Dear Editor and Referees,

First of all, we deeply appreciate for all your valuable and insightful suggestions to the paper titled "*A Multiagent Socio-hydrologic Framework for Integrated Green Infrastructures and Water Resource Management at Various Spatial Scales*". We have checked the paper carefully and made minor revisions as referees suggested and also spent some time in checking the English writing and grammar. In addition, we have further carefully edited the manuscript to eliminate the shortcomings. All the revisions will be shown in the list as follows.

If you have any question about this paper, please do not hesitate to let us know. Your acknowledgement will be highly appreciated.

Sincerely yours,
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Response to Referee #1

Thank you so much for your objective and constructive comments to this study, which are of great significance to improve the quality of the paper. We have tried to revise the paper thoroughly following your instruction, and according to your other helpful suggestions, we have made revisions as following:

Overall Impression: I recommend accepting the manuscript but ask that the authors *consider* updating the overall focus on green infrastructures (GIs) to be more specific to rainwater harvesting (RWH) systems and to specify that this is a fictitious case study designed to demonstrate how such a framework could be carried out in the event that RWH becomes widely adopted and thus impacts theoverall water supply balance of cities. However, I would still accept the paper without this change, if the authors disagree and prefer to maintain focus on the terminology of GIs, because I can tell that they tried to add robust justification for this choice throughout the paper after a similar suggestion in the previous round of reviews. Their overall case study methodology uses a diverse set of GI types, so it might not be feasible to make this change. The actual methodology is very thorough. However, discussion of the technical results is limited and could benefit from deeper insights.

Response:

1. **About "scopes of GIs"**

Thank you for your suggestion to emphasize 'rainwater harvesting systems.' However, as you noted, this paper focuses on the broader impacts of GI on urban and watershed-scale water management. As defined in the paper, GIs encompass decentralized, nature-based solutions for capturing and recharging rainwater and stormwater. Specifically, we examine three types of GIs: (1) rainwater harvesting systems, which collect rainwater from rooftops before it reaches the ground; (2) stormwater harvesting systems, which capture runoff from land areas, including roofs and ground surfaces (Steffen et al., 2013); and (3) infiltration-based GIs, which enhance groundwater recharge by increasing the infiltration rates of pervious surfaces.

In theory, these three GI types exert distinct hydrologic effects on the urban water cycle and watershed-scale hydrologic regime. On one hand, this diversity complicates urban and watershed hydrological dynamics, posing challenges for water resource management. On the other hand, it provides urban water managers with a versatile toolkit to boost local water supplies and reduce water use costs. Our paper aims to explore these complex socio-hydrologic interactions driven by GIs in urban and watershed water management. Moreover, our results (see Figure 5 Page 20) highlight the distinct roles of these GI types across four urban water use patterns under varying hydrologic and climate conditions, underscoring their differential impacts on water management.

Thus, we believe it is essential to investigate the effects of diverse GI types on urban and watershed water resource management. We sincerely thank you again for your understanding and support of our paper's core focus. We also find your suggestion highly valuable - rainwater harvesting systems indeed play a prominent role in integrated GI and water resource management (IGWM) across spatial scales—and we plan to prioritize this aspect in future studies.

2. **About "Discussion"**

We appreciate your first-round comments and suggestions regarding the 'Discussion' section of our paper. In response, we have thoroughly revised Sections 4.2, 4.3, and 4.4 (Results and

Discussion) to deliver a more detailed, nuanced, and comprehensive analysis of our findings. These revisions directly address your concerns by deepening the discussion with richer insights into the socio-hydrological dynamics of IGWM across various spatial scales. Below, we outline the key modifications and explain how they enhance the paper, aligning with your feedback. These improvements cover critical aspects such as water costs and inter-community conflicts, communication between governance levels, the role of modeling assumptions, implications for water policy, and considerations of social equity.

1) Water costs and inter-community conflicts

In the original Section 4.2, we briefly noted an upstream-downstream imbalance in water resource access and the dual impact of GI on costs and equity. The revised version significantly expands this analysis with quantitative evidence and conceptual framing. For example:

- We now highlight that upstream areas (e.g., Urban Area 1) rely on surface water for 85% of their needs, while downstream areas (e.g., Urban Area 9) depend on it for only 73% in scenarios without GI. This disparity forces downstream communities to turn to costlier groundwater sources, exacerbating economic burdens (See Lines 575 - 578).
- GI adoption, while reducing city-scale water use costs (e.g., through stormwater harvesting), decreases downstream inflows by 12 - 18%, intensifying inter-urban conflicts. We liken this to a "tragedy of the commons," where localized benefits for upstream areas undermine watershed-scale equity (See Lines 578 - 584).

These revisions provide a clearer picture of how water costs and access disparities drive conflicts, emphasizing the need for a balanced approach to GI deployment across adjacent communities.

2) Importance of communication between governance levels

The original text hinted at the need for watershed managers (WM agents) to address upstream-downstream imbalances but lacked specificity. The modified Section 4.2 now underscores the critical role of communication and coordination between WM agents and urban water managers (UWM agents):

- We identify fragmented governance as a key driver of inefficiencies, where UWM agents optimize local costs (e.g., via GI) without considering downstream consequences, such as reduced streamflow (See Lines 618 - 625).
- To address this, we propose interactive data platforms that provide real-time hydrologic and economic data. These tools would enable adaptive GI investments and withdrawal limits, aligning city-scale actions with watershed-wide goals (See Lines 625 - 629).

This addition highlights the necessity of bridging communication gaps to mitigate conflicts and promote equitable resource management.

3) The role of modeling assumptions

Our original discussion did not fully explore the implications of modeling assumptions. The revised sections (4.2 and 4.3) now delve into how these assumptions shape our understanding of socio-hydrological dynamics:

- Markov Property: In Section 4.2, we clarify that the Markov property - where UWM agents base decisions on immediate inputs - leads to short-sighted strategies that neglect downstream effects, such as reduced surface water availability. This exacerbates inequities, especially under variable hydrologic conditions driven by climate change (See Lines 619 - 625).

- Stackelberg Framework: In Section 4.3, we use this framework to model power asymmetries between WM and UWM agents. While WM agents enforce equity through penalties, UWM agents may counteract with actions such as excessive groundwater extraction, undermining aquifer sustainability and inflating costs. This dynamic reveals the challenges of policy enforcement in a hierarchical system (See Lines 669 - 675).

These insights deepen the technical discussion by linking modeling choices to real-world governance and equity outcomes.

4) Implications for water policy as GIs become more popular

The original manuscript lacked a robust policy discussion, which we have rectified in the revised Sections 4.3 and 4.4:

- We emphasize GI's dual nature: while it lowers local costs, uncoordinated adoption risks entrenching watershed-scale inequities. For example, downstream communities face reduced inflows and higher costs despite upstream GI benefits (See Lines 581 - 584).
- To address this, we recommend negotiated water-sharing agreements and adaptive management principles. In Section 4.3, we suggest using iterative penalty rate adjustments in streamflow penalty strategies, ensuring they balance cost reduction and equity in water resources distributions (See Lines 699 - 703). Section 4.4 concludes with a call for frameworks that harmonize localized GI benefits with broader sustainability goals (See Lines 714 - 716).

These revisions provide actionable policy insights, addressing the referee's call for deeper implications as GI adoption grows.

5. Insights on social equity in water decisions

Social equity was underexplored in the original text. The revised sections now offer a detailed equity analysis:

- In Section 4.3, we use the Gini coefficient to show how downstream regions disproportionately bear water use costs, even under streamflow penalty strategies. Upstream areas may face higher penalties, but downstream communities remain structurally disadvantaged due to reduced streamflow (See Lines 693 - 696).
- We propose redirecting cost savings from efficient water management to support vulnerable downstream stakeholders, alongside policies that prioritize their needs (Section 4.4). This approach aims to reduce disparities and promote sustainable equity across urban boundaries (See Lines 714 - 716).

This expanded focus ties technical results to social justice, enriching the discussion with a human-centered perspective.

In short, in Section 4.2, we enhanced with quantitative data (e.g., surface water reliance, inflow reductions) and conceptual framing (e.g., "tragedy of the commons") to explore water costs, conflicts, and governance communication.

In section 4.3, we introduced the Stackelberg framework and penalty strategy analysis, linking modeling assumptions to policy outcomes and equity challenges.

In Section 4.4, we added concluding remarks advocating for adaptive management and interactive data platforms to prioritize downstream equity.

References

Steffen, J., Jensen, M., Pomeroy, C.A. and Burian, S.J., 2013. Water supply and stormwater management benefits of residential rainwater harvesting in US cities. JAWRA Journal of the American Water Resources Association, 49(4), pp.810-824.

Response to Referee #2

Thank you very much again for your arduous and excellent comments and suggestions on our paper. Your comments at 1st round for the paper would take you a lot of energy, which is undoubtedly of great significance to improve the quality of the paper, especially the paper structure. We sincerely appreciate your understanding and acceptance of our work.