Supplementary Materials

Appendix A. Content analysis of groundwater governance

The qualitative content analysis method by Mayring (2007) was employed to analyse relevant publication results. Variables from Ostrom's (2007) Social-Ecological System (SES) framework were assigned and developed via "coding", which creates "codes" to act as labels that allocate a unit of meaning to descriptive information (Basit 2003). Such coding was carried out with the qualitative data analysis software ATLAS.ti (2022) software.

First, original second-tier variables suggested by Ostrom (2007), some of which are already relevant to informational governance (i.e., Interaction between the resource units, Mobility of the resources, Knowledge about SES, Information shared, and Technology used, Monitoring and sanctioning processes), were used deductively to code text segments ranging from a few sentences to a phrase in length. After a review of coded text segments, descriptive and Central Asia (CA) specific codes were inductively developed to reveal patterns.

Secondly, in consideration of informational governance in this analysis, four categories relevant to informational governance were anticipated based on research themes for informational governance established by Mol (2006). These included "Power constellations", "Uncertainty", "Dynamics and Mechanisms", "Multiple knowledges", and "Reform design" of informational governance. These informational governance themes were referenced to identify informational governance relevant text segments, first deductively coded. Text segments were later reviewed to develop new inductive and descriptive codes based on the CA literature. Inductively developed end codes were placed into relevant SES framework first-tier categories, resulting in informational codes within Governance system, Users, Interactions, and Outcomes first-tier SES components.

The inter-coded reliability of the coding process was achieved in two steps. First, each text was coded with inductive categorisation in mind. As coding continued, the codebook was revisited multiple times to ensure that the codes used were individual and descriptive, while appearing often enough to be notable in the overall study. If a code appeared twice or less within the overall literature, it was discarded. After condensing the codebook to ensure the reliability of codes, inductive end codes were confirmed. Over 75% of papers were again reviewed to ensure that inductive end codes were systematic and congruent with their codebook-established definition.

ATLAS.ti functions such as code co-occurrence tables, literature groups, and code occurrence counts by literature group were utilised to explore and describe trends in SES variables. Co-occurrence tables reveal how often specific codes overlap while code occurrence counts report how many text segments were given a specific code. Literature groups were used to group state specific literature, and therefore differentiate between literature focused on Uzbekistan versus on transboundary CA.

Appendix B. Bibliometric analysis of publications

To create a CA overview based on literature results, which included diverse geographic focuses and scopes, literature was grouped by geographic focus (a state or the transboundary region), then assessed according to its thematic focuses. Literature was assessed according to whether it had a groundwater (GW) focus or discussed water generally while containing GW-relevant information. Our results confirm that GW receives little attention in the region compared to surface water. Literature also appeared to differ according to water use focus including irrigation, livestock and domestic uses.

Papers were considered empirical if based on collecting new data through surveys, interviews, or other methods. Literature reviews or papers with a lack of clarity on methods were classified as non-empirical. State-specific literature tended to use empirical methods more frequently while region-wide literature was more likely nonempirical, as displayed in Table B 1.

Table B 1. Breakdown of comparative focuses of papers considered

Countries	**Papers**	**Empirical**	**Non-empirical**	**GW focus**	**Irrigation Focus**	**Domestic Focus**	**Livestock Focus**
Uzbekistan	14	12	2	3	5	0	0
Kazakhstan	8	6	2	1	0	0	0
Tajikistan	9	7	2	0	2	0	0
Turkmenistan	3	3	0	1	0	0	1
Kyrgyzstan	8	7	1	0	0	1	0
Central Asia	15	7	8	2	1	0	0

Figure B 1 presents results by their publication year. Groundwater interest appears to increase. FAO country profiles are available for all five states and were published in 2012, therefore counted as one result in this figure to avoid unnecessarily inflating results for this year. For Uzbekistan, literature publication dates ranged from 2001 to 2022. Grey literature was sought out for all CA nations to be able to include more Turkmenistan relevant work, which was scarce.

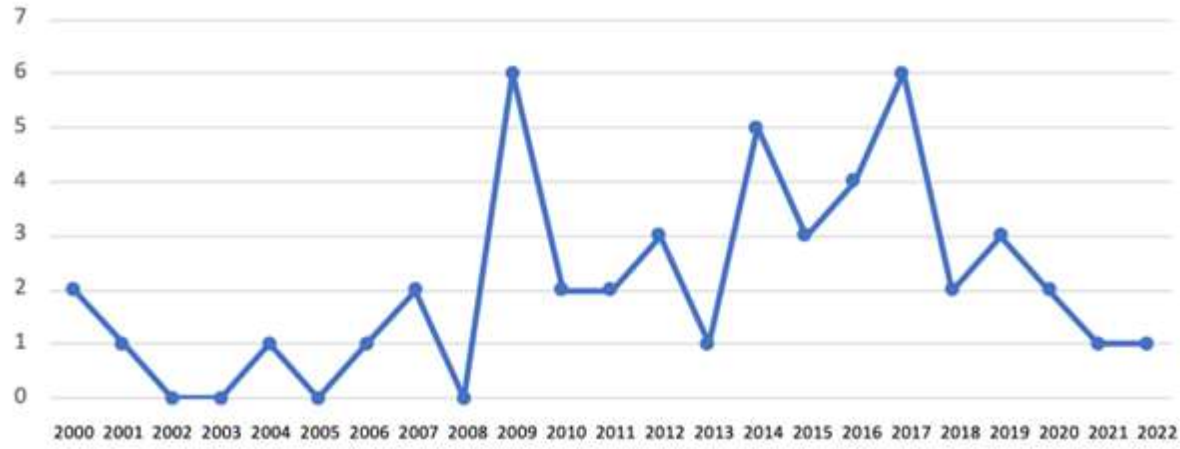

Figure B 1. Line graph of literature review results by their publication year

Observing trends in GW publications, the expansion of agriculture and the use of GW for irrigation comes up in all literature, clearly illustrating the importance of irrigated agriculture throughout CA. GW pollution is most often cited throughout literature, with significant aquifer water quality impacts from human activity in neighbouring countries and distinct recognition of mining pollution. Deteriorating GW quality has recognised health impacts implied by domestic water use, as well as land quality impacts, such as soil salinisation. GW scarcity and climate change are often discussed together, particularly in Uzbekistan and Kazakhstan.

References

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