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Assessing the water security effectiveness of integrated river basin management: Comparative case study analysis for lesson-drawing

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Climate change, population growth, over-abstraction and industrial pollution are impacting the security of water resources globally, raising policy relevant questions over the optimality of institutional arrangements for their management. This paper seeks to add to this debate by assessing the effectiveness of integrated river basin management for achieving water security, in two case studies: the Konya Closed Basin in Turkey, and the Kern County Subbasin in California. A modified Institutional Analysis and Development (IAD) framework is employed to compare biophysical, community and governance factors in these cases to show how they influence water security, measured through a dedicated set of indicators. Results show that differentials in water security outcomes between the cases is, in part, related to how organizational rules compel actor participation in planning processes and the degree of coherence between multi-level institutions, particularly inter-agency collaboration. On this basis, the paper then engages with the public policy theory literature on lesson-drawing to assess the potential for policy learning for these specific contexts and other countries. The significance of the study therefore relates to its holistic integration of governance analysis, comparative case design and lesson-drawing for informing future river basin institutional design in achieving effective water security.

KEYWORDS

water security, integrated river basin management, institutions, institutional incoherence, lesson-drawing, case studies

Introduction

Water security is a critical governance challenge globally. Industrial and domestic pollution, population growth, climate change and over-abstraction are increasing risks to water resources (United Nations (UN), 2018). Although countries have made significant progress in achieving the UN's Sustainable Development Goal (SDG) 6 for ensuring access to water and sanitation, 2 billion people still lack safely managed domestic water provision, including 1.2 billion without a safe drinking water supply

(World Health Organization (WHO) and the United Nations Children's Fund, 2021). In addition, 40% of the global population, some 2.3 billion, lives in river basins experiencing severe water stress (World Water Council., 2018). As a result, major urban areas face so-called "Day Zero" scenarios (see Maxmen, 2018), where they could run out of water completely. The expectation that ever more people will be living under water stress puts the sustainability of water resources, along with economic and social development, into further jeopardy (World Meteorological Organization (WMO), 2021). Maintenance of water security, defined by Grey and Sadoff (2007: 545) as "[t]he availability of acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies", therefore raises important questions regarding the most appropriate forms of governance for its achievement.

One response from governments globally has been the establishment of integrated river basin management (IRBM) institutions. This concept relates to "the management of all surface and subsurface water resources of the river basin in its entirety with due attention to water quality, water quantity and environmental integrity", involving establishing dedicated institutions for participatory planning that holistically integrate social, economic and environmental interests in decision-making (Jaspers, 2003: 79). Based upon integrated water resources management (IWRM) principles, this approach has become the dominant institutional mode for governing at the river basin scale globally (Benson et al., 2015). The European Union (EU), for example, has adopted the Water Framework Directive (2000) to counter risks to the sustainability of water resources in its Member States through river basin management planning (Chave, 2001). Subsequent export of the WFD model to non-EU countries in Eastern Europe, Central Asia and Africa has further increased the prevalence of IRBM (Fritsch et al., 2017). Ever-present drought risks in California, meanwhile, have led the state government to establish institutions for integrated river basin management (Langridge and Ansell, 2018). A critical legal driver in this respect is the Sustainable Groundwater Management Act 2014 (SGMA), aimed at ensuring sustainable groundwater management in river basins (ibid.). Globally, the United Nations Sustainable Development Goal target 6.5 also requests governments to adopt IWRM institutions by 2030 to counter water security risks (United Nations (UN), 2015).

However, the expansion of integrated river basin management as a key governance mechanism for attaining water security raises important questions over its effectiveness. The "integrative" paradigm is arguably better placed to tackle water insecurity concerns than traditional "reductionist" water governance, based on hard engineering responses, due its participatory nature and holistic consideration of different interests (Zeitoun et al., 2016). Multiple studies have assessed implementation of integrated river basin management processes such as public participation in national contexts (for example, Jager et al., 2016) or the implications for environmental sustainability of governance models (for example, Langridge and Ansell, 2018; Smith, 2021). In addition, comparative learning between countries on the implementation of integrated water management is a fast emerging research topic (Fritsch and Benson, 2019; see also Lukat et al., 2022; Popovici et al., 2022). Such research has now attained added significance due to the SDG 6.5 target (Benson et al., 2020). Measuring water security outcomes is also critical to gauging wider SDG implementation (Gain et al., 2016). That said, little theoretically-driven comparative research has been specifically conducted into the effectiveness of integrated river basin management for achieving water security outcomes, despite its worldwide growth: a significant research gap. Scope therefore exists for conducting comparative research as a basis for cross-national "lesson-drawing" (Rose, 1991) on optimal integrative approaches to governing water security. A critical research question for investigation is consequently: *how can comparative analysis of integrated river basin management provide lessons on effective water security governance?*

To address this question, this paper employs a comparative, small-N case study analysis of two integrated river basin management processes: the Konya Closed Basin in central Turkey and Kern County Subbasin in central California, USA. Both cases are comparable in socio-economic terms, as agriculture is the dominant industry within these basins, while they experience similar water security concerns, primarily groundwater depletion and dependence, water pollution and periodic drought risks. To compare the effectiveness of integrated river basin management, an analytical framework developed from the Institutional Analysis and Development (IAD) framework (Ostrom, 2005, 2010; Ostrom et al., 2014) is combined with a dedicated water security index for measuring outcomes. Comparative analysis of the two case studies is then employed to identify potential lessons for future water security governance and develop research agendas. The study therefore addresses a critical research gap by theoretically and empirically analyzing the water security effectiveness of integrated river basin management using comparative methods, while also adding value to the expanding water security, water policy, comparative lesson-drawing and policy learning literatures through its integrated, holistic and interdisciplinary approach.

Methods

Comparative case design

The study employed a theory testing, comparative case study design (Yin, 2018), combined with the development of a water security index. Two case studies of integrated river basin management were selected for comparison on the basis of their national significance, comparable water security issues, climatic conditions and the functional equivalence of institutions. First, the Konya Closed Basin is internationally ecologically significant as host to two Ramsar Convention protected areas, plus is economically important as the breadbasket of Turkey due to its high-value agricultural sector (Bozyigit and Tapur, 2009; Berke et al., 2014; Tapur and Bozyigit, 2015). The Basin has experienced severe environmental impacts from the over-use of water for agriculture and industrial water pollution. Sinkholes, attributed to extensive groundwater abstraction, are increasingly prevalent in the basin: 17 were recorded between 2010 and 2014 but their number had increased to 43 in 2020 (Anadolu Ajansi., 2022). As a result, land subsidence is becoming severe, in places up to 75 mm/year within the basin (Orhan, 2021: 174). Such impacts are exacerbated by a Mediterranean type climate with low annual precipitation and periodic drought. Land surface temperatures, in addition, increased by around 2°C between 1984 and 2011, adding to pre-existing drought problems (Orhan et al., 2019). In response, the Turkish government has prioritized implementing integrated river basin management, using the EU Water Framework Directive planning model (Demirbilek and Benson, 2019). Second, the Kern County case is also nationally significant as the basin is a key agricultural area in the USA. The Kern County Subbasin is one of 21 "critically overdrafted", or over-abstracted, basins in California (Department of Water Resources., 2021 see also Smith, 2021), experiencing declining groundwater levels and land subsidence problems (Kern Groundwater Authority., 2020). Water quality degradation from nitrates, arsenic and saline pollution further reduce water security in the basin. As in the Konya Closed Basin, this area of California has a semi-arid Mediterranean type climate, with hot summers associated with low precipitation and milder, wetter winters. To counter water security risks, the California State Government has designated Kern County as a "high priority" basin under the SGMA. This legislation obliges authorities to establish a Groundwater Sustainability Agency (GSA) and Groundwater Sustainability Plan (GSP), to manage basin water resources within an integrated planning approach (Department of Water Resources., 2017; Langridge and Ansell, 2018).

The modified IAD theoretical framework

To allow comparison of how integrated river basin management supports water security in these two basins, established theoretical arguments on Institutional Analysis and Development were utilized (Ostrom, 2005, 2010; Ostrom et al., 2014). The IAD framework is widely used in the environmental management literature to provide "a shared orientation for studying, explaining, and understanding phenomena of interest" (Ostrom et al., 2014: 267), making it ideal for comparatively analyzing water security. Comprised of seven components, the framework seeks to explain the design and effectiveness of common pool resource (CPR) institutions (Figure 1). In common pool resources, such as river systems, it is difficult to exclude all beneficiaries thereby requiring institutions to manage their access to ensure sustainable use (Ostrom, 2008). The main analytical focus of IAD is consequently the "action arena", primarily comprised of the "action situation" or the specific institutional venue that includes the actors involved, their specific management positions and permitted actions, plus their influence over outcomes (Ostrom, 2005; Ostrom et al., 2014; Schlager and Cox, 2018). Within the action situation, in this case integrated river basin management institutions, actors undertake activities to resolve CPR problems, thereby resulting in "outcomes", i.e., the institutional effects on the original problem. For the study analysis, the outcome is water security effectiveness.

In turn, the action situation reflects three main types of external variables (Figure 1), comprising *biophysical conditions*, *attributes of a community* and *rules-in-use*: the latter including formal rules guiding interaction between actors in institutional venues and also sanctions for non-compliance (Ostrom, 2010: 646–647). Interaction between these independent variables shapes the action situation thereby determining management outcomes, i.e., the dependent variable. Evaluation of outcomes supports adaptive change to the external variables by allowing institutional learning and incremental adjustment to the action situation (Ostrom, 2010). For the study, data were collected on four biophysical conditions: basin size (in km^2); primary land use (i.e., agriculture); water availability across the basin; and precipitation (in mm per annum). Attributes of the community assessed were basin population size, the primary economic sector (as a percentage of the overall basin economy), and access to water and sanitation (percentage of total population). The rules-in-use factors are however replaced by governance variables in the study framework (Figure 1).

One reason for this modification is that while the IAD has been successfully employed to analyse CPR institutions in different national contexts (Andersson, 2006; Lejano et al., 2014; Huber-Stearns et al., 2015; Schlager, 2016; Heikkila and Andersson, 2018), it has been subject to criticism. Notably, Ostrom herself (Agrawal and Ostrom, 2001), Sikor (2006) and Clement (2010) criticize institutional analyses for their limited consideration of political power and processes within institutions, since they primarily focus on rules. Responding to this critique, Ostrom developed the Social-Ecological Systems (SES) framework (Ostrom, 2007, 2009). Despite similarities, one major difference between the SES and IAD is the former's inclusion of governance attributes in the analytical framework instead of just rules-in-use, including consideration of governmental and non-governmental organizations, network structures, property rights, rules (operational, constitutional, and collective choice), monitoring and sanctioning (Schlager and Cox, 2018). However, to date the SES framework lacks widespread testing in national contexts using comparative

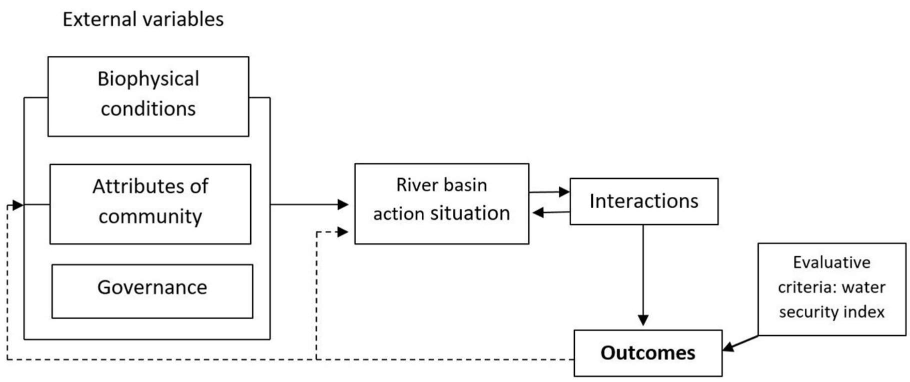

FIGURE 1
The modified IAD framework (adapted from Ostrom, 2010: 646).

analysis. Moreover, the IAD approach lends itself to theoretical modification to suit specific research questions (for example, Huber-Stearns et al., 2015). A governance component was therefore employed within a modified IAD framework, thereby providing a hybrid perspective.

TABLE 1 The study water security index.

Index number	Component	Indicator
1	Agriculture	Sector water availability and use
2	Environment	Environmental flows
3	Independence	Water deficits
4	Risk management	Water replenishment

Water security index

A water security index was developed to compare outcomes from integrated river basin management in the two cases, acting as "evaluative criteria" in the modified IAD framework. Academic development of water security indicators initially focused on water availability (Falkenmark, 1989). Subsequent studies sought to move beyond this quantitative focus by including other water security factors, including poverty (Sullivan, 2001, 2002), environmental parameters (Bordalo, 2001; dos Santos Simões et al., 2008) and vulnerability (Raskin et al., 1997; Gunda et al., 2015). Other indexes employ a combination of factors, for example Gain et al. (2016) who assess water security through water availability, accessibility, safety and quality, and management. However, our study draws upon on the holistic water security index of Lautze and Manthrithilake (2012). They employ five components for evaluation: 1. basic needs; 2. agricultural production; 3. the environment; 4. risk management; and 5. independence (ibid.: 78). As conceptualisations of "basic needs" varies between national contexts, quantitative indices were only developed for agriculture (sector water availability and use, measured by total annual available water), environment (environmental flows, measured using annual surface water flow), risk management (water replenishment) and independence (water deficits) components, to allow cross-comparison between the basins (Table 1). These indicators were each qualitatively assessed using "high", "medium" and "low" security ratings to help approximate an overall level of water security for the basins.

Data sources and collection

Two types of data are employed to assess water security outcomes from the comparative IAD analysis. Documentary sources were used to assess governance variables in both case studies. In the Konya Closed Basin, operational rules are established by the EU's Water Framework Directive (Official Journal of the European Communities., 2000) and Turkish national implementing regulations (Demirbilek and Benson, 2019). Official government documents, obtained from agency sources, were analyzed to identify these rules, while collective choice and constitutional rules were studied using local government agency documents; primarily implementation reports. Similarly, the participation of governmental and non-governmental organizations in the WFD process, along with network structures and property rights were derived from official documentary sources supplemented with academic studies. In the Kern County case, the research primarily utilized state government reports from the California Department of Water Resources (DWR), the Kern Groundwater Authority (KGA) and academic studies, journals and local agency documents, to understand governance structures and processes.

Qualitative material was also combined with quantitative data. Official or published sources were used to derive data for biophysical variable indicators, including basin size, primary land use, water availability and precipitation, plus socio-economic community attributes, specifically population size, economic development and access to water and sanitation in basins. Data were also collected on the "action situations" of integrated river basin management, including the planning processes of basin characterization, public participation, monitoring and compliance: primarily derived from local agencies. Water security index data for each basin were obtained from official government sources, mainly the General Directorate of State Hydraulic Works and General Directorate of Water Management in Turkey, and the California State Water Resources Control Board and Kern Groundwater Authority. Additional quantitative data was sourced from the USGS database (USGS., 2022) to help measure groundwater storage change in Kern County. Finally, the SGMA online portal, published by the California Department of Water Resources, provided information regarding basin prioritization and historical water resource conditions (Department of Water Resources., 2022).

Results

Results are presented for each case study in this section. The results show the external IAD variables (biophysical conditions, attributes of a community and governance) (Tables 2, 3), action situations and water security outcomes for the Konya Closed Basin and Kern County Subbasin.

Konya Closed Basin

External variables and indicators

Biophysical conditions variables in the Konya Closed Basin (Figure 2) were measured using basin size, primary land use, basin water availability and precipitation (Table 2). The Konya Closed Basin covers 53,000 km^2: the third largest river basin in Turkey (Divrak and Demirayak, 2011: 166). Land use is dominated by agriculture; discussed further below. Water availability is low in the basin with abstraction undertaken mainly from groundwater rather than surface water, due to climatic conditions (Ribamap., 2017). Some variability in water availability exists within the Beyşehir Lake sub-basin, which typically receives higher rainfall from its mountain catchment (Demir, 2022). Rainfed agricultural areas only constitute 45.9% of total cultivated land, while the irrigated fields ratio is 34% (Ribamap., 2018). Furthermore, Konya experiences severe problems with aridity and water scarcity (Ribamap., 2018). The average annual basin-wide precipitation is only 407mm; one of the lowest in Turkey (Ribamap., 2017: 2).

TABLE 2 IAD variables, indicators and results for the Konya Closed Basin.

External variable	Indicator	Results
Bio-physical conditions	Basin size	53,000 km^2
	Primary land use	Agriculture
	Basin water availability	Low
	Precipitation	407 mm per annum
Attributes of a community	Population characteristics	3 million
	Primary economic sector	Agriculture-—45% of basin economy, 34% of basin employment
	Access to water and sanitation	High accessibility
Governance	Participating governmental and non-governmental actors	Government agencies (SYGM, DSI)
	Network structure	Hierarchical
	Property rights	Centralized
	Rules (operational, constitutional, collective choice)	National water law and WFD by-laws
	Monitoring and sanctioning	Limited monitoring and sanctions

Attributes of a community variables include population size, economic development, and access to water and sanitation. The total basin population is 3 million, primarily concentrated in Konya, Aksehir and Isparta. Agriculture is the primary economic sector, accounting for 45% of the basin's economic production. Main crops are wheat, corn and sugar beet (Divrak and Demirayak, 2011). Moreover, the Konya Closed Basin is nationally economically significant, with its agricultural production constituting 2.7% of gross value added and 3.5% of employment in Turkey (Ribamap., 2018). Critically for the local community, agriculture comprises 34% of the basin labor force. Access to water and sanitation is high: 91% of the basin population is connected to the mains water supply network, with 82% receiving sewerage services and 62% benefitting from water treatment plant services, primarily in Nigde and Aksaray provinces (Ribamap., 2017).

The *governance* external variable included participating governmental and non-governmental actors, network structure, property rights, rules, monitoring and sanctioning. Within the basin, the main actors are the government General Directorate of State Hydraulic Works (DSI in the Turkish acronym) which is responsible for water supply, infrastructure works

FIGURE 2
Map showing the Konya Closed Basin in Turkey.

and licensing and enforcing water allocation amongst water users, and the General Directorate of Water Management (SYGM in the Turkish acronym). This particular government agency has the main responsibility for coordinating river basin management planning under the WFD implementation process. The SYGM also has government authorization to determine strategic water allocations between economic sectors in order to implement river basin management plans, as stated in the National River Basin Strategy (Ak et al., 2022). The agency has additional powers for determining the quality and quantity of water nationally, preparing protection strategies and standards, and monitoring overall water quality (Öktem and Aksoy, 2014). Other important actors are irrigation unions, who have specific powers for determining irrigation allocations and charges. Network structures for integrated river basin management are consequently hierarchical within basins, with government agencies leading plan decision-making within River Basin Committees (Demirbilek, 2019). Property rights are determined by central government legislation. Successive changes to national water laws have transferred historical rights of individuals to surface and groundwater to the Turkish state (Demirbilek and Benson, 2018). Meanwhile, operational, constitutional and collective choice rules are set by legal obligations under national water law and WFD implementing by-laws (ibid.; Demirbilek and Benson, 2019). Under the national Groundwater Law (1960), permission for drilling wells and abstracting groundwater is licensed by the DSI (Ak et al., 2022). By-laws also establish the rules for river basin management planning in the basin, including plan processes and monitoring (Demirbilek, 2019). That said, DSI monitoring within the basin remains underdeveloped due to technical and institutional incapacities, while agency enforcement of water allocation license conditions is poor (Ak et al., 2022).

The action situation

The action situation reflects the implementation of the WFD in the basin through its institutions, participation mechanisms and holistic integration of water users. In institutional terms, a system of river basin management was established in 2003 starting with a WFD pilot project, "Toward Wise Use of the Konya Closed Basin", initiated by the Turkish government in response to Turkey's EU accession process (Demirbilek, 2019). A river basin action plan was then adopted to cover surface and groundwater management during the period 2009–2011 (SYGM., 2016). Water management tasks were split between the DSI and SYGM, as described above, with the SYGM responsible for developing a river basin management plan through coordinating a River Basin Committee. Public participation has been conducted during the planning process, as specified by Article 14 of the WFD, through consultation with stakeholders and provision of information. However, this process is considered government agency dominated with only minimal input from citizens and agricultural interests (Demirbilek, 2019). The SYGM has attempted to integrate sectoral demands into plan preparation through assessing water volumes, predicting future demands and prioritizing the water needs of agriculture (SYGM., 2018a,b,c). Ecological impacts for both groundwater and surface waters were also analyzed during the planning process, along with water pollution levels (SYGM., 2018a).

Water security outcomes

Water security outcomes from this institutional approach are presented in this section. As stated in the Methods section, the Water Security Index featured four indicators. For the agriculture component, basin-wide data for the *sector water availability and use* indicator shows a picture of declining water availability per capita combined with increasing agricultural sector withdrawals, i.e., low water security. During the period between 2014 and 2017, the Total Available Water Potential per capita declined from 2,532.314 liters per person to 1,622.105 liters per person respectively (see total available water potential data: DSI., 2020a). Meanwhile, data for the agricultural sector shows that water use is increasing significantly, from 2,719 hm^3 in 2012 to 3,114 hm^3 in 2022, with predictions anticipating sector withdrawals will grow to 3,301 hm^3 by 2030 (SYGM., 2018b). The environment component was assessed using *environmental flows,* based on annual average surface water flows. Data show that basin average annual water flow decreased significantly from 452 to 260 hm^3 between 2014 and 2017 (see annual surface water potential data: DSI., 2020a). However, in 2017 it remained stable compared to the previous year. On this basis, this indicator is given a medium water security rating. Basin independence was assessed by calculating *water deficits via* an independence ratio of available basin water vs. transferred water from other basins. Despite the basin experiencing significant water deficits, between 2014 and 2017 no transference occurred meaning that basin independence was maintained, i.e., high water security, although this may decline due to future demand pressures and ongoing transfer

FIGURE 3
Map showing the Kern County Subbasin in California.

TABLE 3 IAD variables, indicators and results for the Kern County Subbasin.

External variable	Indicator	Results
Bio-physical conditions	Basin size	7871 km^2
	Primary land use	Agriculture
	Basin water availability	Low
	Precipitation	127–304 mm per annum
Attributes of a community	Population characteristics	909,235
	Primary economic sector	Agriculture
	Access to water and sanitation	High accessibility
Governance	Participating governmental and non-governmental actors	State government agencies, KGA, farmers, local governments, industry, citizens
	Network structure	Collaborative
	Property rights	Common law rights, state enforcement rights
	Rules (operational, constitutional, collective choice)	SGMA
	Monitoring and sanctioning	Highly developed monitoring and sanctions

schemes. In 2019, the first phase of the Blue Tunnel water transfer project was completed, connecting irrigation in the basin to the Bagbaşi Dam. Risk management was measured through *water replenishment*. In Konya, dam fill rate, used as a proxy indicator, shows that in the absence of significant rainfall between 2014 and 2017, the fill rate first increased (2014–2015) before lowering by 50% in 2016 and improving again during 2017 (DSI., 2020b). However, due to a significant overall decline in replenishment during this period, risk management is equated with low water security.

Kern County Subbasin

External variables and indicators

In terms of *biophysical conditions*, Kern County is the largest subbasin in California (Figure 3), with the hydrological boundary covering 7,671 km^2 (Table 3). Approximately 50% of the basin land area is used by agriculture, making it the dominant land use sector (Kern County Water Agency., 2020). Water availability is low throughout the basin. As a result, during drought episodes the groundwater ratio of total water use increases significantly due to abstraction (TODD Groundwater., 2020, 2021). Another factor is low annual precipitation: only 127 mm in the interior basin and 228–304 mm at the eastern, southern and western basin boundaries (Department of Water Resources., 2003). The main surface water resource is the Kern River but over 50% of basin surface water is supplied through conveyance from the Central Valley Project and State Water Project (TODD Groundwater., 2021).

A key basin *attributes of a community* is its population of 909,235 in 2020 (Census Bureau., 2021). Rural agricultural areas have low population densities compared to the main metropolitan area of Bakersfield (population 400,000) where they are relatively high. As in the Konya case, agriculture is an important economic sector within the basin. California is the leading agricultural producer state in the USA, while Kern County is the most significant agricultural area nationally, with an industry worth $7.669 billion in 2020 (Kern Groundwater Authority., 2020; Department of Agriculture Measurement Standards., 2021). Main crops include citrus fruits, pistachios, milk and grapes, with a combined annual value of $5.5 billion (Department of Agriculture Measurement Standards., 2021). In line with the California State legal "Right to Water", mandated under Assembly Bill (AB) 685, high quality, accessible, affordable water services are generally available in the basin and the surrounding region (Office of Environmental Health Hazard Assessment (OEHHA), 2021).

Governance within the basin reflects the multi-level, polycentric nature of the US political system (see Langridge and Ansell, 2018). Key actors in the SGMA implementation include state government agencies, including the Department of Water Resources that monitors basin water resources, plus the Kern Groundwater Authority that interacts with farmers, local authorities, citizens and businesses in implementing planning.

The network structure is characterized by collaborative governance, involving state and non-state actors in basin co-management. Water rights are determined by common law rights to water, set out in the State Constitution for "reasonable and beneficial" individual use of groundwater, and state laws such as the SGMA. The latter recognizes common law rights, balancing them with the responsibilities of the KGA, as implementing agency, to register, monitor and enforce compliance for groundwater abstraction, under DWR oversight. Operational, constitutional and collective choice rules are determined by SGMA obligations, as set out in State implementing Bills (AB 1739, SB 1319; and, SB 1168). Finally, the SGMA requires monitoring of its legal obligations and compliance, including those for achieving sustainability goals (Langridge and Ansell, 2018; Smith, 2021), achieved through state agency water monitoring in the basin and application of punitive legal action for transgressions.

The action situation

Institutions, participation mechanisms and holistic integration of water users within the action situation in the Kern County Subbasin differs compared to the Konya case. Basin institutions are determined by the SGMA implementation requirements for high-priority basins. Kern County initiated plan procedures in 2016 and then formed the Kern Groundwater Authority in 2017 as a GSA to coordinate basin-wide groundwater management planning (Kern County Water Agency., 2014; Westside District Water Authority., 2019). Its initial Groundwater Sustainability Plan only included 13% of the basin but has been gradually expanded, in four main phases (Kern County Water Agency., 2020). In line with the SGMA, participation is strongly supported at an institutional level: the basin is managed in coordination with 16 district agencies. Groundwater Sustainability Plans and annual reports assess implementation benefits for all water users, while they are encouraged to participate in the planning. Monthly public meetings are held by the KGA to communicate actions (ibid.). Outreach stakeholder meetings are also used to facilitate external input to plan development. The GSP reflects the SGMA requirement for integrated river basin management through incorporating the views of different interests, primarily agriculture given its economic significance in the basin, through the inclusive planning process. An extensive monitoring network within the basin provides data for annual reporting, which in turn supports adaptive management and measures conformity with the SGMA water management objectives.

Water security outcomes

Water security outcomes from this institutional arrangement were measured with the sector water availability and use, environmental flows, basin water deficits and water replenishment indicators for the four components. Data show that overall *sector water availability and use* was variable in the period after 2016 (TODD Groundwater., 2020), eliciting a "Medium" water security rating for the Agriculture component. Between 2017 and 2021, there was a decrease of 209,373-acre feet in groundwater storage change: an annual decrease of 58,075-acre feet in storage conditions (TODD Groundwater., 2022). In addition, 2021 was a severe drought year in California; conditions that have continued into 2022. Despite this pattern of declining water availability for farmers in the basin, overall annual water use by the agricultural sector has actually fallen following the SGMA implementation in 2016 (TODD Groundwater., 2021), with limited impacts on productivity to date. The GSP reports also show that the basin meets the minimum sustainable criteria set by the SGMA for surface water depletion, suggesting that the GSP has contributed to meeting *environmental flow* objectives during these years (TODD Groundwater., 2019, 2020, 2022). On this basis, a "High" rating for the Environment component is appropriate. Regarding basin independence, Kern County does counter *water deficits* by receiving water from external sources such as the State Water Project and Central Valley Project, although its dependency ratio is declining: down from 37% of water availability in 2019 to 26% in 2020 (ibid.), suggesting a "Medium" rating for basin Independence. Finally, the annual reports show that for risk management there is little storage or reservoir construction planned in Kern County for *water replenishment* but groundwater banking is employed to increase replenishment capacity, for example the New Cawelo GSA water banking, Kern Water Bank and Kern Fan Groundwater Storage Project (see TODD Groundwater., 2020, 2021, 2022). While risk management is therefore an issue, these measures should ensure that water replenishment is addressed in future—reflected in a "Medium" risk rating.

Discussion

Comparative IAD analysis and water security outcomes

From this analysis, it could be concluded that Kern County's approach is more effective for achieving water security outcomes, raising questions regarding which intervening factors are potentially influential. Table 4 shows that the Konya Closed Basin was rated lower overall for water security across the index (Agriculture = Low; Environment = Medium; Independence = High; Risk management = Low) than the Kern County Subbasin (Agriculture = M, Environment = H, Independence = M; Risk management = M). Comparative case analysis can therefore be employed to identify which factors could explain such difference.

The difference in water security outcomes between the Konya WFD implementation and Kern County SGMA

TABLE 4 A comparison of the water security ratings for the Konya Closed Basin and Kern County Subbasin.

Index number	Component	Indicator	Konya Closed Basin—water security rating	Kern County Subbasin—water security rating
1	Agriculture	Sector water availability and use	L	M
2	Environment	Environmental flows	M	H
3	Independence	Water deficits	H	M
4	Risk management	Water replenishment	L	M

H, high rating; M, medium rating; L, low rating.

implementation cannot be readily interpreted by either bio-physical or community factors using the modified IAD framework. Both basins are experiencing low and declining rainfall: the Konya Basin receives only 407 mm of rain annually but areas of Kern County Subbasin receive even less, for example the 127 mm of rainfall in the interior basin. Basin-wide water availability is comparably low as a result. Nonetheless, Kern County achieves a higher water security outcome through its integrated river basin management even though California, as identified above, has endured another severe drought period since 2020. Indeed, 2022 was the driest year recorded in the state for 128 years, while Kern County Subbasin is currently classified as experiencing "exceptional drought" (Drought.gov., 2022). Water security differences are also difficult to directly attribute to agricultural land use and the agricultural sector. Both basins have a similar proportion of their land area in agricultural production with analogous water-intensive crops grown, suggesting that sectoral water use pressures are comparable. Population densities are also less in the Konya basin while it also has equivalent levels of domestic access to water services, meaning that these community factors alone do not explain why its water resources are less secure than in Kern County.

The main influencing differences therefore pertain to governance structures, notably the inclusion of governmental and non-governmental organizations within network structures, plus property rights, rules, monitoring and sanctioning procedures. In Konya, despite the introduction of the participatory WFD process, government agencies (DSI, SYGM) dominate water management within a hierarchical actor network that only provides limited input from user groups such as farmers or non-governmental organizations. Property rights, rules (operational, constitutional, collective choice), monitoring and sanctioning are largely determined by the framework of national laws and by-laws, with limited local flexibility. The Konya Closed Basin therefore reflects a legacy of top-down, centralized and reductionist water governance in Turkey (Demirbilek and Benson, 2018). In contrast, governance in the Kern County Subbasin compels state and non-state actors to cooperate. Doubts have been raised over the effects on resource sustainability of actor task allocation within the SGMA implementation in basins, due in part to the legal application of property rights for water (Langridge and Ansell, 2018). Yet, the approach is more collaboratively networked than in Konya, with government agencies legally obliged to engage with non-state actors including farmers and local citizens within the GSP process. As described above, monitoring and sanctioning mechanisms are, in comparison, also highly developed in Kern County. The legal framework set by the SGMA is then more effective in supporting the "action situation" within the basin in countering water security issues such as over-abstraction from agricultural sources. This feature is not evident in the Konya case, where the WFD process has been problematic due to institutional sub-optimality and implementation deficits (Demirbilek, 2019; Ak et al., 2022).

There is consequently a correlation between the "policy style" (Howlett and Tosun, 2019) or "administrative style" (Bayerlein and Knill, 2019) of governance of integrated river basin management and water security. Past comparative studies have noted how policy styles can significantly influence environmental policy implementation (Vogel, 1986; Kagan, 2000). For example, deliberative forms of governance can shape how successfully climate change adaptation is achieved *via* water policies in divergent national contexts (Vink et al., 2015). When comparing the Konya case with Kern County, the administrative style of the latter allows for greater agency engagement with water users in determining collective planning solutions, which is reflected in declining agricultural water use and maintenance of environmental flows even during the drought period. This observation reflects arguments in the wider academic literature concerning the normative benefits of collaborative governance for achieving environmentally positive outcomes (for example, Wondolleck and Yafee, 2000; Margerum, 2011), particularly within river basin management (Smith et al., 2015; Collins et al., 2020).

Lesson-drawing potential

Given that the Kern County case proved more effective for water security outcomes, potential governance lessons can be identified from the comparative case studies for supporting future water security at the river basin scale. In public policymaking, a comparative lesson is definable as "an action oriented conclusion about a programme or programmes in operation elsewhere" that can inform future policy options (Rose, 1991: 7). On this basis, three governance aspects of the SGMA approach can be discussed for lesson-drawing.

First, the Kern County experience of SGMA implementation demonstrates the importance of measuring and communicating baseline water conditions to support river basin planning. The measurement allowed identification of "critically overdrafted" basins, including Kern County, by the state Department of Water Resources for determining production of Groundwater Sustainability Plans. These plans also identify responsible agencies plus require descriptions of the physical environment and the aquifer system, maps and use of historical data to establish water demand and future water use projections. A Groundwater Exchange website was also created by stakeholders to provide information regarding basins and groundwater basin conditions for all users (Groundwater Exchange., 2022). Although authorities in the Konya Closed Basin were required to prepare a characterization of water resources report under the WFD process, data such as water use, consumption amounts, costs and recovery rates were not included, thereby limiting consideration of management options.

Second, monitoring of outcomes is more advanced in the SGMA implementation compared to the Konya Closed Basin example. The SGMA compels monitoring of sustainable management criteria, including storage and groundwater levels, land subsidence and surface water depletion (Department of Water Resources., 2017: 1–2). As a result, California has an extensive river basin monitoring network. Kern County for example established sustainability indicators, monitored them and evaluated attainment in annual reports. In contrast, despite WFD requirements for monitoring, the authorities in the Konya Closed Basin lacked requisite institutional and technical capacity (Ak et al., 2022). Only limited monitoring data was then available to assess progress against plan objectives, as evident in the annual implementation reports (ibid.).

Third, the cases provide lessons regarding public participation and inter-agency collaboration in planning. In California, all GSA's are required under the SGMA to consider the needs of users, including farmers, and support their participation in Groundwater Sustainability Plan production. Implementation in Kern County involved monthly stakeholder meetings, in contrast to the Konya Closed Basin where the WFD planning process lacked inclusion of non-governmental actors (see Demirbilek, 2019; Ak et al., 2022). Additional SGMA requirements mandate local agency collaboration within basins; implemented through a Joint Power Arrangement in Kern County. Such collaboration is not evident in the Konya Closed Basin or indeed other Turkish river basins under the WFD process (Ak et al., 2022). Different agencies (SYGM, DSI) are responsible for different tasks in the planning process with only limited coordination, leading to institutional incoherence. Inter-agency competition over plan implementation has occurred as a result (Demirbilek, 2019). An important lesson from both cases is that meaningful participation and agency collaboration are important to ensuring positive water security outcomes from integrated river basin management, thereby endorsing the findings of previous studies on integrated river basin institutional design (for example, Smith et al., 2015).

That said, lesson-drawing from the Californian system comes with two caveats. The Kern County case also shows that long term sustainability of water resources is still not being achieved by institutions in the basin, reflecting the findings of other studies on the SGMA implementation (Langridge and Ansell, 2018; Smith, 2021). Basin independence in Kern County is being challenged through transfers from outside the basin from the State Water Project and Central Valley Project which are, despite recent reductions in transferred water, potentially unsustainable in the future given the combined state-wide risks from drought and climate change (see State of California., 2018). Another feature of cross-national lesson-drawing is that policy is not necessarily transferable in its original form, given different legal, economic, political and cultural contexts. Recommendations for policy transfer should therefore be cognizant to the governance context of integrated river basin management.

Conclusions

In the introduction of this paper, we argued that the growth in integrated river basin management globally raises valid questions over how comparative analysis can provide lessons on effective water security governance. In response, this paper developed a modified IAD framework and water security index for analyzing them using a comparative case design. Analysis of the two case studies of integrated river basin planning showed that, despite the importance of bio-physical factors such as climate, water security effectiveness largely reflected the governance context in both Konya and Kern County. Further analysis identified several lessons for future governance, most notably the need to strongly embed organizational rules for multi-actor participation and inter-institutional coherence within integrated river basin management at the strategic policy level: here, California's SGMA could be considered a potential model for lesson-drawing. However, it remains problematic to forward definitive answers on the basis of just two in-depth case studies, thereby necessitating further examination of the modified IAD framework and water security index in other national cases.

The research consequently highlights areas of potential future study. Given the global growth of integrated river basin management as the main institutional form for governing water resources, its contribution to achieving water security requires further examination. Comparative analysis can be undertaken through large N statistical studies, both within and between national contexts, to examine the independent governance factors determining water security outcomes, in order to inform lesson-drawing on policy design. As such, policy learning or lesson-drawing research on integrated river basin management could inform a productive agenda within the wider water security debate. Such research moreover could also help guide governments in attaining the UN's SDG 6 targets for 2030.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

MA: conceptualization, data collection, data analysis, and text writing. DB: conceptualization and text writing. Both authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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