Programmes of Measures in form of consultant reports". Available (for each Member State individually) from (downloaded 2016-02-9): http://ec.europa.eu/environment/water/water-framework/impl_reports.htm

DG Environment. 2015. "WFD: Timetable for Implementation". Available from (viewed 2016-02-09): http://ec.europa.eu/environment/water/water-framework/info/timetable_en.htm

EEA. 2012a. "WISE WFD Database". Available from (downloaded 2016-01-22): http://www.eea.europa.eu/data-and-maps/data/wise_wfd

EEA. 2012. "Ecological and chemical status and pressures in European waters – Thematic assessment for EEA Water 2012 Report". Available from (downloaded 2016-02-22): http://icm.eionet.europa.eu/ETC_Reports

Esaiasson, Peter., Mikael Giljam, Henrik Oscarsson and Lena Wängnerud. 2007. "Metodpraktikan – Konsten att Studera Samhälle, Individ, och Marknad". Tredje upplagan. Vällingby: Norstedts Juridik.

European Commission. 2012a. "Report from the Commission to the European Parliament and The Council – on the Implementation of the Water Framework Directive (2000/60/EC) River Basin Management Plans". Available from (downloaded 2015-11-01): http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52012DC0670

European Commission. 2012. "A Blueprint to Safeguard Europe's Water Resources". Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of The Regions. Available from (downloaded 2016-02-10): http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0673&from=EN

European Commission Publications Office. 2010. “Water Framework Directive”. Available from (downloaded 2016-02-10): http://ec.europa.eu/environment/pubs/pdf/factsheets/water-framework-directive.pdf

Gassert, Francis., Matt Landis, Matt Luck, Paul Reig and Tien Shiao. 2013. *Aqueduct Metadata Document – Aqueduct Global Maps 2.0*. WRI Working Paper. Available from (downloaded 2015-11-04): http://www.wri.org/sites/default/files/pdf/aqueduct_metadata_global.pdf

Hoekstra, Arjen Y., Ashok C. Chapagain, Maite M. Aldaya and Mesfin M. Mekonnen. 2011. “The Water Footprint Assessment Manual – Setting the Global Standard”. TJ International Ltd: Padstow, Cornwall.

King, Gary., Robert O. Keohane and Sidney Verba. 1994. “Designing Social Inquiry – Scientific Inference in Qualitative Research”. Princeton: Princeton University Press.

Landman, Todd. 2004. “Issues and Methods in Comparative Politics – An Introduction”. Third Edition. New York: Routledge.

LPAA. 2015. *About the Lima-Paris Action Agenda*. Available from: http://newsroom.unfccc.int/lpaa/about/#downloads

Mekonnen, M.M. and A.Y. Hoekstra. 2011a. “National Water Footprint Accounts: The Green, Blue and Grey Water Footprint of Production and Consumption – Volume 2: Appendices”. UNESCO-IHE – Institute for Water Education. Available from (downloaded 2015-12-05): http://waterfootprint.org/en/resources/publications/value-water-research-report-series-unesco-ihe/

Mekonnen, M.M. and A.Y. Hoekstra. 2011. “National Water Footprint Accounts: The Green, Blue and Grey Water Footprint of Production and Consumption – Volume 1: Main Report”. UNESCO-IHE – Institute for Water Education. Available from (downloaded 2015-12-05): http://waterfootprint.org/en/resources/publications/value-water-research-report-series-unesco-ihe/

OECD. 2012. *Meeting the Water Reform Challenge – Executive Summary*. Available from (downloaded 2015-11-16): http://www.oecd.org/environment/resources/49839058.pdf

Srinivasan, V., E. F. Lambin, S. M. Gorelick, B. M. Thompson, and S. Rozelle. 2012. “The nature and cause of the global water crisis: Syndromes from a meta-analysis of coupled human-water studies”. *Water Resources Research*. Vol. 48, W10516.

SIWI. 2015. *High Level Panel: Raising the Profile of Water Towards COP21*. Available from (viewed 2015-12-01): http://programme.worldwaterweek.org/event/4581

Sullivan, Caroline A.. 2011. Quantifying water vulnerability: a multi-dimensional approach. *Stochastic Environmental Research& Risk Assessment*. Volume 25, Issue 4: 627-640. Available from (downloaded 2015-11-12): http://epubs.scu.edu.au/cgi/viewcontent.cgi?article=1929&context=esm_pubs

UN-Water. 2014. *Delivering As One on Water Related Issues*. Strategy 2014-2020. Available from (downloaded 2015-11-22): http://www.unwater.org/fileadmin/user_upload/unwater_new/docs/UN-Water_Strategy_2014-2020.pdf

WEF. 2015a. *Global Risks 2015 – 10th Edition*. Insight Report. Available from (downloaded 2015-11-04): http://reports.weforum.org/global-risks-2015/#read

WEF. 2015. *World Economic Forum Annual Meeting – The New Global Context*. Global Agenda document and report from the annual meeting. Available from (downloaded 2015-11-14): http://www.weforum.org/reports/world-economic-forum-annual-meeting-2015-new-global-context

WEF. 2012a. *Global Agenda Council on Water Security 2012-2014*. Available from (downloaded 2015-12-01): http://www3.weforum.org/docs/GAC/2013/Connect/WEF_GAC_WaterSecurity_2012-2014_Connect.pdf

WEF. 2012. *The Water Resources Group – Background, Impact and the Way Forward*. Briefing report prepared for the World Economic Forum Annual Meeting 2012. Available from (downloaded 2015-11-15): http://www3.weforum.org/docs/WEF/WRG_Background_Impact_and_Way_Forward.pdf

WEF 2011. *Water Security – The Water-Food-Energy-Climate Nexus*. Washington: Island Press.

WEF. 2010. *Managing Our Future Water Needs*. Available from (downloaded 2015-11-04): http://www3.weforum.org/docs/WEF_WI_Overview_2010.pdf

WEF. 2009. *Managing Our Future Water Needs for Agriculture, Industry, Human Health and Environment – The Bubble is Close to Bursting: A Forecast of the Main Economic and Geopolitical Water Issues Likely to Arise in the World during the Next Two Decades*. Draft for Discussion at the World Economic Forum Annual Meeting 2009. Available from (downloaded 2015-11-04): http://www.weforum.org/reports/managing-our-future-water-needs-agriculture-industry-human-health-and-environment

WEF. 2008. *Managing our Future Water Needs for Agriculture, Industry, Human Health and Environment.* Discussion Document for the World Economic Forum Annual Meeting 2008. Available from (downloaded 2015-11-04): http://www.weforum.org/reports/managing-our-future-water-needs-agriculture-industry-human-health-and-environment

WFD Reporting Guidance. 2016. Final Draft 6.0.4. Available from (downloaded 2016-02-01): http://cdr.eionet.europa.eu/help/WFD/WFD_521_2016

WHO. 2016a. “Global Health Observatory data repository – Burden of disease, Inadequate water in low- and middle-income countries”. Available from (downloaded 2016-02-16): http://apps.who.int/gho/data/node.main.INADEQUATEWSH?lang=en

WHO. 2016. “Water Sanitation Health – Water-related diseases: information sheets”. Available from (viewed 2016-02-16): http://www.who.int/water_sanitation_health/diseases/diseasefact/en/

Winpenny, James. 2003. *Report of the World Panel on Financing Water Infrastructure – Financing Water for all*. Available from (downloaded 2015-12-03): http://www.oecd.org/greengrowth/21556665.pdf

World Bank. 2016. “World Development Indicators – Population, total”. Available from (downloaded 2015-12-01): http://data.worldbank.org/indicator/SP.POP.TOTL

WRC. 2015. “Assessment of Member States’ progress in the implementation of Programmes of Measure during the first planning cycle of the Water Framework Directive – Member State Report: Belgium (BE)”. Available (for each Member State individually) from (downloaded 2016-02-9): http://ec.europa.eu/environment/water/water-framework/impl_reports.htm

WRC. 2015a. “Assessment of Member States’ progress in the implementation of Programmes of Measure during the first planning cycle of the Water Framework Directive – Member State Report: Germany (DE)”. Available (for each Member State individually) from (downloaded 2016-02-9): http://ec.europa.eu/environment/water/water-framework/impl_reports.htm

WRC. 2015b. “Assessment of Member States’ progress in the implementation of Programmes of Measure during the first planning cycle of the Water Framework Directive – Member State Report: France (FR)”. Available (for each Member State individually) from (downloaded 2016-02-9): http://ec.europa.eu/environment/water/water-framework/impl_reports.htm

WRI. 2016. “Aqueduct Water Risk Atlas”. Online tool, available from (used from 2015-12-01 to 2016-01-20): http://www.wri.org/applications/maps/aqueduct-atlas/#x=6.95&y=0.09&s=ws!20!28!c&t=waterrisk&w=Custom&g=0&i=BWS-16!WSV-4!SV-2!HFO-4!DRO-4!STOR-8!GW-8!WRI-4!ECOS-2!MC-0!WCG-0!ECOV-0!&tr=ind-1!prj-1&l=2&b=terrain&m=custom&init=y

WWC. 2015c. *7th World Water Forum Conference of Parliamentarians for Water – Parliamentarian Statement*. Available from (downloaded 2015-12-03): http://www.worldwatercouncil.org/forum/daegu-gyeongbuk-2015/

WWC. 2015b. *7th World Water Forum Ministerial Process – Ministerial Declaration*. Available from (downloaded 2015-12-03): http://www.worldwatercouncil.org/forum/daegu-gyeongbuk-2015/

WWC. 2015a. *7th World Water Forum – The Major Outcomes.* Available from (downloaded 2015-12-03): http://www.worldwatercouncil.org/forum/daegu-gyeongbuk-2015/

WWC. 2015. *Background.* Available from (viewed 2015-12-03): http://www.worldwatercouncil.org/about-us/background/

Data sets

WISE-WFD. 2012. Data on status of water sources within WFD river basins. Available from (downloaded 2015-12-02): http://www.eea.europa.eu/data-and-maps/data/wise_wfd

Legal documents

Directive 2000/60/EC. "Establishing a framework for Community action in the field of water policy". Available from (downloaded 2016-02-09): http://eur-lex.europa.eu/resource.html?uri=cellar:5c835afb-2ec6-4577-bdf8-756d3d694eeb.0004.02/DOC_1&format=PDF

9 Appendices

9.1 Appendix A: Raw Data, First Character of Water Crisis

The following table holds the raw data used for the plotting of the first character of water crisis (chapter 4). In the context of the scatter plots, agricultural baseline water stress represents the y-value and per capita internal (blue) water footprint of consumption of agricultural products represents the x-value.

Table 17: River basin raw data (Character 1)

River Basin	Country	Baseline Water Stress (agricultural)	Per capita internal (blue) water footprint of consumption of agricultural products
Amudaryo (1/4)	Afghanistan	3,27	0
Harirud (1/2)	Afghanistan	0,02	0
Helmand	Afghanistan	1,82	0
Danube (1/18)	Albania	2,38	94,71126025
Lake Chad (7/7)	Algeria	3,36	70,15323146
Niger (5/10)	Algeria	3,35	70,15323146
Congo (1/10)	Angola	3,07	8,208830502
Zambezi (1/8)	Angola	0,19	8,208830502
Parana (2/3)	Argentina	0,81	75,80299677
Danube (2/118)	Austria	2,38	1,870879251
Rhine (3/6)	Austria	2,65	1,870879251
Kura (3/3)	Azerbajdan	0,24	136,9408429
Ganges Brahmaputra (5/5)	Bangladesh	0,82	48,51190445
Dniepr (2/3)	Belarus	3,49	7,977521542
Escaut (Schelde) (2/3)	Belgium	0,88	0,102747148
Meuse (2/3)	Belgium	3,52	0,102747148
Seine (2/2)	Belgium	1,85	0,102747148
Niger (6/10)	Benin	3,35	0,671197536
Volta (3/6)	Benin	0,00	0,671197536
Ganges	Bhutan	0,82	0

Brahmaputra (3/5)			
Amazonas (2/6)	Bolivia	0,71	35,67987936
Danube (3/18)	Bosnia and Herzegovina	2,38	4,440213026
Limpopo (2/4)	Botswana	0,10	6,641422257
Orange (2/4)	Botswana	3,00	6,641422257
Zambezi (3/8)	Botswana	0,19	6,641422257
Amazonas (1/6)	Brazil	0,71	41,23563918
Parana (1/3)	Brazil	0,81	41,23563918
Sao Francisco	Brazil	0,23	41,23563918
Niger (4/10)	Burkina Faso	3,35	10,71378524
Volta (2/6)	Burkina Faso	0,00	10,71378524
Congo (2/10)	Burundi	3,07	8,674430472
Nile (9/11)	Burundi	3,56	8,674430472
Mekong (5/6)	Cambodia	1,65	44,89132827
Congo (3/10)	Cameroon	3,07	6,502975759
Lake Chad (5/7)	Cameroon	3,36	6,502975759
Niger (9/10)	Cameroon	3,35	6,502975759
St. Lawrence (2/2)	Canada	2,79	21,65683578
Congo (4/10)	Central African Republic	3,07	14,73054125
Lake Chad (4/7)	Central African Republic	3,36	14,73054125
Lake Chad (2/7)	Chad	3,36	12,6037003
Niger (8/10)	Chad	3,35	12,6037003
Rio Maipo	Chile	2,29	118,2692736
Amur (2/2)	China	2,40	92,16759249
Daliao He	China	0,00	92,16759249
Dong Jiang	China	1,88	92,16759249
Fuchun Jiang	China	3,40	92,16759249
Ganges Brahmaputra (4/5)	China	0,82	92,16759249
Hong(Red River)	China	4,92	92,16759249
Huang He	China	4,83	92,16759249

(Yellow River)			
Huangpu Jiang	China	0,77	92,16759249
Indus (2/3)	China	4,07	92,16759249
Liao He	China	0,71	92,16759249
Mekong (1/6)	China	1,65	92,16759249
Min Jiang	China	0,34	92,16759249
Salween (1/3)	China	0,44	92,16759249
Tuhai He	China	4,91	92,16759249
Xi Jiang (1/2)	China	0,42	92,16759249
Xitang He	China	2,70	92,16759249
Yangtze River (Chang Jiang)	China	1,69	92,16759249
Yongding He	China	4,99	92,16759249
Amazonas (5/6)	Colombia	0,71	28,62153173
Magdalena	Colombia	2,53	28,62153173
Congo (5/10)	Congo, Dem Republic	3,07	1,182765716
Nile (5/11)	Congo, Dem Republic	3,56	1,182765716
Congo (6/10)	Congo, Republic	3,07	348,2077725
Niger (2/10)	Côte d'Ivoire	3,35	5,245284233
Volta (5/6)	Côte d'Ivoire	0,00	5,245284233
Danube (4/18)	Croatia	2,38	0,602674271
Danube (5/18)	Czech Republic	2,38	0,973902833
Elbe River (2/2)	Czech Republic	1,72	0,973902833
Oder River (1/3)	Czech Republic	0,46	0,973902833
Awash Wenz (2/2)	Djibouti	1,00	0
Amazonas (4/6)	Ecuador	0,71	138,3974734
Nile (3/11)	Egypt	3,56	393,461512
Niger (10/10)	Eritrea	3,35	1,382885323
Nile (11/11)	Eritrea	3,56	1,382885323
Awash Wenz (1/2)	Ethiopia	1,00	15,59799666
Lake	Ethiopia	0,02	15,59799666

Turkana (2/2)			
Nile (1/11)	Ethiopia	3,56	15,59799666
Shebelle (1/2)	Ethiopia	0,52	15,59799666
Escaut (Schelde) (1/3)	France	0,88	20,76808823
Loire	France	4,14	20,76808823
Meuse (1/3)	France	3,52	20,76808823
Po (3/3)	France	1,21	20,76808823
Rhine (5/6)	France	2,65	20,76808823
Rhone (2/2)	France	5,00	20,76808823
Seine (1/2)	France	1,85	20,76808823
Kura (2/3)	Georgia	0,24	79,82186119
Danube (6/18)	Germany	2,38	1,037764912
Oder River (3/3)	Germany	0,46	1,037764912
Rhine (4/6)	Germany	2,65	1,037764912
Weser	Germany	2,38	1,037764912
Elbe River (1/2)	Germany	1,72	1,037764912
Volta (6/6)	Ghana	0,00	1,407345233
Niger (1/10)	Guinea	3,35	3,500516678
Senegal (1/4)	Guinea	0,13	3,500516678
Danube (7/18)	Hungary	2,38	7,450251697
Brahmani River (Bhahmani)	India	1,83	170,8856878
Cauvery River	India	4,08	170,8856878
Damodar River	India	4,27	170,8856878
Ganges Brahmaputra (1/5)	India	0,82	170,8856878
Godavari	India	1,57	170,8856878
Indus (3/3)	India	4,07	170,8856878
Krishna	India	4,31	170,8856878
Mahanadi River (Mahahadi)	India	1,04	170,8856878
Mahi River	India	0,02	170,8856878
Narmada	India	1,08	170,8856878
Palar River	India	2,07	170,8856878

Penner River	India	4,15	170,8856878
Rupnarayan	India	4,66	170,8856878
Sabarmati River	India	4,83	170,8856878
Subarnarekha River	India	1,13	170,8856878
Tapti River	India	2,81	170,8856878
Air Musi	Indonesia	0,13	36,99302375
Brantas	Indonesia	4,97	36,99302375
Solo (Bengawan Solo)	Indonesia	4,46	36,99302375
Qom (Namak Lake)	Iran	3,53	479,8412861
Tigris & Euphrates (4/5)	Iran	3,60	479,8412861
Tigris & Euphrates (3/5)	Iraq	3,60	0
Dead Sea (Jordan) (2/5)	Israel	0,46	100,2232257
Danube (8/18)	Italy	2,38	41,19789625
Po (1/3)	Italy	1,21	41,19789625
Tone	Japan	3,21	10,91754564
Dead Sea (Jordan) (1/5)	Jordan	0,46	56,86077811
Sirdaryo (4/4)	Kazahkstan	4,76	301,83
Galana (1/2)	Kenya	2,27	6,586111858
Lake Turkana (1/2)	Kenya	0,02	6,586111858
Nile (6/11)	Kenya	3,56	6,586111858
Han-Gang (Han River) (2/2)	Korea, Dem People's Rep	2,50	53,07875826
Taedong	Korea, Dem People's Rep	2,10	53,07875826
Han-Gang (Han River) (1/2)	Korea, Republic	2,50	9,010552068
Tigris & Euphrates (5/5)	Kuwait	3,60	13,74893668

Sirdaryo (1/4)	Kyrgyzstan	4,76	204,803364
Mekong (3/6)	Laos	1,65	52,15027551
Dead Sea (Jordan) (3/5)	Lebanon	0,46	146,7645504
Orange (4/4)	Lesotho	3,00	2,580880781
Rhine (2/6)	Lichtenstein	2,65	0
Danube (9/18)	Macedonia	2,38	34,39943246
Zambezi (7/8)	Malawi	0,19	8,908865712
Niger (3/10)	Mali	3,35	87,55645047
Senegal (2/4)	Mali	0,13	87,55645047
Volta (1/6)	Mali	0,00	87,55645047
Senegal (3/4)	Mauritania	0,13	52,10298152
Grisalva	Mexico	3,43	69,02072552
Rio Balsas	Mexico	1,70	69,02072552
Rio Grande (Bravo) (2/2)	Mexico	0,29	69,02072552
Santiago	Mexico	3,68	69,02072552
Danube (10/18)	Moldova	2,38	102,5318581
Yenisei (1/2)	Mongolia	0,57	29,4148177
Danube (11/18)	Montenegro	2,38	0
Limpopo (4/4)	Mozambique	0,10	5,358290715
Zambezi (8/8)	Mozambique	0,19	5,358290715
Irrawaddy	Myanmar	3,19	35,95980821
Mekong (2/6)	Myanmar	1,65	35,95980821
Salween (2/3)	Myanmar	0,44	35,95980821
Orange (1/4)	Namibia	3,00	14,29223908
Zambezi (2/8)	Namibia	0,19	14,29223908
Ganges Brahmaputra (2/5)	Nepal	0,82	99,78239027
Escaut (Schelde) (3/3)	Netherlands	0,88	2,609233921
Meuse (3/3)	Netherlands	3,52	2,609233921
Rhine (6/6)	Netherlands	2,65	2,609233921
Lake Chad	Niger	3,36	37,5739537

(1/7)			
Niger (7/10)	Niger	3,35	37,5739537
Cross	Nigeria	0,00	7,748978529
Lagos	Nigeria	3,08	7,748978529
Lake Chad (3/7)	Nigeria	3,36	7,748978529
Indus (1/3)	Pakistan	4,07	32,67295596
Dead Sea (Jordan) (4/5)	Palestine	0,46	0
Parana (3/3)	Paraguay	0,81	32,72805645
Amazonas (3/6)	Peru	0,71	106,5261738
Danube (12/18)	Poland	2,38	1,719296262
Oder River (2/3)	Poland	0,46	1,719296262
Wisla	Poland	1,14	1,719296262
Tejo (2/2)	Portugal	3,52	145,5432747
Danube (13/18)	Romania	2,38	26,61221029
Dniepr (3/3)	Russia	3,49	43,80598239
Don	Russia	2,03	43,80598239
Volga	Russia	0,97	43,80598239
Amur (1/2)	Russia	2,40	43,80598239
Ob (Tobol)	Russia	0,90	43,80598239
Ob	Russia	0,20	43,80598239
Yenisei (2/2)	Russia	0,57	43,80598239
Congo (7/10)	Rwanda	3,07	1,672949027
Nile (8/11)	Rwanda	3,56	1,672949027
Senegal (4/4)	Senegal	0,13	21,90736243
Danube (14/18)	Serbia	2,38	0
Danube (15/18)	Slovakia	2,38	10,93002979
Danube (16/18)	Slovenia	2,38	0,51442767
Shebelle (2/2)	Somalia	0,52	0
Limpopo (1/4)	South Africa	0,10	64,18381094
Orange (3/4)	South Africa	3,00	64,18381094
Congo (8/10)	South Sudan	3,07	0
Nile (10/11)	South Sudan	3,56	0
Tejo (1/2)	Spain	3,52	188,7665531
Lake Chad (6/7)	Sudan	3,36	0

Nile (2/11)	Sudan	3,56	0
Danube (17/18)	Switzerland	2,38	0,080193484
Po (2/3)	Switzerland	1,21	0,080193484
Rhine (1/6)	Switzerland	2,65	0,080193484
Rhone (1/2)	Switzerland	5,00	0,080193484
Dead Sea (Jordan) (5/5)	Syria	0,46	257,8335622
Tigris & Euphrates (2/5)	Syria	3,60	257,8335622
Amudaryo (2/4)	Tajikistan	3,27	334,654949
Sirdaryo (3/4)	Tajikistan	4,76	334,654949
Congo (9/10)	Tanzania	3,07	15,41946975
Galana (2/2)	Tanzania	2,27	15,41946975
Nile (7/11)	Tanzania	3,56	15,41946975
Zambezi (6/8)	Tanzania	0,19	15,41946975
Chao Phraya	Thailand	3,57	125,0831469
Mekong (4/6)	Thailand	1,65	125,0831469
Salween (3/3)	Thailand	0,44	125,0831469
Volta (4/6)	Togo	0,00	79,4
Kura (1/3)	Turkey	0,24	147,7796524
Tigris & Euphrates (1/5)	Turkey	3,60	147,7796524
Amudaryo (3/4)	Turkmenistan	3,27	615,9729471
Harirud (2/2)	Turkmenistan	0,02	615,9729471
Nile (4/11)	Uganda	3,56	0,284457937
Thames	UK	3,53	0,868029958
Danube (18/18)	Ukraine	2,38	30,25003593
Dniepr (1/3)	Ukraine	3,49	30,25003593
Dniestr	Ukraine	0,86	30,25003593
Colorado River (Pacific Ocean)	USA	1,97	123,7145823
Columbia River	USA	3,97	123,7145823
Delaware River	USA	4,58	123,7145823

Mississippi River	USA	1,27	123,7145823
Rio Grande (Bravo) (1/2)	USA	0,29	123,7145823
St. Lawrence (1/2)	USA	2,79	123,7145823
Amudaryo (4/4)	Uzbekistan	3,27	280,5902243
Sirdaryo (2/4)	Uzbekistan	4,76	280,5902243
Amazonas (6/6)	Venezuela	0,71	38,90256692
Orinoco	Venezuela	1,73	38,90256692
Hong(Red River)	Vietnam	4,92	59,31407939
Mekong (6/6)	Vietnam	1,65	59,31407939
Song Dong Nai	Vietnam	1,40	59,31407939
Xi Jiang (2/2)	Vietnam	0,42	59,31407939
Congo (10/10)	Zambia	3,07	18,70898701
Zambezi (5/8)	Zambia	0,19	18,70898701
Limpopo (3/4)	Zimbabwe	0,10	46,77970799
Zambezi (4/8)	Zimbabwe	0,19	0,669233207

9.2 Appendix B: Raw Data, Second Character of Water Crisis

The following table holds the raw data used for the plotting of the second character of water crisis (chapter 4). In the context of the scatter plots, industrial baseline water stress represents the y-value and per capita internal (blue) water footprint of consumption of industrial products represents the x-value.

Table 18: River basin raw data (Character 2)

River Basin	**Country**	**Baseline water stress (industrial)**	**Per capita internal (blue) water footprint of consumption of industrial products**
Amudaryo (1/4)	Afghanistan	3,45	0
Harirud (1/2)	Afghanistan	0,01	0

Helmand	Afghanistan	1,99	0
Danube (1/18)	Albania	1,48	2,7
Lake Chad (7/7)	Algeria	2,90	0,55
Niger (5/10)	Algeria	1,76	0,55
Congo (1/10)	Angola	2,13	0,03
Zambezi (1/8)	Angola	0,42	0,03
Parana (2/3)	Argentina	0,49	2,69
Danube (2/18)	Austria	1,48	4,78
Rhine (3/6)	Austria	2,65	4,78
Kura (3/3)	Azerbajdan	0,33	8,63
Ganges Brahmaputra (5/5)	Bangladesh	0,82	0,07
Dniepr (2/3)	Belarus	3,46	5,59
Escaut (Schelde) (2/3)	Belgium	1,67	13,3
Meuse (2/3)	Belgium	3,54	13,3
Seine (2/2)	Belgium	1,85	13,3
Niger (6/10)	Benin	1,76	0,13
Volta (3/6)	Benin	0,00	0,13
Ganges Brahmaputra (3/5)	Bhutan	0,82	0
Amazonas (2/6)	Bolivia	0,35	0,35
Danube (3/18)	Bosnia and Herzegovina	1,48	0
Limpopo (2/4)	Botswana	0,07	0,58
Orange (2/4)	Botswana	2,79	0,58
Zambezi (3/8)	Botswana	0,42	0,58
Amazonas (1/6)	Brazil	0,35	2,03
Parana (1/3)	Brazil	0,49	2,03
Sao Francisco	Brazil	0,28	2,03
Niger (4/10)	Burkina Faso	1,76	0,01
Volta (2/6)	Burkina Faso	0,00	0,01
Congo (2/10)	Burundi	2,13	0,07
Nile (9/11)	Burundi	3,65	0,07
Mekong (5/6)	Cambodia	1,76	0,02

Congo (3/10)	Cameroon	2,13	0,12
Lake Chad (5/7)	Cameroon	2,90	0,12
Niger (9/10)	Cameroon	1,76	0,12
St. Lawrence (2/2)	Canada	2,12	22,3
Congo (4/10)	Central African Republic	2,13	0,02
Lake Chad (4/7)	Central African Republic	2,90	0,02
Lake Chad (2/7)	Chad	2,90	0
Niger (8/10)	Chad	1,76	0
Rio Maipo	Chile	2,39	5,24
Amur (2/2)	China	2,33	2,35
Daliao He	China	0,01	2,35
Dong Jiang	China	1,56	2,35
Fuchun Jiang	China	3,40	2,35
Ganges Brahmaputra (4/5)	China	0,82	2,35
Hong(Red River)	China	4,95	2,35
Huang He (Yellow River)	China	4,81	2,35
Huangpu Jiang	China	0,60	2,35
Indus (2/3)	China	3,87	2,35
Liao He	China	0,30	2,35
Mekong (1/6)	China	1,76	2,35
Min Jiang	China	0,37	2,35
Salween (1/3)	China	0,36	2,35
Tuhai He	China	4,89	2,35
Xi Jiang (1/2)	China	0,37	2,35
Xitang He	China	2,70	2,35
Yangtze River (Chang Jiang)	China	1,36	2,35
Yongding He	China	4,99	2,35
Amazonas (5/6)	Colombia	0,35	0,21
Magdalena	Colombia	2,80	0,21
Congo (5/10)	Congo, Dem	2,13	0,01

	Republic		
Nile (5/11)	Congo, Dem Republic	3,65	0,01
Congo (6/10)	Congo, Republic	2,13	0,02
Niger (2/10)	Côte d'Ivoire	1,76	0,2
Volta (5/6)	Côte d'Ivoire	0,00	0,2
Danube (4/18)	Croatia	1,48	0,58
Danube (5/18)	Czech Republic	1,48	3,82
Elbe River (2/2)	Czech Republic	1,73	3,82
Oder River (1/3)	Czech Republic	1,00	3,82
Awash Wenz (2/2)	Djibouti	0,85	0
Amazonas (4/6)	Ecuador	0,35	3,2
Nile (3/11)	Egypt	3,65	1,87
Niger (10/10)	Eritrea	1,76	0
Nile (11/11)	Eritrea	3,65	0
Awash Wenz (1/2)	Ethiopia	0,85	0,01
Lake Turkana (2/2)	Ethiopia	0,11	0,01
Nile (1/11)	Ethiopia	3,65	0,01
Shebelle (1/2)	Ethiopia	0,46	0,01
Escaut (Schelde) (1/3)	France	1,67	13,23
Loire	France	3,50	13,23
Meuse (1/3)	France	3,54	13,23
Po (3/3)	France	0,60	13,23
Rhine (5/6)	France	2,65	13,23
Rhone (2/2)	France	5,00	13,23
Seine (1/2)	France	1,85	13,23
Kura (2/3)	Georgia	0,33	5,86
Danube (6/18)	Germany	1,48	10
Oder River (3/3)	Germany	1,00	10
Rhine (4/6)	Germany	2,65	10
Weser	Germany	2,41	10
Elbe River (1/2)	Germany	1,73	10

Volta (6/6)	Ghana	0,00	0,15
Niger (1/10)	Guinea	1,76	0,06
Senegal (1/4)	Guinea	0,01	0,06
Danube (7/18)	Hungary	1,48	10,61
Brahmani River (Bhahmani)	India	1,66	0,97
Cauvery River	India	4,23	0,97
Damodar River	India	4,01	0,97
Ganges Brahmaputra (1/5)	India	0,82	0,97
Godavari	India	0,71	0,97
Indus (3/3)	India	3,87	0,97
Krishna	India	4,14	0,97
Mahanadi River (Mahahadi)	India	1,00	0,97
Mahi River	India	0,01	0,97
Narmada	India	1,08	0,97
Palar River	India	1,66	0,97
Penner River	India	4,15	0,97
Rupnarayan	India	4,66	0,97
Sabarmati River	India	4,86	0,97
Subarnarekha River	India	1,00	0,97
Tapti River	India	2,81	0,97
Air Musi	Indonesia	0,13	0,06
Brantas	Indonesia	4,95	0,06
Solo (Bengawan Solo)	Indonesia	4,46	0,06
Qom (Namak Lake)	Iran	3,53	0,47
Tigris & Euphrates (4/5)	Iran	2,98	0,47
Tigris & Euphrates (3/5)	Iraq	2,98	0
Dead Sea (Jordan) (2/5)	Israel	0,85	0,48
Danube (8/18)	Italy	1,48	8,16

Po (1/3)	Italy	0,60	8,16
Tone	Japan	3,20	4,59
Dead Sea (Jordan) (1/5)	Jordan	0,85	0,21
Sirdaryo (4/4)	Kazahkstan	4,76	6,47
Galana (1/2)	Kenya	2,21	0,09
Lake Turkana (1/2)	Kenya	0,11	0,09
Nile (6/11)	Kenya	3,65	0,09
Han-Gang (Han River) (2/2)	Korea, Dem People's Rep	2,68	3,82
Taedong	Korea, Dem People's Rep	2,25	3,82
Han-Gang (Han River) (1/2)	Korea, Republic	2,68	1,71
Tigris & Euphrates (5/5)	Kuwait	2,98	0,13
Sirdaryo (1/4)	Kyrgyzstan	4,76	2,07
Mekong (3/6)	Laos	1,76	0,95
Dead Sea (Jordan) (3/5)	Lebanon	0,85	1,51
Orange (4/4)	Lesotho	2,79	0,28
Rhine (2/6)	Lichtenstein	2,65	0
Danube (9/18)	Macedonia	1,48	3,27
Zambezi (7/8)	Malawi	0,42	0,14
Niger (3/10)	Mali	1,76	0,15
Senegal (2/4)	Mali	0,01	0,15
Volta (1/6)	Mali	0,00	0,15
Senegal (3/4)	Mauritania	0,01	0,4
Grisalva	Mexico	3,24	1,07
Rio Balsas	Mexico	1,53	1,07
Rio Grande (Bravo) (2/2)	Mexico	0,42	1,07
Santiago	Mexico	3,56	1,07
Danube (10/18)	Moldova	1,48	11,95
Yenisei (1/2)	Mongolia	0,67	1,2
Danube (11/18)	Montenegro	1,48	0
Limpopo (4/4)	Mozambique	0,07	0,01

Zambezi (8/8)	Mozambique	0,42	0,01
Irrawaddy	Myanmar	3,37	0,11
Mekong (2/6)	Myanmar	1,76	0,11
Salween (2/3)	Myanmar	0,36	0,11
Orange (1/4)	Namibia	2,79	0,24
Zambezi (2/8)	Namibia	0,42	0,24
Ganges Brahmaputra (2/5)	Nepal	0,82	0,08
Escaut (Schelde) (3/3)	Netherlands	1,67	6,5
Meuse (3/3)	Netherlands	3,54	6,5
Rhine (6/6)	Netherlands	2,65	6,5
Lake Chad (1/7)	Niger	2,90	0,01
Niger (7/10)	Niger	1,76	0,01
Cross	Nigeria	0,00	0,07
Lagos	Nigeria	3,07	0,07
Lake Chad (3/7)	Nigeria	2,90	0,07
Indus (1/3)	Pakistan	3,87	0,07
Dead Sea (Jordan) (4/5)	Palestine	0,85	0
Parana (3/3)	Paraguay	0,49	0,27
Amazonas (3/6)	Peru	0,35	2,4
Danube (12/18)	Poland	1,48	11,54
Oder River (2/3)	Poland	1,00	11,54
Wisla	Poland	0,96	11,54
Tejo (2/2)	Portugal	3,52	4,1
Danube (13/18)	Romania	1,48	8,57
Dniepr (3/3)	Russia	3,46	3,61
Don	Russia	1,90	3,61
Volga	Russia	0,99	3,61
Amur (1/2)	Russia	2,33	3,61
Ob (Tobol)	Russia	0,66	3,61
Ob	Russia	0,14	3,61
Yenisei (2/2)	Russia	0,67	3,61
Congo (7/10)	Rwanda	2,13	0,04
Nile (8/11)	Rwanda	3,65	0,04

Senegal (4/4)	Senegal	0,01	0,17
Danube (14/18)	Serbia	1,48	0
Danube (15/18)	Slovakia	1,48	2,78
Danube (16/18)	Slovenia	1,48	9,01
Shebelle (2/2)	Somalia	0,46	0
Limpopo (1/4)	South Africa	0,07	0,41
Orange (3/4)	South Africa	2,79	0,41
Congo (8/10)	South Sudan	2,13	0
Nile (10/11)	South Sudan	3,65	0
Tejo (1/2)	Spain	3,52	5,3
Lake Chad (6/7)	Sudan	2,90	0
Nile (2/11)	Sudan	3,65	0
Danube (17/18)	Switzerland	1,48	6,08
Po (2/3)	Switzerland	0,60	6,08
Rhine (1/6)	Switzerland	2,65	6,08
Rhone (1/2)	Switzerland	5,00	6,08
Dead Sea (Jordan) (5/5)	Syria	0,85	0,78
Tigris & Euphrates (2/5)	Syria	2,98	0,78
Amudaryo (2/4)	Tajikistan	3,45	2,88
Sirdaryo (3/4)	Tajikistan	4,76	2,88
Congo (9/10)	Tanzania	2,13	0,02
Galana (2/2)	Tanzania	2,21	0,02
Nile (7/11)	Tanzania	3,65	0,02
Zambezi (6/8)	Tanzania	0,42	0,02
Chao Phraya	Thailand	3,58	1,12
Mekong (4/6)	Thailand	1,76	1,12
Salween (3/3)	Thailand	0,36	1,12
Volta (4/6)	Togo	0,00	0,14
Kura (1/3)	Turkey	0,33	2,1
Tigris & Euphrates (1/5)	Turkey	2,98	2,1
Amudaryo (3/4)	Turkmenistan	3,45	0,67

Harirud (2/2)	Turkmenistan	0,01	0,67
Nile (4/11)	Uganda	3,65	0,06
Thames	UK	3,57	3,8
Danube (18/18)	Ukraine	1,48	9,4
Dniepr (1/3)	Ukraine	3,46	9,4
Dniestr	Ukraine	0,98	9,4
Colorado River (Pacific Ocean)	USA	2,02	27,96
Columbia River	USA	4,48	27,96
Delaware River	USA	4,55	27,96
Mississippi River	USA	2,11	27,96
Rio Grande (Bravo) (1/2)	USA	0,42	27,96
St. Lawrence (1/2)	USA	2,12	27,96
Amudaryo (4/4)	Uzbekistan	3,45	1,54
Sirdaryo (2/4)	Uzbekistan	4,76	1,54
Amazonas (6/6)	Venezuela	0,35	0,52
Orinoco	Venezuela	1,68	0,52
Hong(Red River)	Vietnam	4,95	5,28
Mekong (6/6)	Vietnam	1,76	5,28
Song Dong Nai	Vietnam	1,12	5,28
Xi Jiang (2/2)	Vietnam	0,37	5,28
Congo (10/10)	Zambia	2,13	0,19
Zambezi (5/8)	Zambia	0,42	0,19
Limpopo (3/4)	Zimbawe	0,07	0,66
Zambezi (4/8)	Zimbawe	0,42	0,66

9.3 Appendix C: Raw Data, Third Character of Water Crisis

The following table holds the raw data used for the plotting of the third character of water crisis (chapter 4). In the context of the scatter plots, upstream protected land represents the y-value and deaths/100,000 population due to inadequate water quality represents the x-value.

Table 19: River basin raw data (Character 3)

River Basin	**Country**	**Upstream protected land**	**Deaths/100,000 population due to inadequate water quality**
Amudaryo (1/4)	Afghanistan	5	21,5
Harirud (1/2)	Afghanistan	5	21,5
Helmand	Afghanistan	5	21,5
Danube (1/18)	Albania	5	0,1
Lake Chad (7/7)	Algeria	5	1,5
Niger (5/10)	Algeria	5	1,5
Congo (1/10)	Angola	5	65,5
Zambezi (1/8)	Angola	5	65,5
Parana (2/3)	Argentina	5	0,4
Danube (2/18)	Austria	3	
Rhine (3/6)	Austria	3	
Kura (3/3)	Azerbajdan	5	0,9
Ganges Brahmaputra (5/5)	Bangladesh	5	3,7
Dniepr (2/3)	Belarus	4	0,1
Escaut (Schelde) (2/3)	Belgium	4	
Meuse (2/3)	Belgium	4	
Seine (2/2)	Belgium	4	
Niger (6/10)	Benin	3	18,7
Volta (3/6)	Benin	3	18,7
Ganges Brahmaputra (3/5)	Bhutan	3	3,2
Amazonas (2/6)	Bolivia	2	3,4
Danube (3/18)	Bosnia and Herzegovina	4	0
Limpopo	Botswana	3	5,3

(2/4)			
Orange (2/4)	Botswana	3	5,3
Zambezi (3/8)	Botswana	3	5,3
Amazonas (1/6)	Brazil	1	0,6
Parana (1/3)	Brazil	1	0,6
Sao Francisco	Brazil	5	0,6
Niger (4/10)	Burkina Faso	4	23,2
Volta (2/6)	Burkina Faso	4	23,2
Congo (2/10)	Burundi	1	42,5
Nile (9/11)	Burundi	1	42,5
Mekong (5/6)	Cambodia	2	2,5
Congo (3/10)	Cameroon	4	25,8
Lake Chad (5/7)	Cameroon	4	25,8
Niger (9/10)	Cameroon	4	25,8
St, Lawrence (2/2)	Canada	5	
Congo (4/10)	Central African Republic	4	65,3
Lake Chad (4/7)	Central African Republic	4	65,3
Lake Chad (2/7)	Chad	5	54,3
Niger (8/10)	Chad	5	54,3
Rio Maipo	Chile	5	0,3
Amur (2/2)	China	5	0,1
Daliao He	China	5	0,1
Dong Jiang	China	5	0,1
Fuchun Jiang	China	5	0,1
Ganges Brahmaputra (4/5)	China	5	0,1
Hong(Red River)	China	5	0,1
Huang He (Yellow River)	China	5	0,1
Huangpu Jiang	China	5	0,1
Indus (2/3)	China	5	0,1
Liao He	China	5	0,1
Mekong (1/6)	China	5	0,1

Min Jiang	China	5	0,1
Salween (1/3)	China	5	0,1
Tuhai He	China	5	0,1
Xi Jiang (1/2)	China	5	0,1
Xitang He	China	5	0,1
Yangtze River (Chang Jiang)	China	5	0,1
Yongding He	China	5	0,1
Amazonas (5/6)	Colombia	1	0,3
Magdalena	Colombia	3	0,3
Congo (5/10)	Congo, Dem Republic	3	65,8
Nile (5/11)	Congo, Dem Republic	3	65,8
Congo (6/10)	Congo, Republic	3	65,8
Niger (2/10)	Côte d'Ivoire	3	24,8
Volta (5/6)	Côte d'Ivoire	3	24,8
Danube (4/18)	Croatia	4	
Danube (5/18)	Czech Republic	3	
Elbe River (2/2)	Czech Republic	3	
Oder River (1/3)	Czech Republic	3	
Awash Wenz (2/2)	Djibouti	5	15,3
Amazonas (4/6)	Ecuador	3	0,9
Nile (3/11)	Egypt	3	1
Niger (10/10)	Eritrea	5	20,2
Nile (11/11)	Eritrea	5	20,2
Awash Wenz (1/2)	Ethiopia	2	18,6
Lake Turkana (2/2)	Ethiopia	2	18,6
Nile (1/11)	Ethiopia	2	18,6
Shebelle (1/2)	Ethiopia	2	18,6
Escaut (Schelde) (1/3)	France	5	
Loire	France	5	
Meuse (1/3)	France	5	
Po (3/3)	France	5	

Rhine (5/6)	France	5	
Rhone (2/2)	France	5	
Seine (1/2)	France	5	
Kura (2/3)	Georgia	5	0,1
Danube (6/18)	Germany	5	
Oder River (3/3)	Germany	5	
Rhine (4/6)	Germany	5	
Weser	Germany	5	
Elbe River (1/2)	Germany	5	
Volta (6/6)	Ghana	3	11,2
Niger (1/10)	Guinea	4	23,7
Senegal (1/4)	Guinea	4	23,7
Danube (7/18)	Hungary	4	
Brahmani River (Bhahmani)	India	5	15,6
Cauvery River	India	5	15,6
Damodar River	India	5	15,6
Ganges Brahmaputra (1/5)	India	5	15,6
Godavari	India	5	15,6
Indus (3/3)	India	4	15,6
Krishna	India	3	15,6
Mahanadi River (Mahahadi)	India	4	15,6
Mahi River	India	4	15,6
Narmada	India	5	15,6
Palar River	India	5	15,6
Penner River	India	4	15,6
Rupnarayan	India	4	15,6
Sabarmati River	India	3	15,6
Subarnarekha River	India	3	15,6
Tapti River	India	3	15,6
Air Musi	Indonesia	2	0,7
Brantas	Indonesia	4	0,7
Solo (Bengawan	Indonesia	4	0,7

Solo)			
Qom (Namak Lake)	Iran	4	0,6
Tigris & Euphrates (4/5)	Iran	4	0,6
Tigris & Euphrates (3/5)	Iraq	5	2,5
Dead Sea (Jordan) (2/5)	Israel	3	
Danube (8/18)	Italy	4	
Po (1/3)	Italy	4	
Tone	Japan	4	
Dead Sea (Jordan) (1/5)	Jordan	3	0,6
Sirdaryo (4/4)	Kazahkstan	5	0,5
Galana (1/2)	Kenya	2	17,9
Lake Turkana (1/2)	Kenya	2	17,9
Nile (6/11)	Kenya	2	17,9
Han-Gang (Han River) (2/2)	Korea, Dem People's Rep	5	0,6
Taedong	Korea, Dem People's Rep	5	0,6
Han-Gang (Han River) (1/2)	Korea, Republic	5	
Tigris & Euphrates (5/5)	Kuwait	5	
Sirdaryo (1/4)	Kyrgyzstan	5	1,1
Mekong (3/6)	Laos	4	5,7
Dead Sea (Jordan) (3/5)	Lebanon	3	
Orange (4/4)	Lesotho	5	16,8
Rhine (2/6)	Lichtenstein	4	
Danube (9/18)	Macedonia	4	0
Zambezi (7/8)	Malawi	3	0,2
Niger (3/10)	Mali	5	35,8
Senegal (2/4)	Mali	5	35,8
Volta (1/6)	Mali	5	35,8

Senegal (3/4)	Mauritania	5	18
Grisalva	Mexico	5	0,6
Rio Balsas	Mexico	5	0,6
Rio Grande (Bravo) (2/2)	Mexico	5	0,6
Santiago	Mexico	5	0,6
Danube (10/18)	Moldova	4	
Yenisei (1/2)	Mongolia	3	1,6
Danube (11/18)	Montenegro	3	0
Limpopo (4/4)	Mozambique	5	23,8
Zambezi (8/8)	Mozambique	5	23,8
Irrawaddy	Myanmar	4	6,2
Mekong (2/6)	Myanmar	4	6,2
Salween (2/3)	Myanmar	4	6,2
Orange (1/4)	Namibia	4	5,6
Zambezi (2/8)	Namibia	4	5,6
Ganges Brahmaputra (2/5)	Nepal	2	7,6
Escaut (Schelde) (3/3)	Netherlands	4	
Meuse (3/3)	Netherlands	4	
Rhine (6/6)	Netherlands	4	
Lake Chad (1/7)	Niger	5	39,6
Niger (7/10)	Niger	5	39,6
Cross	Nigeria	3	30,7
Lagos	Nigeria	3	30,7
Lake Chad (3/7)	Nigeria	3	30,7
Indus (1/3)	Pakistan	4	12,3
Dead Sea (Jordan) (4/5)	Palestine	3	
Parana (3/3)	Paraguay	3	1,2
Amazonas (3/6)	Peru	4	0,3
Danube (12/18)	Poland	3	
Oder River (2/3)	Poland	3	
Wisla	Poland	3	

Tejo (2/2)	Portugal	5	
Danube (13/18)	Romania	5	0
Dniepr (3/3)	Russia	4	0,3
Don	Russia	4	0,3
Volga	Russia	4	0,3
Amur (1/2)	Russia	4	0,3
Ob (Tobol)	Russia	4	0,3
Ob	Russia	4	0,3
Yenisei (2/2)	Russia	4	0,3
Congo (7/10)	Rwanda	3	10,9
Nile (8/11)	Rwanda	3	10,9
Senegal (4/4)	Senegal	3	16,2
Danube (14/18)	Serbia	5	0,1
Danube (15/18)	Slovakia	4	
Danube (16/18)	Slovenia	4	
Shebelle (2/2)	Somalia	5	59
Limpopo (1/4)	South Africa	5	7,3
Orange (3/4)	South Africa	5	7,3
Congo (8/10)	South Sudan	3	30
Nile (10/11)	South Sudan	3	30
Tejo (1/2)	Spain	5	
Lake Chad (6/7)	Sudan	5	20,3
Nile (2/11)	Sudan	5	20,3
Danube (17/18)	Switzerland	3	
Po (2/3)	Switzerland	3	
Rhine (1/6)	Switzerland	3	
Rhone (1/2)	Switzerland	3	
Dead Sea (Jordan) (5/5)	Syria	3	1,1
Tigris & Euphrates (2/5)	Syria	5	1,1
Amudaryo (2/4)	Tajikistan	4	2,9
Sirdaryo (3/4)	Tajikistan	4	2,9
Congo (9/10)	Tanzania	1	
Galana (2/2)	Tanzania	1	
Nile (7/11)	Tanzania	1	

Zambezi (6/8)	Tanzania	1	
Chao Phraya	Thailand	3	1,2
Mekong (4/6)	Thailand	3	1,2
Salween (3/3)	Thailand	3	1,2
Volta (4/6)	Togo	3	22,5
Kura (1/3)	Turkey	5	0,4
Tigris & Euphrates (1/5)	Turkey	5	0,4
Amudaryo (3/4)	Turkmenistan	5	3,5
Harirud (2/2)	Turkmenistan	5	3,5
Nile (4/11)	Uganda	3	17,9
Thames	UK	5	
Danube (18/18)	Ukraine	5	0,2
Dniepr (1/3)	Ukraine	5	0,2
Dniestr	Ukraine	5	0,2
Colorado River (Pacific Ocean)	USA	5	
Columbia River	USA	5	
Delaware River	USA	5	
Mississippi River	USA	5	
Rio Grande (Bravo) (1/2)	USA	4	
St, Lawrence (1/2)	USA	5	
Amudaryo (4/4)	Uzbekistan	5	0,5
Sirdaryo (2/4)	Uzbekistan	5	0,5
Amazonas (6/6)	Venezuela	1	
Orinoco	Venezuela	2	
Hong(Red River)	Vietnam	3	0,4
Mekong (6/6)	Vietnam	3	0,4
Song Dong Nai	Vietnam	3	0,4
Xi Jiang (2/2)	Vietnam	3	0,4
Congo (10/10)	Zambia	2	14,8
Zambezi	Zambia	2	14,8

(5/8)			
Limpopo (3/4)	Zimbawe	3	15,5
Zambezi (4/8)	Zimbawe	3	15,5

9.4 Appendix D: Raw Data, Fourth Character of Water Crisis

The following table holds the raw data used for the plotting of the fourth character of water crisis (chapter 4). In the context of the scatter plots, upstream protected land represents the y-value and per capita internal (grey) water footprint of national consumption represents the x-value.

Table 20: River basin raw data (Character 4).

River Basin	Country	Upstream protected land	Per capita internal (grey) water footprint of national consumption
Amudaryo (1/4)	Afghanistan	5	0
Harirud (1/2)	Afghanistan	5	0
Helmand	Afghanistan	5	0
Danube (1/18)	Albania	5	233,27
Lake Chad (7/7)	Algeria	5	34,47
Niger (5/10)	Algeria	5	34,47
Congo (1/10)	Angola	5	4,95
Zambezi (1/8)	Angola	5	5,95
Parana (2/3)	Argentina	5	131,73
Danube (2/18)	Austria	3	87,72
Rhine (3/6)	Austria	3	87,72
Kura (3/3)	Azerbajdan	5	169,55
Ganges Brahmaputra (5/5)	Bangladesh	5	89,06
Dniepr (2/3)	Belarus	4	236,57
Escaut (Schelde) (2/3)	Belgium	4	138,01
Meuse (2/3)	Belgium	4	138,01
Seine (2/2)	Belgium	4	138,01
Niger (6/10)	Benin	3	9,35
Volta (3/6)	Benin	3	9,35

Ganges Brahmaputra (3/5)	Bhutan	3	0
Amazonas (2/6)	Bolivia	2	23,22
Danube (3/18)	Bosnia and Herzegovina	4	31,59
Limpopo (2/4)	Botswana	3	42,7
Orange (2/4)	Botswana	3	42,7
Zambezi (3/8)	Botswana	3	42,7
Amazonas (1/6)	Brazil	1	116,99
Parana (1/3)	Brazil	1	116,99
Sao Francisco	Brazil	5	116,99
Niger (4/10)	Burkina Faso	4	19,34
Volta (2/6)	Burkina Faso	4	19,34
Congo (2/10)	Burundi	1	6,04
Nile (9/11)	Burundi	1	6,04
Mekong (5/6)	Cambodia	2	5,48
Congo (3/10)	Cameroon	4	15,48
Lake Chad (5/7)	Cameroon	4	15,48
Niger (9/10)	Cameroon	4	15,48
St. Lawrence (2/2)	Canada	5	370,32
Congo (4/10)	Central African Republic	4	4,2
Lake Chad (4/7)	Central African Republic	4	4,2
Lake Chad (2/7)	Chad	5	2,64
Niger (8/10)	Chad	5	2,64
Rio Maipo	Chile	5	145,19
Amur (2/2)	China	5	228,13
Daliao He	China	5	228,13
Dong Jiang	China	5	228,13
Fuchun Jiang	China	5	228,13
Ganges Brahmaputra (4/5)	China	5	228,13
Hong(Red River)	China	5	228,13
Huang He	China	5	228,13

(Yellow River)			
Huangpu Jiang	China	5	228,13
Indus (2/3)	China	5	228,13
Liao He	China	5	228,13
Mekong (1/6)	China	5	228,13
Min Jiang	China	5	228,13
Salween (1/3)	China	5	228,13
Tuhai He	China	5	228,13
Xi Jiang (1/2)	China	5	228,13
Xitang He	China	5	228,13
Yangtze River (Chang Jiang)	China	5	228,13
Yongding He	China	5	228,13
Amazonas (5/6)	Colombia	1	133,19
Magdalena	Colombia	3	133,19
Congo (5/10)	Congo, Dem Republic	3	2,75
Nile (5/11)	Congo, Dem Republic	3	2,75
Congo (6/10)	Congo, Republic	3	7,25
Niger (2/10)	Côte d'Ivoire	3	24,48
Volta (5/6)	Côte d'Ivoire	3	24,48
Danube (4/18)	Croatia	4	152,51
Danube (5/18)	Czech Republic	3	197,77
Elbe River (2/2)	Czech Republic	3	197,77
Oder River (1/3)	Czech Republic	3	197,77
Awash Wenz (2/2)	Djibouti	5	0
Amazonas (4/6)	Ecuador	3	290,99
Nile (3/11)	Egypt	3	238,68
Niger (10/10)	Eritrea	5	6
Nile (11/11)	Eritrea	5	6
Awash Wenz (1/2)	Ethiopia	2	6,75
Lake Turkana (2/2)	Ethiopia	2	6,75

Nile (1/11)	Ethiopia	2	6,75
Shebelle (1/2)	Ethiopia	2	6,75
Escaut (Schelde) (1/3)	France	5	140,39
Loire	France	5	140,39
Meuse (1/3)	France	5	140,39
Po (3/3)	France	5	140,39
Rhine (5/6)	France	5	140,39
Rhone (2/2)	France	5	140,39
Seine (1/2)	France	5	140,39
Kura (2/3)	Georgia	5	295,86
Danube (6/18)	Germany	5	117,96
Oder River (3/3)	Germany	5	117,96
Rhine (4/6)	Germany	5	117,96
Weser	Germany	5	117,96
Elbe River (1/2)	Germany	5	117,96
Volta (6/6)	Ghana	3	14,24
Niger (1/10)	Guinea	4	11,21
Senegal (1/4)	Guinea	4	11,21
Danube (7/18)	Hungary	4	313,88
Brahmani River (Bhahmani)	India	5	129,08
Cauvery River	India	5	129,08
Damodar River	India	5	129,08
Ganges Brahmaputra (1/5)	India	5	129,08
Godavari	India	5	129,08
Indus (3/3)	India	4	129,08
Krishna	India	3	129,08
Mahanadi River (Mahahadi)	India	4	129,08
Mahi River	India	4	129,08
Narmada	India	5	129,08
Palar River	India	5	129,08
Penner River	India	4	129,08
Rupnarayan	India	4	129,08

Sabarmati River	India	3	129,08
Subarnarekha River	India	3	129,08
Tapti River	India	3	129,08
Air Musi	Indonesia	2	86,88
Brantas	Indonesia	4	86,88
Solo (Bengawan Solo)	Indonesia	4	86,88
Qom (Namak Lake)	Iran	4	185,26
Tigris & Euphrates (4/5)	Iran	4	185,26
Tigris & Euphrates (3/5)	Iraq	5	0
Dead Sea (Jordan) (2/5)	Israel	3	54,42
Danube (8/18)	Italy	4	196,45
Po (1/3)	Italy	4	196,45
Tone	Japan	4	112,53
Dead Sea (Jordan) (1/5)	Jordan	3	32,84
Sirdaryo (4/4)	Kazahkstan	5	154,03
Galana (1/2)	Kenya	2	17,12
Lake Turkana (1/2)	Kenya	2	17,12
Nile (6/11)	Kenya	2	17,12
Han-Gang (Han River) (2/2)	Korea, Dem People's Rep	5	136,71
Taedong	Korea, Dem People's Rep	5	136,71
Han-Gang (Han River) (1/2)	Korea, Republic	5	72,39
Tigris & Euphrates (5/5)	Kuwait	5	102,47
Sirdaryo (1/4)	Kyrgyzstan	5	84,31
Mekong (3/6)	Laos	4	35,1
Dead Sea (Jordan) (3/5)	Lebanon	3	69,1

Orange (4/4)	Lesotho	5	138,91
Rhine (2/6)	Lichtenstein	4	0
Danube (9/18)	Macedonia	4	176,66
Zambezi (7/8)	Malawi	3	430,96
Niger (3/10)	Mali	5	34,12
Senegal (2/4)	Mali	5	34,12
Volta (1/6)	Mali	5	34,12
Senegal (3/4)	Mauritania	5	41,38
Grisalva	Mexico	5	155,45
Rio Balsas	Mexico	5	155,45
Rio Grande (Bravo) (2/2)	Mexico	5	155,45
Santiago	Mexico	5	155,45
Danube (10/18)	Moldova	4	157,54
Yenisei (1/2)	Mongolia	3	72,03
Danube (11/18)	Montenegro	3	0
Limpopo (4/4)	Mozambique	5	6,75
Zambezi (8/8)	Mozambique	5	6,75
Irrawaddy	Myanmar	4	24,17
Mekong (2/6)	Myanmar	4	24,17
Salween (2/3)	Myanmar	4	24,17
Orange (1/4)	Namibia	4	40,61
Zambezi (2/8)	Namibia	4	40,61
Ganges Brahmaputra (2/5)	Nepal	2	18,31
Escaut (Schelde) (3/3)	Netherlands	4	21,65
Meuse (3/3)	Netherlands	4	21,65
Rhine (6/6)	Netherlands	4	21,65
Lake Chad (1/7)	Niger	5	7,41
Niger (7/10)	Niger	5	7,41
Cross	Nigeria	3	13,62
Lagos	Nigeria	3	13,62
Lake Chad (3/7)	Nigeria	3	13,62
Indus (1/3)	Pakistan	4	139,46

Dead Sea (Jordan) (4/5)	Palestine	3	0
Parana (3/3)	Paraguay	3	54,98
Amazonas (3/6)	Peru	4	82,04
Danube (12/18)	Poland	3	265,24
Oder River (2/3)	Poland	3	265,24
Wisla	Poland	3	265,24
Tejo (2/2)	Portugal	5	144,46
Danube (13/18)	Romania	5	240,73
Dniepr (3/3)	Russia	4	194,69
Don	Russia	4	194,69
Volga	Russia	4	194,69
Amur (1/2)	Russia	4	194,69
Ob (Tobol)	Russia	4	194,69
Ob	Russia	4	194,69
Yenisei (2/2)	Russia	4	194,69
Congo (7/10)	Rwanda	3	4,09
Nile (8/11)	Rwanda	3	4,09
Senegal (4/4)	Senegal	3	11,27
Danube (14/18)	Serbia	5	0
Danube (15/18)	Slovakia	4	140,24
Danube (16/18)	Slovenia	4	338,85
Shebelle (2/2)	Somalia	5	0
Limpopo (1/4)	South Africa	5	88,97
Orange (3/4)	South Africa	5	88,97
Congo (8/10)	South Sudan	3	0
Nile (10/11)	South Sudan	3	0
Tejo (1/2)	Spain	5	147,08
Lake Chad (6/7)	Sudan	5	0
Nile (2/11)	Sudan	5	0
Danube (17/18)	Switzerland	3	63,47
Po (2/3)	Switzerland	3	63,47
Rhine (1/6)	Switzerland	3	63,47
Rhone (1/2)	Switzerland	3	63,47
Dead Sea (Jordan) (5/5)	Syria	3	179,84

Tigris & Euphrates (2/5)	Syria	5	179,84
Amudaryo (2/4)	Tajikistan	4	132,8
Sirdaryo (3/4)	Tajikistan	4	132,8
Congo (9/10)	Tanzania	1	12,42
Galana (2/2)	Tanzania	1	12,42
Nile (7/11)	Tanzania	1	12,42
Zambezi (6/8)	Tanzania	1	12,42
Chao Phraya	Thailand	3	115,04
Mekong (4/6)	Thailand	3	115,04
Salween (3/3)	Thailand	3	115,04
Volta (4/6)	Togo	3	15,41
Kura (1/3)	Turkey	5	160,49
Tigris & Euphrates (1/5)	Turkey	5	160,49
Amudaryo (3/4)	Turkmenistan	5	77,68
Harirud (2/2)	Turkmenistan	5	77,68
Nile (4/11)	Uganda	3	5,07
Thames	UK	5	54,56
Danube (18/18)	Ukraine	5	328,62
Dniepr (1/3)	Ukraine	5	328,62
Dniestr	Ukraine	5	328,62
Colorado River (Pacific Ocean)	USA	5	431,88
Columbia River	USA	5	431,88
Delaware River	USA	5	431,88
Mississippi River	USA	5	431,88
Rio Grande (Bravo) (1/2)	USA	4	431,88
St. Lawrence (1/2)	USA	5	431,88
Amudaryo (4/4)	Uzbekistan	5	109,79
Sirdaryo (2/4)	Uzbekistan	5	109,79

Amazonas (6/6)	Venezuela	1	148,1
Orinoco	Venezuela	2	148,1
Hong(Red River)	Vietnam	3	235,52
Mekong (6/6)	Vietnam	3	235,52
Song Dong Nai	Vietnam	3	235,52
Xi Jiang (2/2)	Vietnam	3	235,52
Congo (10/10)	Zambia	2	30,76
Zambezi (5/8)	Zambia	2	30,76
Limpopo (3/4)	Zimbawe	3	75,11
Zambezi (4/8)	Zimbawe	3	75,11

9.5 Appendix E: Fusion of River Basin Names (WRI/WFD)

The following table shows the fusion of WRI and WFD river basins respectively into one set of river basins ("assigned names") that is used by this study.

Table 21: Fusion of river basins (WRI/WFD).

WRI	WFD	Country	Assigned name
Danube (2/118)	AT1000 (Danube)	Austria	AT1
Rhine (3/6)	AT2000 (Rhine)	Austria	AT2
Escaut (Schelde) (2/3)	BEEscaut_Schelde_BR	Belgium	BE1
Meuse (2/3)	BEMeuse_RW	Belgium	BE2
Seine (2/2)	BESeine_RW	Belgium	BE3
Danube (4/18)	not available (2012 - not MS)	Croatia	-
Danube (5/18)	CZ_1000 (Danube)	Czech Republic	CZ1
Elbe River (2/2)	CZ_5000 (Elbe)	Czech Republic	CZ2
Oder River (1/3)	CZ_6000 (Oder)	Czech Republic	CZ3
Escaut (Schelde) (1/3)	FRA	France	FR1
Loire	FRG	France	FR2
Meuse (1/3)	FRB1	France	FR3
Po (3/3) + Rhone (2/2)	FRD	France	FR4

Rhine (5/6)	FRC	France	FR5
Seine (1/2)	FRH	France	FR6
Danube (6/18)	DE1000	Germany	DE1
Oder River (3/3)	DE6000	Germany	DE2
Rhine (4/6)	DE2000	Germany	DE3
Weser	DE4000	Germany	DE4
Elbe River (1/2)	DE5000	Germany	DE5
Danube (7/18)	HU1000	Hungary	HU1
Danube (8/18)	ITA	Italy	IT1
Po (1/3)	ITB	Italy	IT2
Escaut (Schelde) (3/3)	NLSC	Netherlands	NL1
Meuse (3/3)	NLMS	Netherlands	NL2
Rhine (6/6)	NLRN	Netherlands	NL3
Danube (12/18)	PL1000	Poland	PL1
Oder River (2/3)	PL6000	Poland	PL2
Wisla	PL2000	Poland	PL3
Tejo (2/2)	PTRH5	Portugal	PT1
Danube (13/18)	RO1000	Romania	RO1
Danube (15/18)	SK4000	Slovakia	SK1
Danube (16/18)	SI_RBD_1	Slovenia	SI1
Tejo (1/2)	ES030	Spain	ES1
Thames	UK06	UK	UK1

9.6 Appendix F: EU River Basins' Surface Water Status

The table below shows the EEA's recording of EU river basins' implementation of the WFD "good status" goal (rightmost column).

Table 22: The implementation of the WFD "good status" goal

River Basin	**High (%)**	**Good (%)**	**Moderate (%)**	**Poor (%)**	**Bad (%)**	**Unknown (%)**	**Total (High+ Good)**
PT1	0	63,4	14,1	5,6	1,4	15,5	63,4
SK1	25,4	37,6	33,5	3	0,4	0	63
RO1	4,3	55,2	38,8	1	0,6	0,2	59,5
ES1	3,2	50,3	24,5	9,9	6,1	6,1	53,5
FR4	7,6	44,3	38,8	5,3	2,9	1,2	51,9
FR3	2,1	47,6	41,4	4,1	2,1	2,8	49,7
SI1	5,8	41,3	38	5	1,7	8,3	47,1
BE2	1,9	42,4	26,1	12,5	6,2	10,9	44,3
AT1	18,3	23,8	51,3	5,4	1,1	0,2	42,1
CZ3	0	41,8	9,6	47,3	0	1,4	41,8
AT2	12,6	28,1	57,3	2	0	0	40,7
IT1	2,7	31,6	7,9	3,3	0,8	53,7	34,3
FR5	0,6	30,3	45,2	17,3	5,6	1	30,9

FR2	4,2	25,6	53	11	4,2	2	29,8
IT2	1,2	28,1	20,5	10,6	1,3	38,4	29,3
FR6	3,1	25,2	44,9	17,9	5,9	2,9	28,3
FR1	0	25	30,9	19,1	25	0	25
DE1	0,6	22,8	41,6	23,8	5,7	5,5	23,4
UK1	0	23,1	53,9	19,8	3,2	0	23,1
DE3	0,3	13,4	27,7	25,3	22,9	10,4	13,7
CZ2	0	13,7	9,1	76,6	0	0,6	13,7
CZ1	0	12,3	24,4	61,7	0	1,5	12,3
HU1	0,5	9,2	29,6	17,8	3,9	39	9,7
DE5	1,2	6,9	31,9	37,8	22,1	0,2	8,1
DE2	1	6,8	23,9	39	29,4	0	7,8
DE4	0,3	7,5	27,9	34,1	29,6	0,6	7,8
PL3	0,8	2,2	12,7	2,6	1,8	79,9	3
PL2	0,8	1,9	13,4	3,9	2,6	77,3	2,7
NL3	0	0,6	36	42	21	0,4	0,6
BE3	0	0	100	0	0	0	0
BE1	0	0	33,3	33,3	33,3	0	0
NL1	0	0	21,4	58,9	17,9	1,8	0
NL2	0	0	31	43,9	22,6	2,6	0
PL1	0	0	18,2	9,1	0	72,7	0