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Hydrodiplomacy and Climate Change: An Assessment on the Transboundary River Basins of Greece †

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Abstract: Hydrodiplomacy is the emerged framework where legal acts, based on technical data and information, aim at supporting commonly accepted solutions to water-related tensions among states with transboundary waters. In the research hydrodiplomacy components laid on (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., the 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 results on a normalized output that quantifies water transboundary cooperation in the climate crisis era.

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 the system, such as the management of transboundary waters, is highly probable to be destabilized by the induced changes of climate change to the water resources. The latest IPCC's report on climate change (AR6) [1] depicts 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 projects with a high confidence the mean streamflow decrease in the Mediterranean, as well as floods increase 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 of 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 have peace; while nations at risk of going to war over issues other than water, they do not also have active water cooperation agreements with the riparian that have conflicts [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, namely political; preventive; integrative; cooperative; and technical aspects.

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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 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, mankind pressures on the hydrosystem and historical disputes among the riparians, (c) cooperative aspects, such as joint development and research programmes and projects and (d) technical aspects, such as 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 the 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 the 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 neighbouring 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.

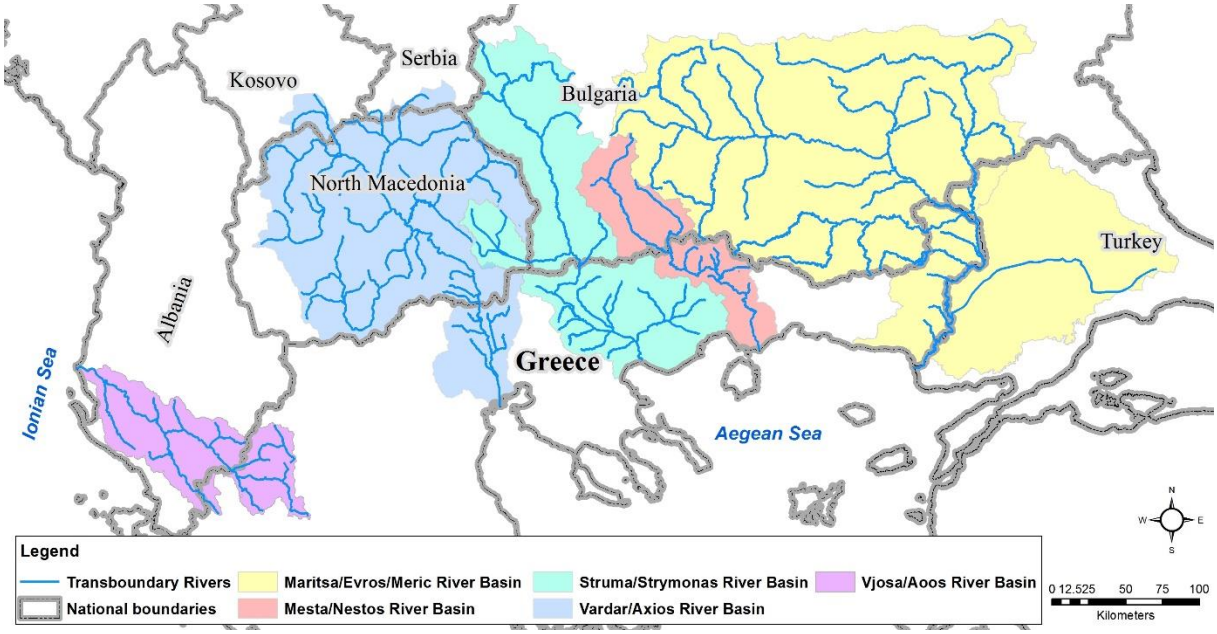

Figure 1. Illustration of the transboundary river basins of Greece that are shared with the neighbouring states.

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 hands, 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 can be classified in 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 Vjosa/Aoos river basin. The latter basin, together with the Mesta/Nestos one, are basins where a bilateral agreement exists between the riparian. Towards this direction, Bulgaria and Greece have formulated since 2010 an active Joint Expert Working Group that focuses on the implementation of the EU Directives at 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 and 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 in the Maritsa/Meric/Evros and Mesta/Nestos river basins there have been published 6 and 9 scientific articles respectively, while 5 publications have been conducted in the Struma/Strymonas river basin, e.g. [12–20] In the case of Vardar/Axios and Vjoosa/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 the 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^2 < 20 = 5 Inhabitants/km^2 ~ 70 = 3 Inhabitants/km^2 > 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. Hydrodiplomay Criteria, Analytical Hierarchical Process and Weighting Factors

The mixing of these heteroclites factors was accomplished with the Analytical Hierarchical Process (AHP) multicriteria method [24]. 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 on 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, 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 are presented in the previous section. By adopting the following considerations, the final weights and the ranking of the 12 criteria is depicted in Table 2.

- 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, 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 affect various mankind activities.

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%

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 in a 1 to 5 scale (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 at 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 they 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 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 to impact 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 with the third higher score (2.86/5), since climate change will probably exaggerate the existing problems.

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 [1]	2.00	3.00	1.60	3.80	1.80	2.40	1.50	4.00	3.00	1.90	2.80	3.00	
	W [2]	0.31	0.30	0.12	0.08	0.04	0.04	0.06	1.01	0.29	0.08	0.10	0.44	**2.86**
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	
	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	**4.11**
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	
	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	**3.70**
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	
	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	**2.41**
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	
	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	**2.48**

[1] I.S: Initial score; [2] W: Weight.

On the contrary, the lack of common water management policies together with the not development of climate change adaptation plans from North Macedonia and Albania is attributed through the relative low scores the Vardar/Axios and Vjoosa/Aoos river basins receive, i.e., 2.41/5 and 2.48/5 respectively. However, both counties are candidates' countries for joining the EU, which is a very promising perspective in terms of common environmental policies with the downstream country.

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 express by an index depicting the dependency of water diplomacy to climate change. The index couples traditional water management factors, such as water quality, floods, 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 output is conceived an important roadmap for the evaluation of the water cooperation status at shared river basins under climatic stress situation.

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