



Proceeding Paper

# Hydrodiplomacy and Climate Change: An Assessment of the Transboundary River Basins of Greece <sup>†</sup>

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**Abstract:** Hydrodiplomacy is the emerging framework where legal acts, based on technical data and information, aim to support commonly accepted solutions to water-related tensions among states with transboundary waters. In this research, hydrodiplomacy components in relation to (a) policy, (b) preventive, (c) cooperative, and (d) technical aspects are considered together with climate change, which is bound to destabilize the core element of hydrodiplomacy, i.e., water. The study area is composed of the five transboundary river basins of Greece. The coupling of all these different nature elements is conducted with the use of the AHP multicriteria method, and the results of a normalized output that quantifies water transboundary cooperation in the climate crisis era are given.

**Keywords:** hydrodiplomacy; transboundary cooperation; shared waters; climate change; Maritsa/Meric/Evros; Mesta/Nestos; Struma/Strymonas; Vardar/Axios; Vjosa/Aoos

## 1. Introduction

Fragile issues that are based on the current status of systems, such as the management of transboundary waters, are highly probable to be destabilized by the induced changes of climate change to water resources. The latest IPCC's report on climate change (AR6) [1] outlines a high confidence that the observed increase in extreme precipitation is associated with an increase in the frequency and magnitude of river floods. High confidence is also expressed on the linkage of the increased frequency and the severity of agricultural/ecological drought with the anthropogenic warming over the last decades. Regarding the future, the report outlines with great confidence mean streamflow decreases in the Mediterranean, as well as flood increases in the same area in terms of magnitude, frequency, and seasonality. Additionally, the upscaling of water management issues from a national level to an international one, i.e., the cases transboundary water resources, will jeopardize existing balances and cooperation agreements. The latter are based on historic water records, with their creditability and accuracy to be doubted under climate change conditions due to the foreseen spatiotemporal variations in relation to the hydrological cycle components.

The mitigation of past hydro-political tensions over shared water systems is confronted by hydrodiplomacy, i.e., the emerging framework that fosters diplomatic processes for resolving or restricting current or imminent disagreements or conflicts between countries that share common water resources [2]. It has been established that in general, nations with active water cooperation share peace, while nations at risk of going to war over issues other than water, tend to not have active water cooperation agreements with the riparian states they have conflicts with [3]. Keskinen et al. [4] introduce a stepwise Water Diplomacy Paths approach for assessing water diplomacy actions, and the authors recognize five key aspects for water diplomacy, and these the political, preventive, integrative, cooperative, and technical aspects.

The research's objective is to assess the impact of climate change on hydrodiplomacy. To do so, and based on the approach proposed by Keskinen et al. [4], the hydrodiplomacy



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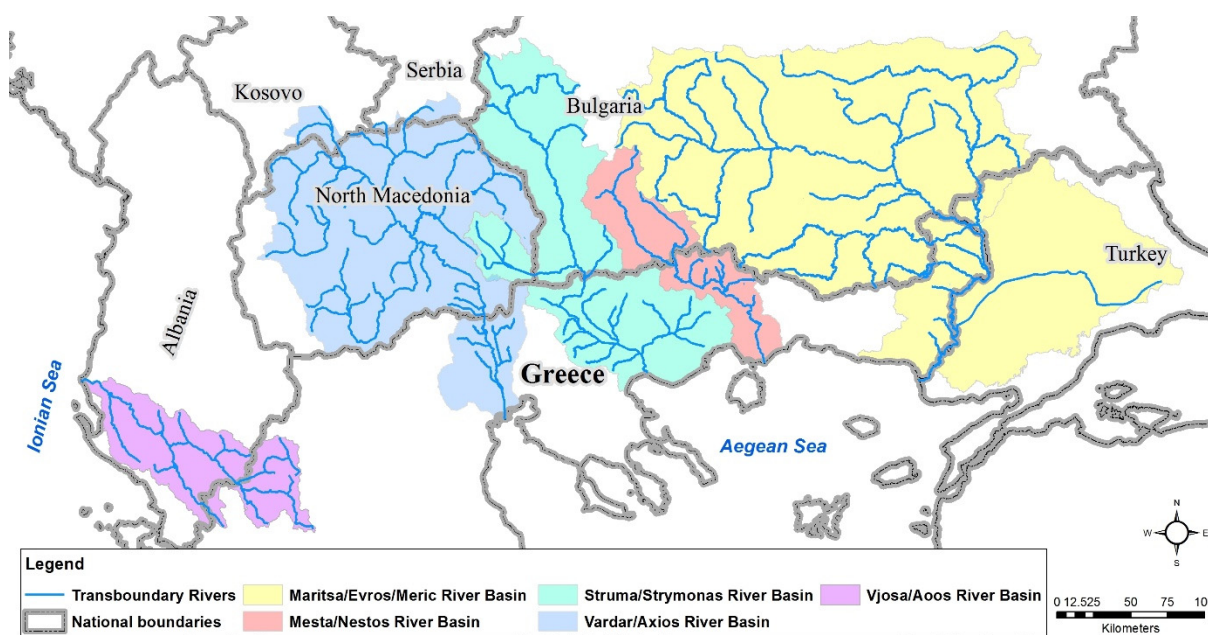
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components laid on (a) policy aspects, such as cooperation agreements and common legal frameworks on water management, (b) preventive aspects, such as socio-political tensions, human pressures on hydrosystems, and historical disputes among riparians, (c) cooperative aspects, such as joint development and research programmes and projects, and (d) technical aspects, such as the quality and quantity status of the transboundary waters, are assessed together with climate change features. The latter are expressed as (e) climate change-related studies on transboundary waters and as (f) climate change-related ratified agreements and protocols. The coupling of the various components is communicated through an index, which is applied in the transboundary river basins of Greece and reflects water-related transboundary cooperation.

## 2. Materials and Methods

### 2.1. Case Study Area

The case study area consists of the five transboundary river basins that Greece shares with its neighboring countries. Particularly from east to west, Greece shares with Bulgaria and Turkey the Maritsa/Meric/Evros river basin, with Bulgaria the Mesta/Nestos river basin, with Bulgaria and North Macedonia the Struma/Strymonas river basin, with North Macedonia the Vardar/Axios river basin, and with Albania the Vjosa/Aoos river basin [5], Figure 1.



**Figure 1.** Illustration of the transboundary river basins of Greece that are shared with the neighboring states.

In terms of water policy, Greece and Bulgaria are the only two states that have common environmental policies since both belong to the European Union (EU) and the water governance follows the EU’s Water Framework and Floods Directives. As a derivative of the Directives’ implementation process, both countries have developed River Basin Management Plans (RBMPs) and Flood Risk Management Plans (FRMPs); thus, the chemical and ecological status of the river water bodies, as well as the pressures on the hydrosystems, have been identified [6]. On the other hand, for the parts of the basins that do not belong in EU Member States, limited information about the water quality status at finer scales is available. However, information relative to population densities, irrigated agriculture demands, and hydropower production can be exploited from the literature [7].

The water-related transboundary disputes between Greece and the other riparian states can be classified into two main categories: one that involves water quantity issues,

such as floods, and one connected with water quality issues. Induced floods from the transboundary waters appear in the Maritsa/Meric/Evros and Struma/Strymonas river basins, while degraded water quality inflows from the upstream countries are mentioned in the Mesta/Nestos and Vardar/Axios river basins [6,8–10]. On the other hand, no water-related transboundary pressures appear in the case of the Vjosa/Aoos river basin. The latter basin, together with the Mesta/Nestos one, are basins where a bilateral agreement exists between the riparian states. Toward this direction, since 2010 Bulgaria and Greece have formulated an active joint expert working group that focuses on the implementation of the EU Directives within their shared waters.

Finally, in terms of climate change, all countries of the case study area have ratified the Kyoto protocol and the Paris Agreement for climate change mitigation and adaptation. Greece, Bulgaria, and Turkey have developed national and regional adaptation policies [11]. On the other hand, North Macedonia and Albania have not proceed with implementing the derived obligations from their international commitments. As for the research on climate change impacts on the transboundary waters, which is expressed through the number of scientific publications, the literature shows that for the Maritsa/Meric/Evros and Mesta/Nestos river basins there have been 6 and 9 published scientific articles, respectively, while 5 publications have been conducted in relation to the Struma/Strymonas river basin, e.g., [12–20]. In the case of the Vardar/Axios and Vjosa/Aoos river basins, 4 publications have been identified for each basin, e.g., [21–23]. To sum up, in the research, all the aforementioned factors, together with climate change, are considered fundamental assets in hydrodiplomacy, with the importance score of each factor/criterion to be given in Table 1.

Table 1. Proposed criteria and scoring scale of each criterion.

No	Criteria	Scoring Scale	No	Criteria	Ranking Scale
1	Rivers' chemical status	Good status > 75% = 5 Good status ~ 50% = 3 Good status < 20% = 0	7	Historical disputes between the riparian	No disputes = 5 Few disputes = 3 Multiple disputes = 0
2	Rivers' ecological status	Good status > 70% = 5 Good status ~ 45% = 3 Good status < 15% = 0	8	Active cooperation agreements	>3 agreements = 5 1–2 agreements = 3 No agreement = 0
3	Vulnerability to floods	No vulnerability = 5 Moderate vulnerability = 3 Vulnerable system = 0	9	Common legislative framework	Yes = 5 Partially = 3 No = 0
4	Population density	Inhabitants/km <sup>2</sup> < 20 = 5 Inhabitants/km <sup>2</sup> ~ 70 = 3 Inhabitants/km <sup>2</sup> > 100 = 0	10	Indicator 6.5.2 of SDG2030	>90% = 5 ~50% = 3 <20% = 0
5	Agriculture activities	Minimum < 10% = 5 Moderate ~ 40% = 3 Extensive > 70% = 0	11	International CC policies in national legislation	Yes = 5 Yes, but not in force = 3 No = 0
6	Hydropower generation	Production < 0.1GW = 5 Production < 0.3GW = 3 Production < 0.6GW = 0	12	Publications on CC and transboundary waters	Publications >10 = 5 3–7 publications = 3 Publications <2 = 1

## 2.2. Hydrodiplomacy Criteria, Analytical Hierarchical Process, and Weighting Factors

The mixing of these heteroclitics factors was accomplished with the Analytical Hierarchical Process (AHP) multicriteria method [24]. The AHP is grounded on pairwise comparisons of the proposed factors, commonly known as criteria, based on the relevant information about the criteria and on the decision maker's knowledge and experience of the thematic. The method provides decisions when multiple factors/actors are involved in the solution by ranking the proposed criteria, with its applicability in various sectors to be acknowledged in the literature [25,26]. In the research, the AHP was used for estimating the weights of the criteria and thus their contribution to the solution by following the

standardized scoring method—from 1 to 9—for each pairwise comparison [27]. It should be mentioned that the scoring is the author’s subjective judgment, which nevertheless is based on the collected information that is presented in the previous section. By adopting the following considerations, the final weights and the ranking of the 12 criteria are depicted in Table 2.

**Table 2.** Criteria weighing and ranking based on the AHP pairwise comparisons.

Name of Criterion	Ranking	Weight
Rivers’ chemical status	7	4.30%
Rivers’ ecological status	12	1.60%
Vulnerability to floods	8	4.20%
Population density	9	3.40%
Agriculture activities	10	2.10%
Hydropower generation	11	2.00%
Historical disputes between the riparian	12	1.60%
Active cooperation agreements	4	10.10%
Common legislative framework	2	15.30%
Indicator 6.5.2 of SDG2030	5	9.50%
International CC policies in national legislation	1	25.20%
Publications on CC and transboundary waters	3	14.60%

- Climate change is conceived as an important emerging hazard for water resources, thus the climate change-related criteria receive the higher score during the pairwise comparison.
- Criteria related to cooperation agreements and common water policies are very significant and get high scores.
- Water dependencies, e.g., hydropower and irrigation, have a critical role in transboundary waters as they show the dependence of the regional economy on the waters.
- Hydrodiplomacy mechanisms are negatively affected by degraded rivers’ water quality, since the water quality affects various human activities.

### 3. Results and Discussion

The impact of climate change on hydrodiplomacy is expressed by an index score (Table 3) that comes from the normalization of the importance of each criterion on a scale of 1 to 5 (1 = less important, 5 = more important) by multiplying the rank of reach criterion (Table 1) with the weights coming from the AHP method (Table 2). The outputs demonstrate that the more secure cooperation bonds on the transboundary river basin scale under climate change conditions are found in the Mesta/Nestos river basin, which receives a score of 4.11 out of 5 (4.11/5). Particularly, both countries that share the specific basin have common water management policies, implement climate change adaptation plans, and have put in force a joint working group for developing common RBMPs. The lack of extensive knowledge about the water quality status of the Bulgarian river water bodies is one of the criteria that receives a low score. Similarly, the Struma/Strymonas river basin has a high score of 3.70 out of 5, with the flooding problems in the transboundary area impacting the final score. The flooding problems in the transboundary zone as well as the lack of knowledge about the waters originating in Turkey results in classifying the Maritsa/Meric/Evros basin with the third higher score (2.86/5), since climate change will probably exaggerate the existing problems.

On the contrary, the lack of common water management policies together with the lack of development of climate change adaptation plans from North Macedonia and Albania are attributed through the relative low scores for the Vardar/Axios and Vjoosa/Aoos river basins, i.e., 2.41/5 and 2.48/5, respectively. However, both counties are candidate for joining the EU, which is a very promising perspective in terms of common environmental policies with the downstream country.

**Table 3.** Hydrodiplomacy and climate change index score for the transboundary river basins of Greece.

Basins		Criteria												Score
		1	2	3	4	5	6	7	8	9	10	11	12	
Maritsa/ Meric/Evros	I.S <sup>1</sup>	2.00	3.00	1.60	3.80	1.80	2.40	1.50	4.00	3.00	1.90	2.80	3.00	2.86
	W <sup>2</sup>	0.31	0.30	0.12	0.08	0.04	0.04	0.06	1.01	0.29	0.08	0.10	0.44	
Mesta/Nestos	I.S	5.00	2.00	1.00	3.50	2.20	3.20	4.00	5.00	5.00	2.90	4.00	5.00	4.11
	W	0.77	0.20	0.08	0.07	0.05	0.05	0.17	1.26	0.48	0.12	0.14	0.73	
Struma/ Strymonas	I.S	5.00	1.00	2.00	4.00	1.30	3.20	2.50	5.00	5.00	3.80	2.50	3.00	3.70
	W	0.77	0.10	0.15	0.08	0.03	0.05	0.11	1.26	0.48	0.16	0.09	0.44	
Vardar/Axios	I.S	2.00	1.00	3.50	3.80	1.50	2.00	4.00	2.50	3.00	3.50	2.00	2.00	2.41
	W	0.31	0.10	0.27	0.08	0.03	0.03	0.17	0.63	0.29	0.15	0.07	0.29	
Vjosa/Aoos	I.S	1.00	2.00	5.00	3.90	5.00	4.20	4.50	2.50	1.00	4.00	3.30	2.00	2.48
	W	0.15	0.20	0.39	0.08	0.11	0.07	0.19	0.63	0.10	0.17	0.11	0.29	

<sup>1</sup> I.S: initial score; <sup>2</sup> W: weight.

#### 4. Conclusions

The research proposes a methodology for assessing the hydrodiplomacy mechanism’s balance in climate change conditions at the scale of transboundary river basins. The proposed approach is expressed using an index that depicts the dependency of water diplomacy on climate change. The index couples traditional water management factors, such as water quality, floods, and cooperation agreements and protocols with climate change factors with the use of the AHP method. Although the proposed methodology is subjective to the ranking of the criteria and the pairwise comparison scores, the final outputs constitute an important roadmap for the evaluation of the water cooperation status at shared river basins under climatic stress situation.

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