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The Ascending and Fading of a Progressive Policy Instrument: The Climate Change Factor in Southern Germany

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Received: 31 January 2020; Accepted: 3 April 2020; Published: 8 April 2020

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Abstract: The climate change factor (CCF) is a precautionary instrument for technical flood protection that was introduced in Southern Germany in the early 2000s. The CCF was designed as a surcharge value to be added to all new technical flood protection facilities, such as dams, protection walls, and retention areas. This paper deconstructs the conditions and processes that led to the creation of this new policy instrument. Following the instrument choice framework, the paper analyzes in a heuristic manner, the institutions, actors, discourses, and decision context that were part of this process from the early 1990s to 2004, when the instrument was introduced. In order to better understand the scope of this regional instrument, the paper also briefly depicts four non-representative cases of flood risk and protection management, where the instrument was either applied or avoided. The article closes with an assessment of the CCF, concluding that the innovativeness of this instrument faded once the overarching sectoral paradigm shifted from technical flood protection to more comprehensive flood risk management.

Keywords: climate change factor; flood risk management; instrument choice framework; Germany; precautionary principle

1. Introduction

Over the last 30 years, some extreme flood events have caused significant economic damage in the Southern German regions of Baden-Württemberg (BW) and Bavaria (BY), particularly the Rhine floods in 1993 and 1995; and the Danube floods in 1999, 2002, and most recently, 2013 [1]. The economic impacts left by these floods have translated, many times, into reforms of water and flood policies [2], reinforcing the reputation of "event-riddenness" of this field. In the early 1990s, the first scientific analyses on the possible impacts of climate change on extreme flood events galvanized the regional debate and expert community, and shifted the attention of the regional water and flood community to climate change. However, for close to a decade, neither scientific nor political closure could be reached on the question of causality between climate change and flood risks [3]. By the early 2000s, once some of the prevailing scientific uncertainties could be settled, the dynamics for a new policy instrument were set in motion. Driven by a strong (rhetorical) reference to the precautionary principle, the federal states of BW and BY decided in 2004 to introduce a new policy instrument, namely, the climate change factor (CCF), as a technical tool to specifically address the impact of climate change on floods above an intensity of a 100-year flood discharge (HQ100, German technical abbreviation for discharge ratio) at the regional level [4].

The focus of this paper is to deconstruct the conditions and processes that led to creating the CCF. The CCF was chosen for analysis because it was the first instrument of technical flood protection to put climate change in direct relation with increasing flood risks and because it was perceived as a highly innovative instrument being explicitly advised by scientific experts as a precautionary measure. The analysis of the creation of the CCF will be guided by an instrument choice perspective from the field of policy studies. Specifically, the paper will draw on a framework devised by Böcher and Töller [5,6]. This framework allows for a heuristic exploration and study of the different dimensions that support, enable, and limit policy change: the institutions, the problem structure, discourses on instrumental alternatives (especially scientific discourses), the actors involved, and the decision situation. In order to better understand the scope of this instrument, this paper will also depict short, non-representative cases of flood management projects that have or have not applied the climate change factor. A total of four short cases, two in BW and two in BY, will serve as aids to put the actual innovative character of this once pioneering instrument into perspective.

The paper is structured as follows: Section 2 describes and substantiates the conceptual framework and introduces the methods applied; Section 3 introduces the CCF as a flood risk management instrument, reconstructs the instrument's creation using the instrument choice framework, and sheds exemplary light on the implementation of the CCF on the ground. The paper closes, in Section 4, with a synoptic assessment of the process that led to the instrument and its short examples.

2. Conceptual Framework and Methods

Policy instruments are the technical, social, and political tools that policymakers use to directly address or influence collective action to address policy problems. Lascoumes and Le Galès [7] define a public policy instrument as, "*A device that is both technical and social, that organizes specific social relations between the state and those it is addressed to, according to the representations and meanings it carries. It is a particular type of institution, a technical device with the generic purpose of carrying a concrete concept of the politics/society relationship and sustained by a concept of regulation*." In the political science literature, there is a broad debate on the different *types* of policy instruments based on the mechanisms they deploy to influence collective action (including binding regulation, financial incentives, or information/persuasion); for an overview, see [5,8,9]. More recently, policy scholars have also been striving to better understand and explain how policy instruments are selected; i.e., the question of *instrument choice*.

Within the instrument-choice literature, there are various explanatory approaches; for an overview, see [5,10–13]. A first approach could be called "naïve instrumentalism"; this approach builds on the assumption that, "*Politicians, when faced with a political problem, have a 'tool-box' of instruments at their disposal, among which they choose the most suitable instrument for the case at hand on the basis of complete information*" [5]. Given the complexities of real-world policy contexts, this approach seems to be naïve, since it overestimates policy-makers' capacities to rationally steer action. Therefore, alternative approaches put greater emphasis on truly *political* variables. Within this group of approaches, some see the selection of policy instruments being mainly driven by cultural values or national policy styles; others conceptualize policy choice in more process-oriented terms, either seeing it as a result of political class struggles or as an outcome of institutionalized bargaining in a broader system of interest representation and its linkages to government [11]. Finally, there are also policy-choice frameworks that strive to integrate variables from various approaches. Linder and Peters, for example, list a number of contributors to variation in instrument choice clustered into systemic variables (including national policy style, political culture, and social cleavages); organizational variables (including organizational culture and clientele); problem-specific variables (including policy domain and resource limitations); and individual variables (including roles, perceptions, ideology, and values) [14].

This paper draws on one of those integrated frameworks; namely, a framework for instrument choice and instrument change in environmental policy developed and published by Böcher and Töller in 2007 [5,6,15]. The authors see instrument choice as the result of the interactions of five different dimensions: institutions, problem structure, discourses on instrumental alternatives, actors and their interactions, and the decision situation (see Figure 1). By zooming in on each dimension, the framework enables a thorough analysis of policy change and agenda setting processes without underestimating or overestimating actors, their interests and knowledge claims, prevailing or new discourses, path dependencies, policy agendas, or even "windows of opportunity" [5,6].

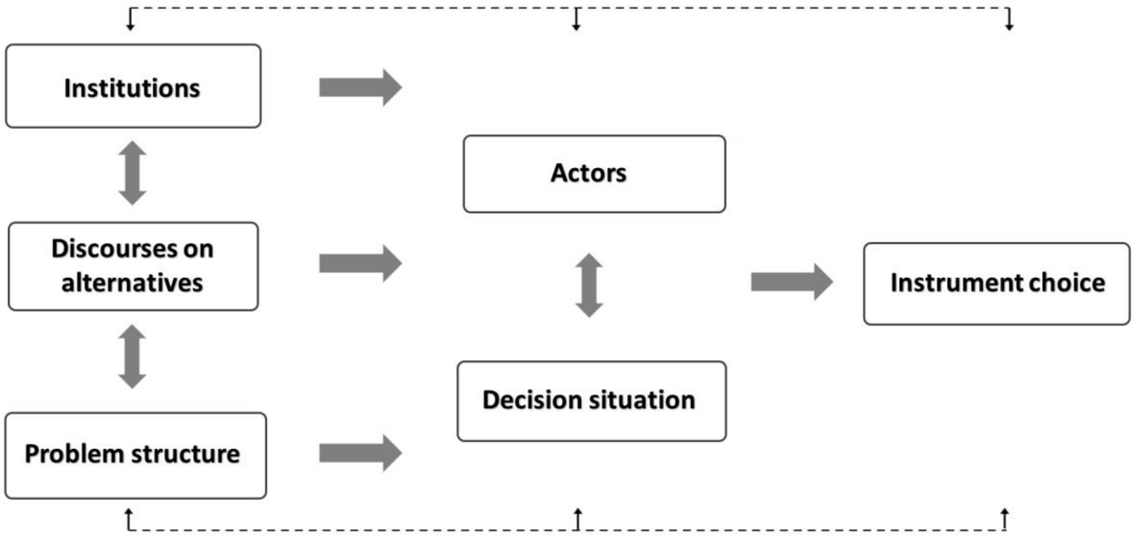


Figure 1. The instrument choice framework by Böcher and Töller, translated and slightly modified [5,6,15].

1. Institutions—understood as the formal and informal rules and norms that organize social, political, and economic relations [16]—affect the choice of environmental policy instruments "*by either extending or limiting the options available for policymakers' choices*" [5] (p. 16). Often, institutional influences hamper instrumental change by means of "path-dependency" [16]; or by "administrative tradition," where certain processes and behaviors persist for a long period of time and individuals internalize both values and rules in their own acting and decision-making [17]. However, institutions can also enable changes in instruments (e.g., via mechanism of institutional isomorphism; cf. [18].
2. The structure of the policy problem has an effect on "*the policy process, the conflicts involved, and the results obtained*" [5] (p. 16), and with that, in the end, also on the policy instrument chosen. In the field of environmental policy, relevant features include the type of environmental effect (e.g., point source versus non-point source pollution, extent of impact and response lag, degree of uncertainty and ignorance, etc.; cf. [19–21]) and the expected distribution of costs and benefits among different actor groups [5].
3. The choice of an environmental policy instrument is also mediated by prevailing—scientific and public—discourses on instrumental alternatives. Arts et al. (2010) introduced the concepts of "meta-discourses" and "regulatory discourses"; the former relates to global economics, politics, and culture in general, and the latter relates to the more specific methods of regulation and instrumentation of policy issues [22]. This can be shown in the obvious tendency that the rise of neoliberalism (as a meta-discourse) implied "*an increased role for markets, leading to an enhanced role for the private sector and voluntary regulation*" [5]. Additionally, in this dimension, scientific experts can challenge prevailing discourses by bringing in new competing claims, which might be eventually included in new policy instruments [23,24].
4. The aforementioned three factors act as boundary conditions for the scope of political actors (including state and private individual and collective actors). Building on a "wide" version of rational-choice theory, Böcher and Töller (2007) argue that actors, in principle, decide based on different action orientations [15,25,26]. Given the complexity of the field of environmental policy, actors can be driven by their (egoistic) interests or own policy agendas; however, "*Actors can also integrate ideas, experiences, intrinsic motivations or tradition. Policy actors cannot choose an ideal option*

by comparing all theoretically possible alternatives in a given case. The context of their decisions is affected by conditions of uncertainty and a limited knowledge base." [5]. Further, the relations between these different political actors influence and define the style of cooperation between scientific expertise, public administration, and policymaking, and how policymaking becomes effective practice [17].

5. Finally, the selection of a policy instrument is dependent on the specific decision situation [15]. Relevant instances include what the advocacy coalition framework spells out as "external (system) events" (including changes in socioeconomic conditions or public opinion) and policy decisions and impacts from other policy subsystems (cf. [26,27]), or what the multiple streams framework conceptualizes as "policy windows" [28]. The decision situation can be further understood as the culmination of the "process of social accommodation" among the interests of science and policy [23,24]. In this dimension the contending claims brought in by different or new actors find their way (or not) into policy change or new policy instruments [23,24].

Additionally, the analysis of Tosun (2012) on policy change and the precautionary principle aids the main analytical framework to explain the relation of this principle and the creation of new policy instruments. According to Tosun (2012), the either endogenous or exogenous origin of the stimulus for policy change can define how far-reaching such change becomes [25]. If the stimulus is initiated by actors related to the inner circle of policymakers, and not by, e.g., public mobilization, the precautionary principle can be implemented in such a way that it emphasizes precaution and serves the purposes of those involved in the policy process and the regulatory status quo [25].

An instrument-choice perspective has already been applied to various fields of environmental policy, including environmental tax reform [15], climate policy [29,30], nature conservation policy [31], agricultural policy [32], and drought policy [33]. However, there are no applications in the fields of water or flood risk policy.

This paper applies the instrument choice framework by Böcher and Töller (2007) [15] in the case of the climate change factor (CCF) in Southern Germany. The CCF was chosen as a case study because it was of the first climate change and flood related instruments introduced in Southern Germany and the wider Alpine region by that time.

Methodologically, the reconstruction of the choice process towards the CCF is based on a qualitative analysis from a social and political sciences perspective [34,35] of policy documents, project documentations, and relevant scientific and gray literature on flood risk management with a special emphasis on the German federal states (*Länder*) of Baden-Württemberg (BW) and Bavaria (BY). Between May 2017 and June 2018 a total of 26 semi-structured interviews were conducted with scientists, professional experts, engineers, and policymakers (see Appendix A). Additionally, the author participated in symposia and workshops on climate change and water management. The collected data has been anonymized, coded, and interpreted using the qualitative research program MAXQDA 12 (VERBI Software, Berlin, Germany).

Even though the paper's main focus is on the formulation of the CCF as a policy instrument, the analysis also briefly sheds light on the implementation of the CCF "on the ground," in order to give the reader a better understanding of what has become of this once pioneering instrument. For that, four non-representative implementation examples were chosen: for BW, a project on flood protection and ecology in Hockenheim (*Hochwasserschutz und Ökologieprojekt Hockenheim*) and a project on dyke relocation and flood protection at the Elz and Dreisam rivers (*Deichrückverlegung Elz-Dreisam*); for BY, a polder project near Riedensheim and flood protection measures in Passau.

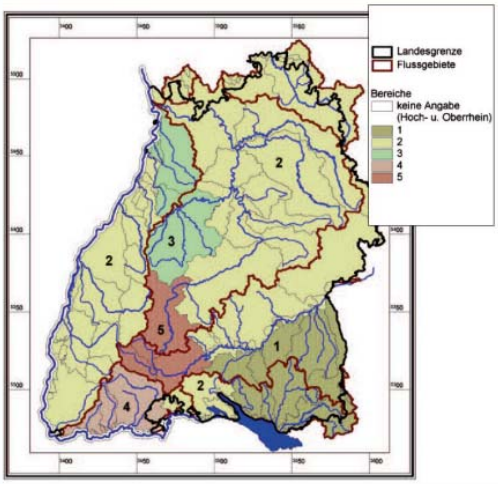
3. Results: The Climate Change Factor

The presentation of results proceeds in three steps: Section 3.1 introduces the CCF and its logic as a policy instrument; Section 3.2 reconstructs the political process of creation of the CCF (drawing on the instrument choice framework by Böcher and Töller); finally, Section 3.3 gives some short insights into how the CCF has been implemented.

3.1. What Is the Climate Change Factor?

The CCF is a precautionary instrument for technical flood protection that was introduced in BW and BY in 2004. Technically speaking, the CCF is designed as a surcharge value (in terms of a percentage markup) to be considered in the flood calculations of all new technical protection measures, such as river dikes, retention basins, flood protection walls, and dams, either as standalone projects or combined [4]. The instrument was elaborated in the context of the Cooperation Project Climate Change and Consequences for Water Management (KLIWA), a joint platform of research institutes and state agencies further described below.

While the general design principles of the CCF in BW and BY are the same, its specific configurations and contexts of emergence differ between the two *Länder*. For BW, the CCF was conceived as a range of surcharge percentages, from 0% to 75% (Figure 2), to be determined according to the location, characteristics of each catchment, and return period of the flood. The set of factors for BW were statistically calculated based on three climate models in regard to extreme weather behavior. Aspects such as land-use changes and space planning were not included in the analysis; for further information on the statistical method, see [4,36]. For BY, the CCF was introduced as a fixed and general 15% surcharge to all flood designs. Another difference in the design of the CCF between the two *Länder* is its degree of binding: In BW, the factor was introduced as a nonbinding "recommendation" in the Guideline for the Design of Technical Flood Protection Measures 2005 (LUBW, Baden-Württemberg Institute for the Environment, Survey and Nature Conservation) [36]. This Guideline recommends the competent authorities, planners, engineering offices, and local administrations to conduct a cost–benefit analysis on the planned project and to apply (or rather not apply) the CCF accordingly. While in BW the CCF is a recommendation, the Bavarian Ministry for the Environment introduced the CCF as a binding factor to be used in all new projects after 2004. However, the official decree also stipulates that it is possible for the implementing agencies "in justified cases" to apply the CCF in a "regionally modified way" [37].



Klimaänderungsfaktoren $f_{(T,K)}$

T (Jahre)	1	2	3	4	5
2	1,25	1,50	1,75	1,50	1,75
5	1,24	1,45	1,65	1,45	1,67
10	1,23	1,40	1,55	1,43	1,60
20	1,21	1,33	1,42	1,40	1,50
50	1,18	1,23	1,25	1,31	1,35
100	1,15	1,15	1,15	1,25	1,25
200	1,12	1,08	1,07	1,18	1,15
500	1,06	1,03	1,00	1,08	1,05
1000	1,00	1,00	1,00	1,00	1,00

Bemerkung: Für Jährlichkeiten T>1000 a ist der Faktor gleich 1,0

Figure 2. Climate Change Factors table for Baden-Württemberg, indicating catchments (in the columns numbered 1–5) and annuality (in the rows indicating probability of recurrence in years), (KLIWA 2004).

3.2. How Did the CCF Come to Existence?

Following the instrument choice framework by Böcher and Töller, this section outlines and analyzes the process leading to the conception and introduction of the CCF.

3.2.1. Institutions

Germany is a federalized country; thus, its jurisdiction and administration in water and flood risk management affairs is also divided between the state of Germany (*Bund*) and its federal states (*Länder*). Overall, the German system is quite decentralized and the main responsibility lies with the level of the *Länder* [38]. The *Bund* provides framework legislation, while the administration and implementation of flood protection and risk management measures fall into the responsibility of the *Länder* and its municipalities.

The institutional framework, both in terms of pertinent legislation and administrative responsibilities, has changed over time, often as a reaction to major flood events [2]. A ruling of the 1957 Federal Water Act (*Wasserhaushaltsgesetz*) saw an extensive reform in 1996 as a reaction to the floods of the Rhine in 1995 and the Christmas floods of 1993–1994 [2]. This reform brought into legislation the first notions of integrated flood protection; e.g., explicitly calling for inundation zones and the preservation of existing and the restoration of former retention areas. Another reform of the legislation was brought as a consequence of the disastrous floods of the Elbe and the Danube in 2002. In 2005, Germany got—for the first time—a federal flood control act (*Hochwasserschutzgesetz*). Guided by the need to implement the European Water Framework Directive 2000/60/EC, this act introduced the concept of flood-prone zones, extended the scope of flood control and protection, and demanded federal state water management agencies to develop flood protection plans for the first time. Another major reform was passed in 2009/2010. This reform was not so much driven by specific flood events, but rather by the need to implement the European Floods Directive 2007/60/EC [39–41]. For the sake of this analysis it is important to note that both the 2005 and the 2009/2010 reforms happened *after* the introduction of the CCF and are therefore could not influence the factor's genesis. This suggests that the CCF was introduced on the verge of both the introduction of major institutional and regulatory changes at the national (and even European) level that would later guide the debates and adoption of flood risk and adaptation measures.

Another important institutional dimension, besides the legislative framework, is the *administrative* setting of the water and flood risk management sector. Both *Länder* saw an administrative reform in the early 2000s. This reform affected the competencies of local water and environment authorities, including the state environmental agencies (LUBW and LfU, Bavarian State Office for the Environment, further described below) (Interviews DE07; DE11). The reform of the environmental administrative system of BW eliminated the Water Directions and integrated those responsibilities into the regional administrations (*Regierungspräsidien*) in 2005/2006 [42]. In contrast, the Bavarian administrative reform of 2003 did not bring deep changes into the structure of the water and flood administration sector. However it did reduce the number of personnel of the different administrative and technical levels, including LfU [42].

From an organizational and institutional perspective, in BW four regional district administrations (*Regierungspräsidien*) are responsible for the technical administration and implementation of flood risk management projects in all category 1 water bodies, and they support municipalities and districts in their administration of category 2 water bodies. Similarly, in BY seventeen regional water authorities (*Wasserwirtschaftsämter*) are responsible for the technical administration and implementation of flood risk management projects in all category 1 water bodies, and for the support to municipalities and local governments in their administration of category 2 water bodies. These rather organizational changes neither affected the way German bureaucracy cooperated with external scientific and technical experts (further explained in Section 3.2.4), nor changed its distinctive corporatist and legalistic policymaking style [17].

3.2.2. Problem Structure

Flood risk management is a very technical policy field [3]. This implies, inter alia, that it is challenging for policymakers to recognize and understand the causes and effects of floods due to inherent complexities and stochastic uncertainties. The professional culture [43] of flood management is traditionally connected to measuring and predicting the behavior of climate, weather, and precipitation as sources of the problem, and the consequential planning and construction of technical flood protection measures as solutions to the problem. Both the definition of the problem and the policies that deal with the problem are disaster driven, meaning that each major flood event creates renewed pressure mostly on policymakers to give rushed real solutions [44,45].

The technical properties of the field imply that "knowledge actors" [46] play a heightened role in the flood management sector. Experts come mostly from the natural sciences, including hydraulic engineering and civil engineering. Scientists play an important role, particularly for risk assessments, while professionals and practitioners (e.g., in research institutes, public agencies, or engineering companies) become more important when the discussion turns to risk management. There is close cooperation between scientists and policy-makers, often including double roles and changes of roles [3]. These characteristics of the community condition the perception and the definition of floods, as problems that can be measured, planned, and contained (Interview DE26). At the same time, the precautionary principle has also played a prominent role in the sector. Historically, the emergence of the precautionary principle (and its spread to neighboring countries) has been associated to German environmental policy making of the early 1970s, and it has since become one of the fundamental principles of German environmental policymaking [25,47,48]; it has also provided general orientation for flood risk management for decades [49]. Increased uncertainties due to the possible impacts of climate change on the frequency and magnitude of floods have led to a revitalization of the precautionary principle in flood risk management. From the beginning until today, the CCF has been presented and legitimized primarily as a "precautionary instrument."

3.2.3. Discourses on Instrumental Alternatives

In Southern Germany, there has been high awareness of flood risks, primarily due to these major floods events: BW and BY witnessed floods with devastating losses in 1993 and 1995 along the Rhine, Alpine floods in 2000 and 2005, and Danube floods in 1999, 2002, and 2013. Additionally, one sees a high level of general awareness among the German population for the impacts of environment-related catastrophes, and since the late 1990s an increasing awareness for climate change [50]. Nevertheless, it took quite a while for the Southern German flood risk community to embrace climate change as a possible driver for floods (Interviews DE03; DE22). Even though the first IPCC reports already pointed to a possible link between climate change and flooding, this debate only took off at the regional level when the hydrologists Bárdossy and Caspary published the first studies on the connections between climate change, European atmospheric circulation patterns, and extreme flood events for South Germany [51,52]. In their studies the scientists concluded that the change in seasonal and monthly frequencies of circulations patterns, and the subsequent more frequent mild and humid winters, and extreme flood events in some catchments, could be also due to the influence of anthropogenic climate change, and warned that, *"We are already in the middle of a serious climatic and hydrological change process"* [51,52]. These publications put the influence of climate change on extreme flood events at the focus of regional scientific debate decades before major studies confirmed a strong correlation between climate change, increased rainfall, and extreme flood events for Central Europe, and at regional level [53,54]. At first, these studies were received by the local water community rather negatively and with sharp critiques to the chosen methodological approach, casting doubt over the actual influence of human-induced climate change on extreme flood events (Interviews DE04; DE08; DE22). Yet, the disruption of the climate change argument into the scientific and policymaking debate forced the community to question existing measuring and modelling methods; to recognize the necessity of more and better scientific knowledge on regional hydrological and meteorological phenomena, and on regional climate modelling (Interviews DE07; DE22); and to address the causality between climate change and extreme flood events.

By the end of 1990s, the scientific and technical debate had shifted from a rather closed position to a more exploratory approach, yet did not include debates on other more comprehensive alternatives from the perspective of land-use or spatial planning, or socio-environmental analysis. This development, coupled with the window of opportunity generated through the late 90s floods (DE03), led to the creation of an expert network with the sole research agenda of analyzing the causality between climate change and (initially) extreme floods (KLIWA, see below), out of which the CCF was created. Debates on adaptive instrumental alternatives for a climate change influenced flood risk field gained importance and presence in this field after 2005; that is, after the debate on the CCF, when the 2008 German Adaptation Strategy (DAS) reached the regional and local level; some of these instruments included climate and floods insurance, climate proofing, heat warning systems, inter alia [55].

3.2.4. Actors

In BW and BY, the sectors of flood risk management and climate change are, as in many other countries [56,57], quite strongly dominated by actors with a technical-scientific background or stance. Here, the state environment agencies, as public bureaucracy branches, play a special role: the State Institute for Environment, Measurements and Nature Conservation for Baden-Württemberg (*Landesanstalt für Umwelt Baden-Württemberg*, LUBW) and the Bavarian Environment Agency (*Bayerisches Landesamt für Umwelt*, LfU) act as technical advisors that moderate and translate between science and policymaking (Interviews DE03; DE07; DE11). Officials of both agencies work closely with departments in their respective environmental ministries, and with technical officials of the regional district administrations in BW and the water administrations in BY. Their role as translating connectors between science and policy gained particular relevance once the context of climate change brought in increased uncertainties to the discussion, and they helped to institutionalize climate change related scientific advice, even before it was done at the national level. The network of relevant actors is complemented by university institutes, especially in the fields of hydrology, hydraulic engineering, and climate change, which are in regular exchange with each other and with the public administration. Other important actors are engineering companies that provide different services to the public administration and environment agencies. The administration structures and steers its work with research and engineering companies via short-time (research) projects, tendering calls, or by assigning contracts directly to experts in the field.

An important new actor in the field was the Cooperation Project Climate Change and Consequences for Water Management (*Kooperation 'Klimaveränderung und Konsequenzen für die Wasserwirtschaft'*, KLIWA). KLIWA was formally established in 1999 by the Environment Ministries of BW and BY, in cooperation with the German Meteorological Office (DWD) [58,59]. KLIWA was created as an open-end research project to scientifically and technically examine the connection between climate change, extreme flood events, and further impacts on the water sector, and to provide science-based recommendations for policymaking (Interviews DE03; DE 07; DE22). The creation of KLIWA was preceded by a scientific debate on the connections between climate change, atmospheric circulation patterns, and extreme flood events in the early 1990s, driven mainly by the second IPCC report and its statements on the global increase of floods due to climate change; and a set of publications by the hydrologists Bárdossy and Caspary [51,52], who reviewed the situation for Southern Germany; for an overview, see [3]. Since its creation, KLIWA has served as an important science-policy interface for knowledge creation and exchange, but principally for drawing attention to climate change as a global and local threat to water systems. In the beginning, its thematic focus was strongly on the causality between climate change and floods. Later on, KLIWA expanded its research to include flash floods, ground water, droughts, water ecology, and biodiversity. KLIWA interacts with the technical community and the wider public through regular symposia, the publication of monitoring reports, and the dissemination of informative leaflets. The symposia in particular, which are organized every 3 to 4 years, have become an important channel for visibility and dialog with the technical community. The symposia also serve as a platform to officially present KLIWA's policy recommendations, and secure and maintain the presence of scientific expertise in local policy processes. One of the very first explicit policy recommendations of KLIWA was the CCF: in 2004, KLIWA recommended the creation of a technical flood protection instrument to be implemented in all new flood protection projects [4].

3.2.5. Decision Situation

As an overarching objective, KLIWA has striven to expand regional knowledge regarding climate change and floods, and to reduce related scientific uncertainties for the technical flood management sector. In the early years, the coordination of KLIWA assigned scientists of the former Technical University of Karlsruhe (today Karlsruhe Institute of Technology, KIT), in close coordination with experts from LUBW, to pursue long-term statistical analyses of extreme flood values, taking the BW-Neckar catchment as an exemplary case study [4]. On the basis of these analyses, experts could table the first regional hydro-climatic results, an analysis meant to be later replicated for the BW-Danube, Rhine, and Main catchments. These first results were welcomed by LUBW and LfU experts because they gave applicable figures for practitioners and implementers to use on technical flood protection projects (Interviews DE03; DE07; DE22). Additionally, the BW-KLIWA team assigned an engineering company to pursue pilot case simulations on different technical flood protection measures in the Black Forest region. Eventually, the BW team presented their results during the 2nd KLIWA Symposium in Würzburg, hosted by the Bavarian Government in May 2004. As part of this presentation, they also recommended the implementation of a differentiated CCF [4] (see Section 3.1 and Figure 2).

The activities and results of the BW side put pressure on the BY side. Even though the KLIWA context allowed for the technical and scientific exchange and debate among its members, each environment agency still had the leading role in their respective *Länder*. Due to insufficient personnel capacities the Bavarian KLIWA working groups could only table a first analysis of the impact of climate change through water balance model simulations for the Upper Main catchment in early 2004 (Interviews DE03, DE07; DE11; DE22). In contrast to their colleagues from BW, the Bavarian team did not yet have regionalized flood simulations under climate change conditions. Nevertheless, the Bavarian Minister of the Environment, as host of the 2004 KLIWA Symposium in Würzburg, still decided to announce at the inauguration of the symposium, the creation of a CCF in BY as well. Interviewees describe this decision as very ad hoc-ish and largely driven by political motivations (Interviews DE03; DE07; DE11; DE08; DE04; DE06; DE22). The Minister justified his decision through reference to the precautionary idea of taking action in spite of high uncertainties, but allowing for future corrections of adaptations of data and modeling ("no regret measure"). In the years following the decision, the Bavarian side complemented its data and projections and published them in later KLIWA reports [60].

3.3. How Is the CCF Actually Implemented?

Having been introduced in 2004, the CCF is already a relatively "aged" policy instrument. Even though the analytical focus of this paper is on the creation of the CCF (through the lens of the instrument choice framework), this section still strives to shortly picture how the CCF has been implemented. In formal terms, the CCF is thought to have been applied (or at least calculated) on all technical protection measures in BW and BY since 2004. According to interviewees, the factors have not been revised or updated ever since. Experts argue that the scientific basis (i.e., regional climate models) "remains valid and relevant" (Interviews DE07; DE11), even though there has not been an explicit evaluation of the scientific basis of the instrument. Up to date, neither of the two Länder has systematically evaluated the implementation of the CCF, nor measured its impact or outreach. There is also no official record, or partial or comprehensive mapping of the number and type of projects constructed under consideration of the CCF. LUBW made one attempt to survey the BW-district administrations and municipal administrations on the number of technical flood measures planned and constructed with the CCF since 2005; however, LUBW was not successful in this attempt (Interview DE07) and has not pursued any further efforts. Thus, overall the information basis for the implementation of the instrument is quite weak and fragmented through different government and administration levels. Practitioners see the applicability of the instrument as strongly dependent on the technical (i.e., hydraulic, geographic, and hydrological) context of each project. Even though the factor is meant to be considered for all technical flood protection measures, it is almost exclusively used in linear measures and not in wide retention measures, such as retention basins or polders (with restrictions).

Considering that there is no official register or systematic account of the projects actually built with (or without) the CCF, the following implementation and non-representative examples serve an exploratory purpose only. The presentation of this examples does not intend to assess the impact of the CCF on flood mitigation projects, or assess whether and how the implementation has protected people and infrastructure from floods under climate change, or assess its effectiveness in combination with other flood risk management instruments. These examples are an attempt to give the reader a short insight into what became of the CCF after its creation. Cases were chosen based on the suggestions of regional experts in the field; selection criteria are (i) the type of technical flood protection measure and (ii) the explicit use of the CCF (yes/no).

Flood Protection Projects and the Climate Change Factor

The four chosen project examples show altogether a rather timid and secondary consideration of the CCF, even though technically the 2004 calculations, i.e., factors, are still valid and therefore applicable [61]. In the first example, the administration of the town of Hockenheim together with LUBW, following the BW Guideline for the Design of Technical Flood Protection Measures, commissioned the retrofitting of the Mühlkanal channel and the Kraichbach creek in 2001. The city had not suffered extreme flood events during the previous twenty years (Interview DE20), so there was not a public awareness of the correlation between climate change and extreme flood events. The engineering company conducted the CCF cost–benefit analysis and determined a favorable and affordable ratio of 2.01 for the project to be constructed with HQ100 plus a CCF markup of 15%, which translates into an increase of ca. 20 cm of dam height to cope with 15.8 m^3/s discharge [62]. After several delays, the project gained more acceptance, publicly and politically, once the planed protection walls and embankments were complemented with renaturalization measures (following the 2003 EU Water Framework Directive), even though the ecology part was significantly costlier than the flood protection part (Interviews DE18; DE15; DE20; unpublished project documents). In the end, the CCF was implemented below the perceptional threshold ("radar") of the public, and as an affordable extra protection for the city's downtown.

In the second BW example, the project area of the Elz/Dreisam in southern BW was already identified back in 2002 as an option for compensatory measures with renaturalization focus (Interview DE21; unpublished project document). A dyke relocation combined with foreshore renaturalization was constructed to provide HQ100 plus freeboard, and 100,000–280,000 m^3 retention volume without CCF. Hydraulic simulations showed that the gained retention and, in consequence, flood protection promised to be secured mainly through the renaturalization of the riparian forest (Interviews DE23; DE24). Even though the BW Guideline for the Design of Technical Flood Protection Measures indicate an obligatory assessment of the cost–benefit ratio of applying the CCF; according to interviewees, such analysis was not conducted, because the project was mainly targeted at compensatory renaturalization; enhanced flood protection was only seen as a secondary aspect (Interview DE24). Awareness of climate change or of the CCF did not play a role, neither publicly nor in the local administration. Due to the strong renaturalization argument and the "additional plus" given by the flood protection measure, the project was positively received by the local municipalities (Interview DE21).

In the third example, the Bavarian city of Passau, situated at the confluence of the rivers Danube, Ilz and Inn, has endured several intense flood events over the decades. In 2009, the Water Administration of Deggendorf and LfU published a flood protection feasibility study that considered the flood discharge of the 1954 peak flood event plus 0.3 m freeboard. However, this study did not recommend the use of CCF. Only after the extreme flood event of June 2013 [61] the public pressure on the city's administration and the regional water administration increased, as citizens demanded improvements of the technical flood protection and the catastrophe warning systems (Interview DE25). In 2014 the LfU revisited the aforementioned study and confirmed that there is no technical justification to forego the CCF. The water administration and the LfU determined six sites for different flood protection measures; i.e., a combination of protection walls and mobile systems to provide protection for a design discharge of 10,120 m^3/s with HQ100 plus 15% CCF justified as "economically and technically feasible" [63]. The 2013 floods brought more local awareness of the consequences of climate change on floods. The planners argue that the implementation of the CCF means "mostly 10 cm to 20 cm higher construction, which has a marginal cost effect on a 3 m to 4 m high protection measure" (Interview DE25).

After the 1999 spring floods, the Government of Bavaria issued an Action Program for Flood Protection (*Hochwasserschutzaktionsprogramm 2020*) to expand the retention capacity through the construction of controlled polders [64]. Commissioned by the Bavarian Ministry of Environment and the LfU, the Technical University of Munich conducted between 2012 and 2014 an extensive study on future flood waves and discharge along the Bavarian Danube. This study suggested up to twelve potential sites for controlled combined polders along the river, with retention capacity of approximately 136 Mio. m^3 for scenarios in the range between HQ200 and HQ300, which are above a HQ100 + 15% CCF scenario [65,66]. According to interviewees, the technical planning of this Polders Program, once one of the flagship programs for the Bavarian Ministry of the Environment, implicitly included and even exceeded the CCF, making an explicit cost–benefit analysis of a CCF unnecessary. In spite of existing awareness of the consequences of climate change on flood events, some local groups are strongly opposed to the Polders Program. The first polder nearby Riedensheim with a retention capacity of 8.1 Mio m^3 is expected to be finished in Winter 2019–2020 and tested in 2020 [67].

4. Discussion and Conclusions

This paper strove to reconstruct the creation of the CCF as an—by the time of its formulation—innovative instrument of flood risk policy. Building on the instrument choice framework by Böcher and Töller [5,15], the paper argued that the elaboration of the CCF can be understood along the interplay of five different factors: institutions, problem structure, discourses on instrumental alternatives, actors and their interactions, and the decision situation (see Figure 1 above).

The CCF was introduced in BW and BY in 2004. By that time, the flood risk community of the two *Länder* was still operating largely in a classical safety paradigm of technical flood protection [3]. The ruling Federal Water Act of 1957 had been reformed in 1996 and again in 2002, and both reforms introduced only first notions of integrated flood protection and restoration of natural retention areas. Further, by the time the CCF was introduced, Germany had not yet introduced the EU Flood and Water Directives into its national and federal legislation. Therefore, the ruling institutional setting and administrative tradition or path dependency [5,6,17] reinforced the traditional definition of floods and their impacts as problems that can be measured, monitored, and contained, and where technical solutions provide necessary, tangible protection. This made the CCF with its "technical markup logic," the perfect fit for including the complex challenge of climate change yet managing the emerging tension between innovation and prevailing discourses [17]. While the flood risk management field was in the middle of an "institutional modernization," the CCF was being formulated to remain isolated in the technical flood protection and therefore to be less accessible for complex flood risk governance processes. This institutional conditioning is reflected in the implementation of the instrument on the ground.

The early 1990s saw high public and scientific awareness for climate change; however, at the regional level climate change was not yet strongly been associated with extreme flood events. A discursive shift was only brought with the scientific publications by Caspary and Bárdossy on connections between climate change, atmospheric circulation patterns, and extreme flood events for South Germany [51,52]. The debate kicked off by these publications challenged the prevailing scientific and policy discourses, and motivated a reconfiguration of the actor landscape. The creation of KLIWA as a joint research project set a new research agenda focused on scientific analysis of the connections between climate change and extreme water and flood events, provided an effective hybrid platform of knowledge exchange between policymakers and experts, drew attention from policymakers to climate change impacts on water systems. The aforementioned institutional changes through the EU Flood and Water Directives did bring the expectation of more participation and inclusion of non-scientific or non-technical actors into the flood risk management field in general. Nevertheless, the actors' landscape remained a rather scientific-technical realm in the practice, and the CCF as purely technical instrument failed to update and profit from these institutional changes. Hence, the actors involved in the analysis of cost–benefit and technical applicability of the CCF are still primarily hydraulic-engineers and hydrologists. In other words, even though new actors and new knowledge disrupted the prevailing system, the change process could not fully challenge all existing assumptions. The CCF could not became a "major policy change" [28] mostly because the problem definition, the disrupting knowledge, and the actors involved were still contained in an overarching "technical fix" paradigm. This is inevitably reflected in the implementation of the CCF on grounds which remain conditioned to be mainly technical; i.e., it tends to exclude deliberations on, e.g., the social–environmental and environmental–political aspects, and it fixates the participation of non-technical actors to the aftermath of extreme flood events in the form of public pressure, as in the example of Passau.

After the disruption of climate change related studies in the flood risk management community, KLIWA soon became the ideal context in which the CCF could be technically forged and politically legitimized. Through the creation of the science-policy interface KLIWA, and the effective inclusion of further scientific disciplines in the analysis of climate change impact on floods, one can argue that change in the policymaking agenda and even in the administrative tradition of the flood risk policy community itself was indeed well on track. Yet, the pathway of scientific influence on policy change in the form of the new CCF instrument ended up being an a staged one: First, KLIWA engaged, in more technical terms, in the compilation of historical flood data series and the promotion of regional hydro-meteorological modelling. Next, it derived policy-relevant and evidence-based conclusions, which eventually materialized in the CCF as a new and concrete instrument. For this technical instrument to be quickly accepted by policymakers, politicians and the public, it was (and continues to be) discursively linked to the precautionary principle as a well-known and approved principle of German environmental policymaking in the context of high uncertainties. Even though the provisional nature precautionary principle makes the CCF by definition an "upgradeable" instrument, neither scientific experts nor policymakers have initiated a revision of this policy. This can suggest that such an update has remained absent because the kindling incentive for creating this instrument came from the same actors already belonging and/or related to the technical flood risk community—what Tosun (2012) defines as "inside access" policy change model that tends to leave a broader spectrum of actors outside the process [25]. The staging of the CCF as a precautionary measure served more to maintain technical flood protection paradigm, than to enhance flood risk policy to a more comprehensive flood risk management approach. The creation process of this instrument, by means of its straightforward design, failed to include means for future change or update of the instrument, and therefore failed to insert itself in the new institutional setting that came into place soon after 2004, and in the debates on alternatives to broader flood risk management measures, beyond the "contain and control" narrative that prevailed in the water and floods community for decades. The necessity to develop own regional i.e., local modelling methods became the priority of the nascent KLIWA, and the CCF became the first palpable result of this for its time innovative science-policy project.

This article aimed to contribute to research on policy change in flood risk management by taking a closer look at the dimensions and science-policy interaction that generated the Climate Change Factor as one of the first climate change adaptation and precautionary instruments of Southern Germany. Through the lens of the Instrument Choice Framework, this article showed how policy change processes are almost inevitably conditioned to the interaction of all dimensions, i.e., the disruptive character of new knowledge, a natural disaster, or a "window of opportunity" may not suffice for bringing attention to pressing climate change related issues, and certainly not enough for significant policy change to happen, or to be effective on the long run. The CCF, alone by its name, communicates the promise of almost tangible protection against climate change induced threats, independently of the consequences of applying it (or not) on actual flood risk measures. It can be said that the CCF was, by the time of its creation, promised a quite progressive policy instrument that was meant to have high impacts on flood risk management. As the above short depiction of four projects in BW and BY showed, the implementation of the CCF did not necessarily live up to the high expectations of the early years. Neither of the two *Länder* has systematically evaluated or followed up on the impact of the CCF's implementation, and there is no official data on its effectiveness. Yet, the CCF continues to be rhetorically used as an effective flood risk management tool against the impacts of climate change. The case studies presented in this paper indicate that the instrument can be used when political or public pressure and risk awareness are high, e.g., after a major flood event, and when the extra costs linked to the factor's implementation are low or costs are covered by a third party. Thus, while regional experts and policymakers still argue that the CCF remains a valid and relevant climate change adaptation instrument, its implementation (or the lack thereof) indicates the fading of an instrument meant to be progressive. This generates a necessary call for further and deeper research on the impact and effectiveness of science-based instruments, the effective changes and impacts of precautionary instruments, and the limitations of scientific expertise in heavily technical policy fields, such as the climate change and flood risk field. Such scientific analysis is without a doubt necessary, especially in current times, where science-based policy making for climate change and risk management is requested like never before.

Funding: This research was funded by the AUSTRIAN CLIMATE AND ENERGY FUND, grant KR14AC7K11809. The article processing charge was funded by the Baden-Wuerttemberg Ministry of Science, Research and Art and the University of Freiburg in the funding programme Open Access Publishing.

Acknowledgments: The author would like to thank Michael Pregernig for his valuable and constructive guidance and comments, and Felicia Linke for her valuable support in the review of the hydrology related literature.

Conflicts of Interest: The author declares no conflict of interest. The funders had no role in the design of the study; in the collection, analysis, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Appendix A

Table A1. List of expert interviews conducted in Baden-Württemberg and Bavaria.

Code	Function	Date
DE01	Baden-Württemberg Regional district administration	3 May 2017
DE02	Baden-Württemberg Regional district administration	11 May 2017
DE03	LUBW, Baden-Württemberg Institute for the Environment, Survey and Nature Conservation	24 May 2017
DE04	Technical University Stuttgart	30 May 2017
DE05	Baden-Württemberg Regional district administration	19 June 2017
DE06	Karlsruhe Institute of Technology	4 July 2017
DE07	LUBW, Baden-Württemberg Institute for the Environment, Survey and Nature Conservation	4 July 2017
DE08	University of Stuttgart	5 July 2017
DE09	Baden-Württemberg Ministry for Environment	12 July 2017
DE10	Baden-Württemberg Regional district administration	27 July 2017
DE11	LfU, Bavarian State Office for the Environment	8 August 2017
DE12	LfU, Bavarian State Office for the Environment	09 August 2017

Table A1. *Cont.*

Code	Function	Date
DE13	Baden-Württemberg Regional district administration	18 August 2017
DE14	LfU, Bavarian State Office for the Environment	4 September 2017
DE15	Baden-Württemberg Regional district administration	19 September 2017
DE16	German Meteorological Service	21 September 2017
DE17	Engineering company	28 November 2017
DE18	Engineering company	28 November 2017
DE19	Bavarian regional water administration	30 January 2018
DE20	Baden-Württemberg City Administration	15 February 2018
DE21	Baden-Württemberg Regional district administration	22 February 2018
DE22	LUBW, Baden-Württemberg Institute for the Environment, Survey and Nature Conservation	10 April 2018
DE23	Engineering company	23 April 2018
DE24	Engineering company	24 May 2018
DE25	Bavarian regional water administration	11 June 2018
DE26	Technical University of Munich	15 June 2018

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