AI, Hydropolitics, and Environmental Law: The Role of AI in Transboundary River Governance

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Abstract: "Thousands have lived without love, not one without water." – W.H. Auden

Every Nation wants to have sole control on its water resources. One issue with rivers is that they don't' know boundaries or territorial jurisdiction and it flows downstream creating a tug of war between riparian nations. Artificial Intelligence (AI) that has already started to reshape the world with technological advancements can be a source to look up to for water resource management. Where its integration can be used to have better management of the rivers and analysis of the hydrological data for the betterment of the mankind.

The inculcation of AI into transboundary water governance can bring a notable change in the legal, ethical, and regulatory challenges. The application of AI can be very much beneficial in monitoring and taking decisions in pertinence to the hydropower projects. An advanced analysis of the environmental impacts, hydrological data, river course can be studied for better planning and execution of projects. But at the same time, we cannot deny the threats associated with the judgments and the Algorithm bias of the AI in this sector. As there are lot of unanswered questions as to the judgment and decisions drawn on behalf of AI. This article makes an attempt to understand the challenges and opportunity with the integration of AI in the hydropolitics and environmental law.

Keywords: Hydropower, Artificial Intelligence, Environmental Law, Transboundary River Management.

I. INTRODUCTION

Rivers naturally flow through more than one country, which makes control and policymaking more difficult. Rivers carry potential benefits that could be great for the states they flow through. At the same time, states are often in the middle of an international argument over how to share rivers or how to use them in ways that might not work well together. Over time, this foreign debate becomes more official and needs to be set up as an institution. This is where hydropolitics comes into being. In a broad sense, hydropolitics is a political conflict that happens when people disagree about how to use river water for different reasons. Transboundary river areas are becoming more important in international relations because of the growing need for water around the world and the effects of climate change.[3]

States need to agree on a lot of new issues. Besides the possibility of a conflict of interest, there is an unreadable data system in rivers in terms of technical parameters. Because rivers are so complicated, more research has been done on the water feature that shows the flow direction of the river in mathematical terms. As technology has improved, studies of rivers that can look at data in more complex ways than before have become more popular. Additionally, work is still being done in the water sector to make it more effective at protecting the environment. As part of these, researchers have begun to look into how artificial intelligence can be used in rivers. Artificial intelligence is seen as a way to find and rate the modeled rivers results that can't be changed in unbearable equations. On the other hand, it helps us learn more about how traits and state change over time in rivers, which is something we don't know much

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about yet.[4] When artificial intelligence is used in rivers, it opens the door for states to make policies that are more efficient and make money for everyone. But because the technology hasn't hit a point where it's protected by national and international law yet, it's hard to say what will happen in terms of following the law and doing the right thing. From here on out, AI use in rivers can be thought of as an island surrounded by water that gets deeper as you go downstream.[5]

II. AI IN HYDROPOLITICS AND WATER RESOURCE GOVERNANCE

In this era of Industry 4.0, more and more parts of the economy and social life are becoming digital. This gives policymakers and lawmakers new problems to solve. One thing that should worry us is the growing use and growth of artificial intelligence (AI), which could be both a chance and a danger for the environment.[6] In the real world, several AI technologies can help solve environmental problems and put the human-earth system back on a road that is sustainable. Examples of these are using AI to protect soil and water or to make sustainable land-use planning work better. Online control of illegal tree cutting can be helped by using drones with AI. When AI is used, the rules about who is responsible for what might need to change a lot. For example, who could be held responsible if a program made a decision that put people in danger? Should it be the person who owns the device, the person who made it, or the person who programmed it? The analytical part looks at some good examples of regulation that has helped lessen the damage that AI does to the environment. It then gives a list of general ideas that should be thought about in order to solve these kinds of problems.[7]

Many people are responsible for keeping an eye on and managing transboundary lakes and rivers. They are able to work together because they can share and analyse cross-border water resource data quickly and easily. The current problems that need to be solved in STEM fields make AI technologies very useful because they offer new ways to describe data, learn, and store knowledge. People talk about the use of AI methods and tools in the field as part of larger discussions about water diplomacy and governance, with a focus on the Mississippi and Nile subbasins. Then it is suggested that AI tools could be used to create a virtual joint data tracking centre.[8]

Water resources are a very critical topic in both environmental politics and hydropolitics because of the ongoing problems with both water quality and quantity. States are more likely to work together in transboundary waters to avoid conflict or work together in creative ways because these waters are often seen as places where disagreements are more likely to happen. In order to do this, there needs to be effective monitoring systems and accurate data for analysing the environment and water quality in real time in order to properly manage the resource and move quickly in case of an emergency. Since recent scientific progress has made it easier to watch and analyse data, the water sector can now use a variety of these kinds of tools. There are many Artificial Intelligence (AI) tools and methods that can help to fill in the gaps in our knowledge in this area and make progress towards the goals of "right to water" for all, "fair and participatory water governance," and "trans-boundary water cooperation."[9]

III. LEGAL AND POLICY FRAMEWORKS FOR TRANSBOUNDARY WATER MANAGEMENT

[4] DEMA, J.M. *A non-zero sum game: How game theory can inform better transboundary water rights treaty drafting.*, 2014.

[5] ECKSTEIN, Gabriel. *Transboundary legal perspective: International water law.*, 2016.

[6] PACHOT, A.; PATISSIER, C. *Towards sustainable artificial intelligence: An overview of environmental protection uses and issues.*, 2022.

[7] COWLS, Jessica; TSAMADOS, Andreas; TADDEO, Mariarosaria; FLORIDI, Luciano. *The AI gambit: leveraging artificial intelligence to combat climate change—opportunities, challenges, and recommendations.* AI & Society, 2023. Available at: https://www.springer.com.

[8] RADELYUK, I.; ZHANG, L.; ASSANOV, D.; MARATOVA, G. *A state-of-the-art and future perspectives of transboundary rivers in the cold climate–a systematic review of Irtysh River.* Journal of Hydrology, 2022. Available at: https://www.sciencedirect.com.

[9] AL-MUQDADI, S.W.H. *The spiral of escalating water conflict: the theory of hydro-politics.* Water, 2022. Available at: https://www.mdpi.com.

Water is a natural resource and a common concern that doesn't respect borders or jurisdictional boundaries. Because of this, countries that share watercourses need to come up with legal and policy mechanisms to manage and use them together. Over the years, international treaties, agreements, declarations, and policies have been made to control how riparian communities deal with each other and encourage them to work together. All these documents states principles of cooperation in good faith, equitable and reasonable utilization of waters, no causing of significant harm, and the employment of joint and basin-wide management alternatives.[10] At the global and regional levels, nations can make, support, and cultivate these frameworks that are good for both parties to improve environmental and socio-economic outcomes.

The evolution of international and regional agreements has increased understanding of the emerging technologies that can be used to make cross-border and interdisciplinary river management better. Many institutional arrangements, such as joint committees, commissions, authorities, and existing bodies, have been set up to allow for regular conversations, the sharing of ideas, and the resolution of disagreements (Concept Paper on the United Nations Water Convention. United Nations, 2023). International and regional development banks and organisations can make cooperation even easier by hosting projects, giving enough money or expertise, and setting up legally binding ways to make sure agreements are followed through on. As we've seen before, this kind of cross-border government can be used to look into the pros and cons of using artificial intelligence (AI) and information systems to solve hydro-political problems. This case study focused on the practicalities of using AI and machine learning to manage transboundary rivers in the Mekong River basin. It also looked at challenges that are getting harder to solve, like the transboundary use of water, energy, fisheries, and navigations, which can only be done by working together.[11]

IV. CHALLENGES, ETHICAL CONCERNS, AND LIMITATIONS OF AI IN WATER GOVERNANCE

Looking at the above opportunities and challenges, this text thinks about how to create a fair method for AI-based river management that takes ethics into account. It shows how adding system thought to current environmental laws could lessen the damage that technological biases could do.[12]

It is a big step forward to use AI in transboundary river control. There are lines on a map that separate and subdivide people, set up power structures, and encourage different goals and values. A river can cross these lines. Because of differences in hydrological regimes, landforms, and social development, some riparian states may have been able to use their water resources to make energy and provide water for farming and other economic and social needs by building dams and barrages. These infrastructures allow riparian states to control and block waterflows, which could cause problems and lead to possible disputes between them. Unilateral management methods might cause a chain reaction of bad things to happen further downstream, like the erosion of riverbanks, changes in the flow of sediment and nutrients, and/or the loss of ecosystem services that people depend on for their livelihoods and the economies of whole regions.

However, agreements that are too strict and can't be changed may make it hard for riparian states to adapt to changes in society and the environment. For example, these changes could make it harder for states to deal with changes in evapotranspiration rate, the amount of rain that falls, or the building of sociotechnical devices that could mess up water allocation and e-flows. Participatory processes may also give power to non-governmental organisations

[10] FISCHHENDLER, Itay; WOLF, Aaron T.; ECKSTEIN, Gabriel E. *The role of creative language in addressing political asymmetries: The Israeli-Arab water agreements.*, 2016

[11] MIRUMACHI, Naho; HURLBERT, Margot. *Reflecting on twenty years of international agreements concerning water governance: Insights and key learning.*, 2022. Available at: https://www.ncbi.nlm.nih.gov.

[12] MANZOOR, M., et al. *Dimensions of environmental sustainability and the use of AI: Challenges and innovations in sustainable resource management.* In: Advanced Manufacturing Processes. CRC Press, 2025, pp. 251–268.

(NGOs) or groups of local players that are not part of the democratic institutions of riparian states. These points make it clear that standard agreements based on states aren't always enforceable or flexible enough to deal with the complexity and changeability of global risk patterns today.

IV.I. The Challenges with Using AI in Hydropolitics

The field of hydropolitics studies how water resources and politics affect each other, especially when they affect foreign areas like river basins. More and more research is being done on artificial intelligence (AI) in the area of environmental management, including problems with water. But there hasn't been a lot of writing in the West about AI and foreign rivers. Using sources from both the West and China, Section 4 starts by giving an overview of the part AI can play in managing rivers that cross borders. The article then talks about three areas of Southeast Asia's management of the Mekong River that show these pros and cons: tracking water quality, early warning of disasters, and talks over the Xayaburi Dam.

Setting up data-sharing agreements between countries that share a transboundary river can be hard because the formats of the data and the computers that can handle them are often different. Also, current governance structures and important stakeholders often look at AI technologies with suspicion and are against them. This is because many of these systems have been built and improved over decades or even centuries and are hard to replace. So, education and improving people's skills are necessary for AI tools to be used effectively, so that everyone understands the ideas behind them and how the different models work. Some people are also worried that using AI in talks that are going well now could weaken the position of local players, leading to pushback and the creation of purposeful data obfuscation, whether this is done on purpose or not. On the other hand, tying talks to how well AI systems do could lead to people making bad decisions. This area is better when people from different fields work together on it. By looking at AI's broader use in water governance and especially hydropolitics, commentators can understand the types of metagovernance structures needed to effectively implement these technologies, how they might go wrong, the natural points of hostility that are likely to slow down early adoption, and ways to get around these problems.[13]

IV.II. Concerns about data privacy

Many types of data need to be collected and analysed before AI can be used to improve government when it comes to sharing rivers, dams, basins, and other things. As technology spreads, it becomes more important than ever to keep private data safe. One of the biggest worries about AI is that governments and businesses could misuse data to control water resource development and market control. This makes us wonder who will watch the watchers?[14] Concerns about ethics also come up when it comes to the tracking that comes with using water and the conditions of the environment. For the right construction and operation of infrastructure, governments will need to have a lot of information on these. As the people who work for the data subjects, you need to protect their right to privacy and to question the research that was done on them. It will be necessary to make rules and guidelines to protect privacy while still letting AI be used. AI ethics have been started, and a plan has been made for how it will be run. Water data, on the other hand, is a separate type that has its own purpose. People say that strict rules on how to gather, store, and use water data are needed to keep people's trust in a future where AI rules everything.

Data privacy is very important for people to believe that AI systems will work right. For its people, the state acts as a guardian. Governments and regulatory bodies must protect the right to privacy of human capital and not collect AI data for reasons other than public safety and state security. In this area, the European Commission is thinking about how to regulate it, and work is being done to set up the right

[13] KUGLITSCH, Matthias; PELIVAN, Ivana; CEOLA, Serena; MENON, Manju; XOPLAKI, Elena. *Facilitating adoption of AI in natural disaster management through collaboration.*, 2022. Available at: https://www.ncbi.nlm.nih.gov.

[14] RADANLIEV, Petar; SANTOS, O.; BRANDON-JONES, A.; JOINSON, A. *Ethics and responsible AI deployment.*, 2024. Available at: https://www.ncbi.nlm.nih.gov.

institutions in the EU. In addition to the above-mentioned methods for transparency and regulation, it is thought that democratising the way AI governance works would help the public and help build the trust that is needed for the proper management of shared water resources. How the public sees how fair and equal the AI decision-making process is has a big impact on trust in AI. That being said, it is suggested that more organised steps be taken to defend personal information and limit how much AI can be used as a safety measure

IV.III. AI Algorithms with Bias

In the public sector, especially when it comes to water management, algorithms are becoming an important part of data-driven optimisation. A very important question is whether and how using computers could be fair and lead to more even political outcomes. Researchers are looking into this question using hydropolitics, mimetic learning, and environmental law. They are focussing on transboundary rivers to look into how two riparian states handle their water using data and how their so-called "innovative" water collaboration is similar to best practices. Some general approaches are to look at how actors across state lines use water diplomacy in shared river basins; how AI algorithms are designed, built, run, and the effects they have on the world; and the mixed reasons behind policy changes in the public sector, movements, and legal changes over natural resources. To be more specific, we need to model how well AI algorithms work in a policy environment that is hard to understand because of mistrust, past water conflicts, and uneven power dynamics between countries, even though some policy areas say they want to work together in a constructive way.[15]

V. CONCLUSION

Artificial Intelligence possesses a high potential to revolutionize the transboundary river governance. AI systems may spot deviations in numbers, such as temperature fluctuations, facilitating focused predictive maintenance instead of merely responding to breakdowns. Additionally, it can compute real-time power production and conduct simulations to ascertain the optimal water levels and parameters for the most efficient turbine operation. Until now, managing water resources to meet energy demands has mostly been based on combining historical weather patterns, such as rainfall and snow melting, with the forecasting of future ones. Maintenance is generally run on cycles, meaning unexpected breakdowns or inefficient equipment pose risks to regular power production. Digitalization is changing this by transforming hydropower plants from reactive to proactive, able to anticipate any problems before they arrive and optimize operations to improve efficiency, generating more power from the available water.

However, the implementation of AI in the automation of hydropower plants remains limited, as the market is proceeding with caution due to concerns about potential failures and disruptions to the network. Cybersecurity is a significant concern. Hydropower facilities may be perceived as vulnerable targets within a nation's infrastructure, rendering them appealing to cybercriminals. It is essential to enhance the security of hardware and systems through firewalls or other sophisticated cybersecurity measures before it is integrated into the river governance.

REFERENCES

[1] Al-Muqdadi, S.W.H., 2022. The spiral of escalating water conflict: the theory of hydro-politics. *Water*. Available at: https://www.mdpi.com.

[2] Cowls, J., Tsamados, A., Taddeo, M. and Floridi, L., 2023. The AI gambit: leveraging artificial intelligence to combat climate change—opportunities, challenges, and recommendations. *AI & Society*. Available at: https://www.springer.com.

[3] Dema, J.M., 2014. A non-zero sum game: How game theory can inform better transboundary water rights treaty drafting. Available at: <[PDF]>.

[4] Drogkoula, M., Kokkinos, K. and Samaras, N., 2023. A comprehensive survey of machine learning *methodologies with emphasis in water resources management.* Applied Sciences, 2023. Available at: https://www.mdpi.com.

[15] DROGKOULA, Maria; KOKKINOS, Konstantinos; SAMARAS, Nikolaos. *A comprehensive survey of machine learning*

learning methodologies with emphasis in water resources management. *Applied Sciences*. Available at: https://www.mdpi.com.

[5] De Lourdes Melo Zurita, M., Thomsen, C.D., Holbrook, J.N., Smith, F.T., Lyth, A., Munro, G.P., de Bruin, A., Seddaiu, G., Roggero, P., Baird, J., Plummer, R., Bullock, R., Collins, K. and Powell, N., 2018. Global water governance and climate change: Identifying innovative arrangements for adaptive transformation.

[6] Eckstein, G., 2016. Transboundary legal perspective: International water law.

[7] Fischhendler, I., Wolf, T.A. and Eckstein, G.E., 2016. The role of creative language in addressing political asymmetries: The Israeli-Arab water agreements.

[8] Imran, M., et al., 2023. Hydropolitics and conundrum of transboundary water issues: A case study of South Asia. *Journal of Politics and International Studies*, 7(1). Available at: https://www.pu.edu.pk.

[9] Kuglitsch, M., Pelivan, I., Ceola, S., Menon, M. and Xoplaki, E., 2022. Facilitating adoption of AI in natural disaster management through collaboration. Available at: https://www.ncbi.nlm.nih.gov.

[10] Manzoor, M., et al., 2025. Dimensions of environmental sustainability and the use of AI: Challenges and innovations in sustainable resource management. *Advanced Manufacturing Processes*. CRC Press, pp. 251-268.

[11] Mirumachi, N. and Hurlbert, M., 2022. Reflecting on twenty years of international agreements concerning water governance: Insights and key learning. Available at: https://www.ncbi.nlm.nih.gov.

[12] Pachot, A. and Patissier, C., 2022. Towards sustainable artificial intelligence: An overview of environmental protection uses and issues.

[13] Radelyuk, I., Zhang, L., Assanov, D. and Maratova, G., 2022. A state-of-the-art and future perspectives of transboundary rivers in the cold climate–a systematic review of Irtysh River. *Journal of Hydrology*. Available at: https://www.sciencedirect.com.

[14] Radanliev, P., Santos, O., Brandon-Jones, A. and Joinson, A., 2024. Ethics and responsible AI deployment. Available at: https://www.ncbi.nlm.nih.gov.