REPORT

The Ethiopian Juba-Shebelle Water Cooperation: The Roles of IOS Enabled Knowledge, Information and Data Supply Chain Collaboration

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The authors wish to convey their heartfelt appreciation to the International Centre for Water Cooperation (ICWC) for the invaluable support and funding, which made this study possible. This investigation was commissioned to tackle the critical challenges associated with water resources management and cooperation in the Juba-Shebelle Basin, while also identifying opportunities for enhanced cooperation among the Ethiopian Juba-Shebelle stakeholders. We extend our profound gratitude to the 115 leaders from various stakeholder organizations involved in water management within the Ethiopian Juba-Shebelle Basin, including representatives from the federal government entities of Ethiopia, regional and local government entities of the Somali government, non-governmental organisations (NGOs), and various universities and research institutions. We greatly appreciate the individuals who provided their expertise and guidance throughout this project. Their insights into water resource management, information technology infrastructure, KID supply chain dynamics, and collaborative governance were instrumental in shaping the framework and forming the recommendations presented in this report.

Executive Summary

The Juba-Shebelle Basin, spanning approximately 800,600 square kilometres across Ethiopia, Somalia, and Kenya, is a critical transboundary water system in the Horn of Africa, vital for supporting sustainable livelihoods, economic growth, and regional stability. This study, commissioned by the International Centre for Water Cooperation (ICWC), investigates the challenges and opportunities for enhanced water and climate resource management within Ethiopia's Juba-Shebelle Basin, emphasizing transboundary cooperation. The research introduces the IOS-Enabled Knowledge, Information, and Data (KID) Supply Chain Collaboration Framework, a novel approach to foster integrated, data-driven water governance through vertical (within Ethiopia) and horizontal (across riparian states) coordination.

The study identifies significant gaps in Ethiopia's water management framework, including limited IT infrastructure, weak data-sharing protocols, and insufficient stakeholder alignment, which hinder effective collaboration. Key findings reveal low scores across critical constructs such as IT resources (average 3.2), collaborative governance (2.9), and trust (3.5), with local government entities and NGOs particularly constrained by capacity limitations. These weaknesses contribute to inefficiencies in data sharing, misaligned objectives, and poor decision synchronization, undermining collaborative advantage and country-level performance in water resource management.

The KID framework, validated through empirical analysis and stakeholder surveys, leverages Transaction Cost Economics, Resource-Based View, and Trust-Based Rationalism to propose solutions. It emphasizes strengthening internal capacities—such as IT infrastructure, standardized data platforms, and incentive alignment—before extending cooperation to downstream neighbours like Somalia. Recommendations include investing in shared IT systems, developing robust data-sharing protocols, and fostering collaborative culture to enhance trust and goal congruence. These interventions aim to improve process efficiency, adaptive response capacity, and innovation, ultimately supporting sustainable water management and regional stability.

By addressing these gaps, Ethiopia can enhance its upstream role in the Juba-Shebelle Basin, aligning national priorities with transboundary cooperation goals. The framework offers a scalable model for integrated water resource management, with potential applications in other transboundary basins facing similar challenges.

1. Background of the Study

1.1 Introduction

The impetus for this study stems from a prior case study within the Juba and Shebelle basin (Tengberg et al., 2023), which investigated the potential of flood risk management measures to contribute to a sustainable blue economy in Somalia, with the support of the International Centre for Water Cooperation (ICWC). That research highlighted a critical issue: flooding problems in the basin originate in upstream areas and are largely attributable to deforestation in Ethiopia. A key recommendation from the study was the urgent need to strengthen information, data sharing, and monitoring capabilities, alongside the pursuit of enhanced transboundary cooperation with Ethiopia. The current study builds directly upon those findings, acting as a crucial first step toward implementing the recommendations. It introduces a novel framework for water cooperation, cantered on the integration of information and operational systems (IOS), coupled with a supply-chain approach to managing knowledge, information, and data (KID) related to water resources. This framework builds on the premise that effective water management in the Juba-Shebelle Basin requires a holistic and coordinated effort, that recognizes the importance of both vertical and horizontal coordination and collaboration in multi-level governance. The Juba-Shebelle Basin presents a complex and challenging context for water collaboration, characterized by a semi-arid climate and erratic rainfall patterns, transboundary dynamics involving Ethiopia, Somalia, and Kenya, and competing interests and fragmented governance structures. These factors underscore the need for a cooperative and data-driven approach, firmly grounded in knowledge, information, and data. By adopting an integrated approach that leverages both vertical (different levels of government) and horizontal (different sectors) collaboration, this research aims to contribute to a more cohesive water governance framework that aligns with the basin's unique needs and Ethiopia's strategic position within it.

1.2 The Juba-Shebelle Basin

The Juba-Shebelle Basin, a vital transboundary water system spanning approximately 800,000 square kilometres across Ethiopia, Somalia, and Kenya, stands as one of the largest river basins in the Horn of Africa (FAO, 2021). Defined by its two principal rivers—the Juba, which discharges into the Indian Ocean, and the Shebelle, which dissipates into Somalia's wetlands during low-flow periods—this basin serves as a lifeline for over 20 million people, underpinning agriculture, domestic water supply, and critical ecosystem services (UNEP, 2022). The basin's unique socio-ecological and climatic context, characterized by arid to semi-arid conditions and erratic rainfall patterns, shapes its complex water

management challenges and underscores the urgent need for collaborative governance among riparian states.

The basin's climate exhibits pronounced variability, with annual rainfall ranging from 400–600 mm in Ethiopia's northern highlands to less than 200 mm in Somalia's southern lowlands (FAO, 2021). This spatial and temporal inconsistency, coupled with distinct wet and dry seasons, drives reliance on the Juba and Shebelle rivers, particularly during dry periods when agriculture and pastoralism—sustaining nearly 70% of the basin's population—face acute water shortages (UNEP, 2022). Seasonal flooding, while occasionally alleviating water deficits, poses significant risks to infrastructure, crops, and livelihoods, exacerbating socio-economic vulnerabilities (IWMI, 2023). Climate change intensifies these challenges, rendering rainfall increasingly unpredictable and amplifying the frequency and severity of droughts and floods, which disrupt agricultural productivity and threaten food security across the region (World Bank, 2021).

Agriculture, predominantly rainfed and irrigated, forms the economic backbone of the basin, with the Juba River supporting key irrigation schemes that bolster food production in water-scarce areas (FAO, 2021). However, competing demands for agricultural, domestic, and industrial water use, particularly during the dry season, strain the basin's resources, heightening tensions among stakeholders (World Bank, 2021). In Somalia and parts of Ethiopia, water scarcity fuels conflicts and competition, undermining social stability and sustainable development efforts (UNEP, 2022). These dynamics highlight the critical need for robust water cooperation frameworks to equitably allocate resources and mitigate socio-economic impacts.

The Juba-Shebelle Basin's transboundary nature necessitates collaborative management to address shared challenges, including water scarcity, flood risks, and climate resilience. Effective governance requires integrated data-sharing systems and coordinated decision-making among Ethiopia, Somalia, and Kenya to balance competing demands and enhance adaptive capacity (IWMI, 2023). By fostering transboundary cooperation, stakeholders can leverage the basin's resources to support sustainable livelihoods, reduce conflict risks, and promote regional stability, aligning with global calls for integrated water resource management (World Bank, 2021).

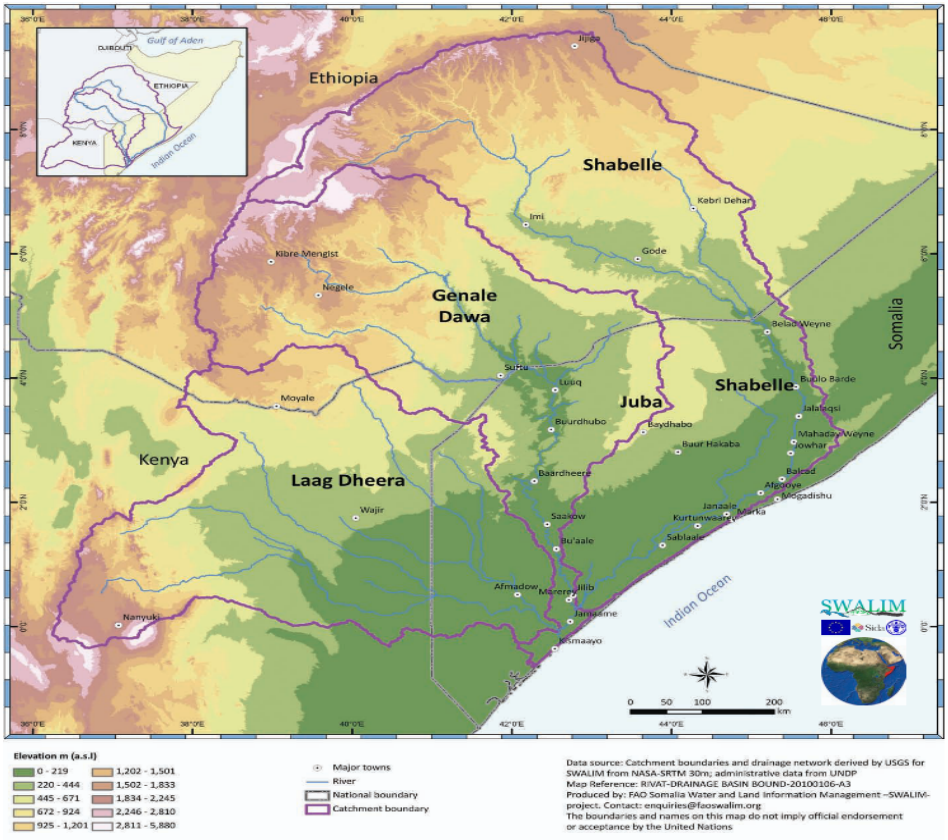

Figure 1. The Juba-Shabelle transboundary basin[1].

Ethiopia's upstream position in the Juba-Shebelle Basin affords it significant control over the basin's water resources, which it has harnessed to advance agricultural expansion and hydropower development, aligning with its national agenda for food security and economic growth (Awulachew et al., 2010). Despite a regulatory framework for water management, persistent coordination challenges between federal and regional governments hinder effective governance (World Bank, 2019). These internal limitations, compounded by underdeveloped data-sharing systems with downstream Somalia, strain transboundary relations (Edossa et al., 2010). Climatic variability further exacerbates these issues, reducing water predictability and challenging agricultural productivity and water management strategies (World Bank, 2016). Against this backdrop, this study examines the intricate dynamics of water resource management, climate adaptation, and Knowledge, Information, and Data (KID) supply chain collaboration within the Juba-Shebelle Basin, with a focus on Ethiopia's role. By analyzing existing cooperative frameworks and proposing pathways for enhanced vertical and horizontal integration, the study seeks to strengthen water governance in this transboundary context.

[1] Source: https://faoswalim.org/resources/river_atlas/River_Atlas_Documents/atlas/River_Atlas_Som_Part1_drainage.pdf

The "inside-out" approach referenced in the provided section refers to a strategic perspective in organizational and management theory, emphasizing the development of internal capabilities and resources as a foundation for achieving external outcomes, such as competitive advantage or, in this context, effective transboundary collaboration. Specifically, in the IOS-Enabled KID Supply Chain Collaboration Framework for the Juba-Shebelle Basin, the inside-out approach prioritizes strengthening Ethiopia's internal governance structures, technological infrastructure, and stakeholder coordination (e.g., within federal, regional, and local government entities) before extending these capabilities to foster regional cooperation with Somalia (the "outside-in" component).

The inside-out approach is grounded in the Resource-Based View (RBV) of the firm, which posits that internal resources—such as IT infrastructure, expertise, and organizational processes—are critical drivers of performance and competitive advantage (Barney, 1991). By first enhancing internal capacities, such as data-sharing systems and collaborative governance within Ethiopia, the framework creates a robust foundation for effective water resource management. This internal strength then enables Ethiopia to engage more effectively in transboundary cooperation, aligning with external stakeholders like Somalia to address shared challenges such as water scarcity and climate resilience.

The inside-out approach is particularly relevant in the context of transboundary water management, where national governance systems must be robust to support regional collaboration. As Cao and Zhang (2011) argue, internal alignment of resources and processes enhances collaborative efficiency, which can then be leveraged for external partnerships. In the Juba-Shebelle Basin, this means improving Ethiopia's internal data-sharing protocols and IT systems to facilitate seamless information flow before engaging in cross-border data exchanges with Somalia (Mentzer et al., 2001). This approach contrasts with an outside-in perspective, which might prioritize external pressures or partnerships first, but the framework adopts a dual strategy to ensure internal readiness underpins regional cooperation.

1.3 Theoretical Foundations

The Knowledge, Information, and Data (KID) Supply Chain Collaboration Framework, designed for the transboundary Juba-Shebelle Basin shared by Ethiopia and Somalia, provides a robust theoretical foundation for addressing complex water management challenges through a data-driven approach. This framework integrates inter-organizational systems (IOS) to enhance water governance by fostering efficient, transparent, and adaptive collaboration among stakeholders. Grounded in multiple theoretical perspectives, it leverages Transaction Cost Economics (TCE), the Resource-Based View (RBV), Trust-Based

Rationalism, the Knowledge and Learning Perspective, and Resource Dependence Theory (RDT) to structure its implementation and guide stakeholder interactions. Transaction Cost Economics emphasizes minimizing coordination and transaction costs in organizational interactions. By integrating IOS, the framework reduces uncertainties, mitigates contractual risks, and eliminates redundancies, facilitating streamlined stakeholder collaboration in water management (Williamson, 1979). This approach ensures efficient governance structures that lower the costs of information exchange and coordination, critical for transboundary resource management.

The Resource-Based View underscores the strategic importance of organizational resources, particularly IT infrastructure and expertise, as key drivers of collaborative success. The framework positions these resources as essential for IOS functionality, enabling effective data sharing and analysis within the KID supply chain (Barney, 1991). By leveraging unique, valuable, and inimitable IT capabilities, stakeholders can enhance their water management practices and achieve collaborative advantage.

Trust-Based Rationalism highlights trust as a cornerstone of successful cooperation. The framework fosters trust through IOS-enabled transparent data exchanges, consistent information quality, and mutual accountability, reducing the need for extensive monitoring and fostering cooperative behaviours among stakeholders (Cook & Santana, 2017). This trust-building mechanism is vital for sustaining collaboration in the complex socio-political context of the Juba-Shebelle Basin.

The Knowledge and Learning Perspective emphasizes continuous learning and adaptability in water governance. Through IOS, the framework enables real-time data access, knowledge sharing, and collaborative strategy development, allowing stakeholders to respond dynamically to evolving water resource challenges (Linn, 2012). This perspective supports adaptive management by integrating new insights and fostering innovation in decision-making processes.

Resource Dependence Theory provides insights into organizational interdependencies and resource access. The framework applies RDT principles to promote equitable resource-sharing agreements, minimizing dependency risks while maximizing mutual benefits among stakeholders (Pfeffer & Salancik, 1978). By fostering strategic alliances, it reduces vulnerabilities and enhances resource security, critical for sustainable water management.

Collectively, these theoretical foundations underpin the IOS-enabled KID Supply Chain Collaboration Framework, offering a comprehensive approach to addressing transboundary water governance challenges. By integrating TCE's focus on efficiency, RBV's emphasis on strategic resources, Trust-Based Rationalism's trust-building mechanisms, the Knowledge and Learning Perspective's adaptability, and RDT's resource-sharing strategies, the framework provides a robust theoretical scaffold for enhancing collaborative water management in the Juba-Shebelle Basin.

1.4 Conceptual Framework, Constructs and Sub-constructs

The structure of the IOS-enabled KID Supply Chain Collaboration Framework is organized around three interconnected building blocks: Antecedents, KID Supply Chain Collaboration Characteristics, and Consequences. The first building block, Antecedents, comprises the fundamental factors that influence the initiation and effectiveness of collaborative efforts. In its ideal state, this building block nurtures an environment characterized by abundant IT resources, broad IOS adoption, a deeply ingrained culture of collaboration, and robust trust-based relationships. Such a foundation fosters seamless information flow, aligns stakeholder goals, and cultivates a shared commitment to sustainable water management practices.

The second building block, KID Supply Chain Collaboration Characteristics, examines the specific traits and processes that shape collaborative activities within the KID supply chain. An ideal KID supply chain facilitates seamless information flow, synchronized decision-making, shared resources, aligned incentives, open communication, and joint knowledge creation. Together, these attributes ensure that relevant data is accessible to all stakeholders, enabling efficient and effective decision-making processes while fostering innovation.

The third building block, Consequences, focuses on the tangible outcomes and benefits derived from effective collaboration within the KID supply chain. The ideal state of this building block signifies the realization of substantial collaborative advantages and enhanced performance at the country level. This encompasses improved process efficiency, greater operational flexibility, the creation of business synergies, the achievement of high-quality outcomes, and the promotion of innovation within the water management landscape. Ultimately, the consequences depicted in this framework encompass broad-reaching impacts, including economic benefits, environmental sustainability, and socio-political stability.

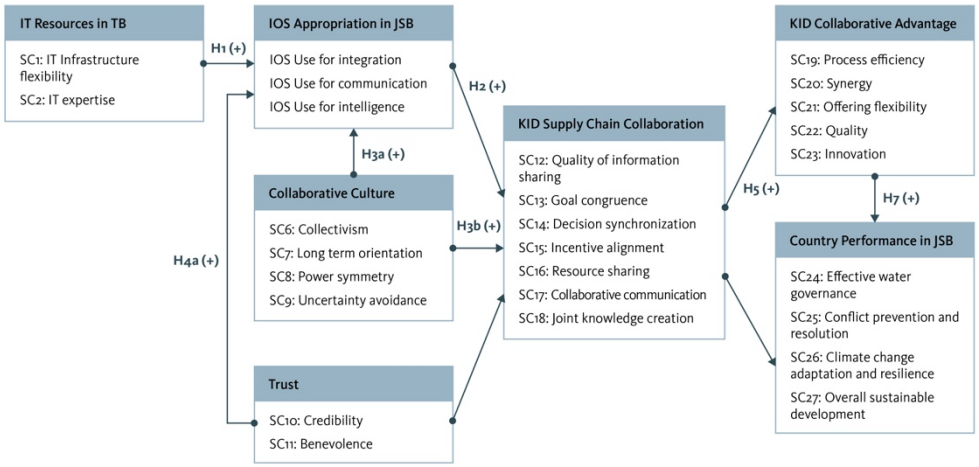

Figure 2. IOS-Enabled KID Supply Chain Collaboration Framework solutions

The proposed framework solution is comprised of seven core constructs, 27 sub-constructs, and more than 256 measurement items with the above defined structural relations defined by Hs are recommendations derived from theories, empirical analysis, case studies and basin best practices. The framework can serve as a benchmarking for organizational and country performance.

The relations within the IOS-Enabled KID Supply Chain Collaboration Framework provide a detailed understanding of how various constructs interact and influence one another, ultimately contributing to collaborative advantages and improved country performance in the context of water management. Each relation, denoted as (Hs), presents the framework solution definitions, not a hypothesis, Here follows a more elaborate examination of the framework solution definition.

1. H1: IT Resources positively impact IOS Appropriation

The framework is designed so that strong IT resources (infrastructure, expertise) enable and facilitate the effective adoption and use of Inter-Organizational Systems (IOS) for water management. This definition of framework solution posits that the availability and quality of IT resources—such as robust IT infrastructure and professional expertise—serve as catalysts for the effective appropriation of inter-organizational systems (IOS). Organizations equipped with flexible IT resources can leverage technology more efficiently, facilitating better integration of systems, improved communication channels, and more informed decision-making.

2. H2: IOS Appropriation strengthens Collaborative Culture and builds Trust

The framework is designed so that effective use of IOS fosters a collaborative culture and enhances trust among stakeholders through improved communication, transparency, and information sharing. This hypothesis suggests that the effective appropriation of IOS contributes to fostering a collaborative culture within organizations, characterized by shared values and mutual goals. As organizations utilize IOS for communication and collaboration, they are likely to enhance transparency and facilitate open exchanges of information, thereby strengthening trust among stakeholders. Trust is essential for reducing uncertainties and promoting cooperation in complex environments like the transboundary water management context.

3. H3: Collaborative Culture and Trust positively impact Supply Chain Collaboration

The framework is designed so that a strong collaborative culture and high levels of trust promote effective collaboration within the KID supply chain, encouraging cooperative behaviours and enhanced coordination. Here, the relationship draws attention to the synergistic effects of a strong collaborative culture and established trust on the ability of stakeholders to work together effectively in the KID supply chain. When collaborative values are deeply ingrained within organizations,

combined with high levels of trust, stakeholders are more inclined to engage in cooperative behaviours that lead to enhanced collaboration.

4. H3a: Collaborative Culture positively impacts Information Sharing and Goal Congruence

The framework is designed so that a well-established collaborative culture encourages open communication and the sharing of information, which aligns organizational goals. This relation emphasizes that a well-established collaborative culture encourages open communication and the sharing of information, which aligns organizational goals. When entities share not only resources but also knowledge and insights, they are more likely to achieve coherency in their objectives.

5. H3b: Trust positively impacts Decision Synchronization and Incentive Alignment

The framework is designed so that trust among stakeholders enhances their willingness to synchronize decisions and align incentives. This relation posits that trust among stakeholders enhances their willingness to synchronize decisions and align incentives. When groups trust each other, they are likely to coordinate their individual actions toward collective goals, achieve better decision-making outcomes, and ensure that rewards and incentives are aligned with shared objectives.

6. H4: Supply Chain Collaboration contributes to Collaborative Advantage

The framework is designed so that working together enables the optimization of processes, reducing redundancies and delays, which enhances overall efficiency within the supply chain. This relation suggests that effective collaboration within the KID supply chain leads to significant competitive advantages. When organizations collaborate efficiently, they can leverage combined strengths to improve processes, innovate solutions, and build synergies that would not be attainable individually.

7. H4a: Supply Chain Collaboration enhances Process Efficiency

The framework is designed so that working together enables the optimization of processes, reducing redundancies and delays, which enhances overall efficiency within the supply chain. In this definition, the assertion is made that working together enables the optimization of processes, reducing redundancies and delays, which enhances overall efficiency within the supply chain. Enhanced process efficiency translates into faster and more responsive operations.

8. H4b: Supply Chain Collaboration enhances Adaptive Flexibility

The framework is designed so that collaboration fosters adaptive flexibility, enabling stakeholders to respond proactively to changes in external environments or water management challenges This relation underscores that collaboration fosters adaptive flexibility, enabling stakeholders to respond proactively to changes in external environments or water management challenges. The ability to quickly adjust operational strategies is vital in the context of transboundary water management, where conditions may shift based on environmental factors, regulatory changes, or socio-political dynamics.

9. H5: Collaborative Advantage positively impacts Country Performance

The framework is designed so that advantages gained through effective collaboration among stakeholders directly translate into improved country performance, encompassing economic gains, better resource management, and enhanced social stability. This framework construct relation posits that the advantages gained through effective collaboration among stakeholders directly translate into improved country performance. Factors such as increased efficiency, innovation, and synergy contribute to a stronger performance at the national level, encompassing economic gains, better resource management, and enhanced social stability.

10. H6: Collaborative Advantage mediates the relationship between Supply Chain Collaboration and Country Performance

The framework is designed so that collaborative advantages act as a key mechanism through which supply chain collaboration improves overall country performance, ensuring that the benefits of cooperation are realized at a broader, national level. This relation suggests that the benefits derived from collaborative activities (i.e., collaborative advantage) mediate the impact of supply chain collaboration on country performance. In other words, while direct collaboration among organizations is crucial, the derived advantages of that collaboration are what ultimately lead to enhanced national outcomes. This mediation highlights the importance of not just collaboration itself but also the quality and effectiveness of the resulting collaborative efforts in shaping broader societal benefits.
Through these relationships, the IOS-Enabled KID Supply Chain Collaboration Framework offers a comprehensive understanding of the intricate dynamics between the foundational resources, collaborative practices, and resulting impacts on performance. It emphasizes the importance of fostering a conducive environment for collaboration, built on robust IT resources, a strong culture of collaboration, and trust among stakeholders, all aimed at achieving sustainable water management in the Ethiopian Juba-Shebelle sub-basin. This intricate interplay sets the groundwork for effective governance and shared success in managing complex and shared water resources.

2. Methodology

This study employs a robust and systematic methodology to investigate Knowledge, Information, and Data (KID) supply chain collaboration within the Ethiopian Juba-Shebelle Basin, structured around three core components: the study methodology, the benchmarking methodology, and the validation methodology. These components collectively ensure a comprehensive exploration of the phenomenon, identification of best practices, and rigorous validation of findings, aligning with the complex transboundary water management context of the basin.

The primary data collection instrument is a structured questionnaire, meticulously designed to measure the constructs and sub-constructs delineated in the study's theoretical framework. A 7-point Likert scale, ranging from "Strongly Disagree" (1) to "Strongly Agree" (7), captures nuanced stakeholder perceptions and experiences, ensuring sensitivity to variations in collaborative dynamics. Prior to participation, all respondents received comprehensive information about the study's purpose, procedures, risks, and benefits, and provided informed consent. To safeguard participant confidentiality and anonymity, stringent protocols were implemented, with all data securely stored and managed in accordance with ethical research standards.

The target population comprises heads of stakeholder organizations involved in water and climate resource management within the Ethiopian Juba-Shebelle Basin, selected for their expertise in transboundary water governance and their organizations' alignment with social, economic, and environmental development goals. A purposive sampling approach was utilized to ensure the inclusion of a diverse range of stakeholders across governance levels and sectors, yielding rich insights into collaborative dynamics. A total of 115 individuals from selected organizations participated, representing federal and regional government agencies, local government entities, NGOs, and research institutions, chosen based on their roles in water management and organizational performance.

To ensure that the data accurately reflected the operational reality of all participants, particularly those with known resource constraints, the purposive sampling focused on key decision-makers within Local Government Entities (LGEs) and NGOs whose roles directly involve water resource coordination, regardless of their existing IT or funding capacity. This robust approach was vital because the low mean scores observed among these constrained groups (e.g., LGEs scoring 3.8 for Power Sharing and Inclusiveness) are understood as critical data points reflecting inherent systemic institutional barriers and potential marginalization within the broader governance structure. Therefore, the survey results accurately capture the perspective of these entities, documenting the depth of their constraints and their limited capacity to participate effectively in the KID supply chain.

Data preparation and cleaning were conducted with rigor to ensure accuracy and consistency. Survey responses were entered into a statistical software package, with meticulous validation to confirm data integrity. Missing data were addressed using appropriate techniques, such as imputation or case-wise deletion, depending on the extent and nature of missingness. Where necessary, data were transformed—through composite score calculations or variable standardization—to facilitate robust analysis. This meticulous process underpins the reliability of the dataset, ensuring it accurately reflects stakeholder perspectives.

Quantitative data analysis employed descriptive statistics, including means, standard deviations, frequencies, and percentages, to summarize sample characteristics and assess the performance of measured constructs and sub-constructs. The analytical approach was designed to identify deviations from an ideal collaborative state and variations among stakeholder groups, providing insights into the strengths and gaps in KID supply chain collaboration. Rigorous data handling procedures were maintained throughout to uphold the accuracy and integrity of the findings, ensuring a credible foundation for evaluating transboundary water governance in the Juba-Shebelle Basin.

Image 1. Agroforestry in the region. Source: Anna Tengberg

3. Findings and Analysis: Antecedents, Characteristics, and Consequences of KID Supply Chain Collaboration

3.1 Antecedents of KID

3.1.1 Overview

Understanding the antecedents of Knowledge, Information, and Data (KID) supply chain collaboration is critical to identifying the factors that drive effective collaboration among riparian countries and relevant stakeholders in transboundary systems. In the Ethiopian Juba-Shebelle Basin, successful KID supply chain collaboration for transboundary water management is contingent upon four fundamental constructs: IT Resources, Inter-Organizational Systems (IOS) Appropriation, Collaborative Culture, and Trust. Each of these constructs plays a vital role in fostering a collaborative environment conducive to effective water governance.

The key antecedent constructs and sub-constructs of KID are visualized in Figure 3. Using responses from organizations spanning government agencies, local government entities, NGOs, and research institutions, the study findings on each antecedent construct and sub-constructs are outlined below.

Figure 3. Framework for Systemic Constructs.

The table 3.1 below summarizes the mean score values for each antecedent construct and sub-construct across the stakeholder groups. The scores reflect stakeholder responses on a seven-point Likert scale, with lower scores indicating greater challenges in each area. The Seven-Point Likert Scale is a widely used measurement tool designed to assess the extent or capacity of specific resources, systems, or practices within a given context. This scale operates on a continuum that ranges from a complete absence to a significant presence.

Table 3.1: The mean score the Antecedents constructs and sub-constructs

Antecedent Constructs and Sub-Constructs	Government Agencies N=11	Regional Government Entities N=9	Local Government Entities N=72	NGOs N=13	Research Institutions N=10
1. Core Construct 1 (IT Resources) - CC1					
IT Infrastructure Flexibility (SC1)	5.2	4.8	3.9	4.2	5.7
Hydrological and Climate Information System Expertise (SC2)	5.8	5.0	4.3	4.4	5.9
Core Construct 2 (IOS Appropriation) - CC2					
IOS Use for Data Sharing and Interoperability (SC3)	5.6	5.0	4.1	4.4	6.0
IOS Use for Data Analysis and Modeling (SC4)	5.9	5.2	4.3	4.2	6.2
IOS Use for Communication and Coordination (SC5)	5.4	4.9	4.3	4.4	5.9
Core Construct 3 (Collaborative Governance) - CC3					
Power Sharing and Inclusiveness (SC6)	5.2	4.5	3.8	4.0	5.1
Shared Vision and Goal Alignment (SC7)	4.6	4.3	3.7	4.0	5.1
Trust and Reciprocity (SC8)	4.8	4.4	3.9	4.1	4.9
Conflict Resolution and Adaptive Management (SC9)	5.0	4.6	4.0	4.1	4.8

3.1.2 Major Findings by Core construct

This section presents a nuanced analysis of stakeholder performance across these core constructs, assessed through a 7-point Likert scale (1 = Strongly Disagree, 7 = Strongly Agree), revealing disparities in technological, systemic, and governance capacities among federal and regional government agencies, local government entities, NGOs, and research institutions. These findings illuminate critical gaps and opportunities for enhancing collaborative water governance in the basin's complex socio-ecological context.

The IT Resources construct, pivotal for enabling adaptive data management in a region marked by climatic variability, evaluates stakeholders' technological infrastructure and expertise. Research institutions demonstrate exceptional adaptability in IT Infrastructure Flexibility, achieving a score of 5.7, which reflects their capacity to integrate innovative technologies for real-time data sharing and responsiveness to environmental shifts. Government agencies exhibit strong expertise in Hydrological and Climate Information System Expertise, with a score of 5.8, supporting informed decision-making and strategic water planning. While this score is the highest among government groups, it represents a notable deviation of 1.2 from the ideal benchmark score of 7, indicating a significant performance gap remains. In contrast, local government entities lag significantly, scoring 3.9 in flexibility and 4.3 in expertise, indicating constrained technological capabilities that hinder their engagement in data-driven governance. These disparities underscore the need for targeted investments in IT infrastructure and training to bolster local capacities, ensuring alignment with basin-wide objectives.

IOS Appropriation assesses stakeholders' use of inter-organizational systems to facilitate data sharing, analysis, and coordination, essential for integrating diverse actors in the transboundary context. Research institutions excel across sub-constructs, achieving 6.0 in Data Sharing and Interoperability and 6.2 in Data Analysis and Modelling, reflecting their ability to leverage IOS for transparent communication and sophisticated predictive modelling. Government agencies perform well in Communication and Coordination, scoring 5.4, which supports synchronized efforts in addressing challenges like resource allocation. Local government entities, however, struggle with scores of 4.1 in data sharing and 4.3 in both analysis and coordination, highlighting limited access to IOS tools and integration challenges that risk fragmenting collaborative efforts. Enhancing local IOS utilization through training and system upgrades is critical to fostering cohesive data exchanges.

Collaborative Governance evaluates the relational and structural mechanisms underpinning stakeholder cooperation, vital for equitable water management in the basin's socio-politically complex environment. Government agencies demonstrate moderate success in Power Sharing and Inclusiveness, with a score of 5.2, fostering fair representation in decision-making processes. Research institutions lead in Shared Vision and Goal Alignment (5.1) and Trust and Reciprocity (4.9),

positioning them as credible partners in driving unified objectives and transparent collaboration. Their strength in Conflict Resolution and Adaptive Management, scoring 5.0, supports resilient governance by effectively managing disputes. Local government entities, however, consistently underperform, with scores of 3.8 in inclusiveness, 3.7 in goal alignment, 3.9 in trust, and 4.0 in conflict resolution, reflecting limited inclusivity and weaker relational dynamics that may marginalize community voices. Strengthening local governance through inclusive dialogue and trust-building initiatives is essential to enhance cooperative dynamics.

The findings reveal a pronounced contrast between the advanced capacities of research institutions and government agencies and the significant limitations of local government entities across all constructs. Research institutions' leadership in IT flexibility, IOS utilization, and collaborative governance positions them as pivotal knowledge hubs, while government agencies' expertise and coordination provide a foundation for effective governance. Local entities' deficiencies, however, risk undermining basin-wide collaboration, necessitating strategic interventions to enhance IT resources, IOS access, and governance frameworks. By addressing these gaps, stakeholders can foster robust vertical and horizontal collaboration, advancing sustainable water management and resilience in the Juba-Shebelle Basin.

3.1.3 Major Findings by sub-construct

IT Resources

The IT Resources antecedent assesses the current technological and infrastructural capacities of organizations involved in the Ethiopian Juba-Shebelle Basin water management. This capability is crucial for establishing an effective KID (Knowledge, Information, and Data) supply chain, as it enables flexible adaptation to evolving data demands and the efficient management of hydrological and climate information systems (HCIS). The overall IT capability across stakeholder groups is found to be low but showing gradual improvement. This is reflected in modest mean scores on a 7-point Likert scale, suggesting a baseline from which incremental progress is being made in this core construct. Key sub-constructs or components assessed here are IT Infrastructure Flexibility (SC1) and HCIS Expertise (SC2).

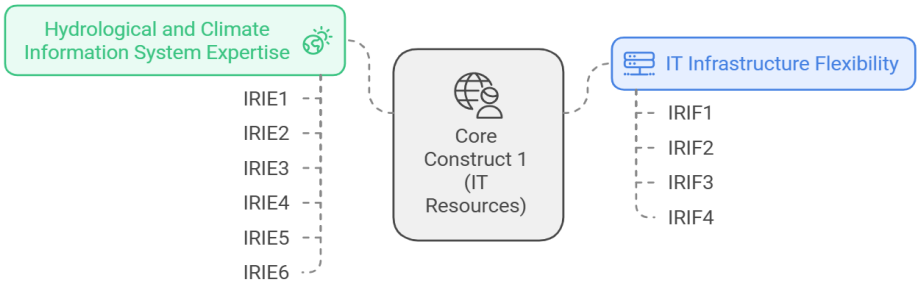

Figure 4. IT resources antecedents to assess the technological and infrastructural capacities of organizations in the Juba-Shebelle Basin.

IT Infrastructure Flexibility (SC1)

IT infrastructure flexibility gauges an organization's ability to adapt its digital systems to changing demands for water and climate data. In the context of transboundary water management, flexible IT infrastructure allows for rapid integration of new tools, scaling of data resources, and adaptive responses to emerging challenges. However, the overall IT infrastructure flexibility within the basin remains low to moderate. The average Likert scale score for IT Infrastructure Flexibility is low across most groups, with government agencies scoring the highest at 3.6.

HCIS Expertise (SC2)

The assessment of the second sub-constructs HCIS Expertise assesses the technical proficiency within organizations to utilize and manage systems designed for hydrological and climate data collection, analysis, and application. Expertise in HCIS is critical for organizations within the basin, as it enables informed decision-making based on accurate water and climate information. Despite some organizations demonstrating solid capabilities, the overall level of HCIS expertise is low but improving, with notable differences across stakeholder groups.

Government agencies and research institutions scored highest in HCIS expertise, with mean scores of 6.1 and 5.9, respectively. Although these scores are categorized as strong compared to other stakeholders, they possess deviations of 1.2 and 1.1, respectively, from the ideal benchmark of 7. This gap signals that even the most technically proficient entities require further capacity enhancement to fully meet the demands of sophisticated, transboundary water management.

In contrast, regional government entities scored 5.0, while local government entities and NGOs scored lower in HCIS expertise, with mean scores of 4.3 (LGEs) and 4.4 (NGOs), respectively, suggesting gaps in technical knowledge and access to training. The deviation of 2.7 for LGEs highlights a critical shortfall in the requisite skills needed to interpret hydrological data for local, contextually relevant decisions.

The analysis reveals that the overall IT capability among stakeholders in the Ethiopian Juba-Shebelle Basin is low but improving, with limited flexibility in IT infrastructure and variable levels of HCIS expertise. While government agencies and research institutions demonstrate higher adaptability and proficiency in HCIS, local entities and NGOs face significant challenges that constrain their ability to participate fully in an effective KID supply chain.

Power sharing and inclusion

The Power Sharing and Inclusiveness sub-construct is a critical factor for achieving equitable participation among stakeholders within the KID supply chain for the Ethiopian Juba-Shebelle Basin. This dimension reflects the extent to which stakeholders can equally contribute to and benefit from collaborative efforts, with

an emphasis on prioritizing collective goals, supporting teamwork, and distributing decision-making authority. Power sharing and inclusiveness enable effective vertical collaboration (across different levels of government) and horizontal collaboration (between organizations at the same level, such as NGOs or local government entities), which are essential for cohesive and sustainable water management.
The results show that overall scores for power sharing and inclusiveness are low, highlighting significant challenges in governance and collaboration. Government agencies scored moderately (average of 4.2), suggesting some prioritization of collective goals and openness to collaboration. However, local government entities and NGOs scored notably lower, with averages of 3.8 and 4.0, indicating limited participation in decision-making processes and disparities in authority and reflected strong presence of to-down and fragmented approach. These low scores point to a lack of structured governance mechanisms that would empower all stakeholders equally, affecting the effectiveness of both vertical and horizontal collaboration within the basin.

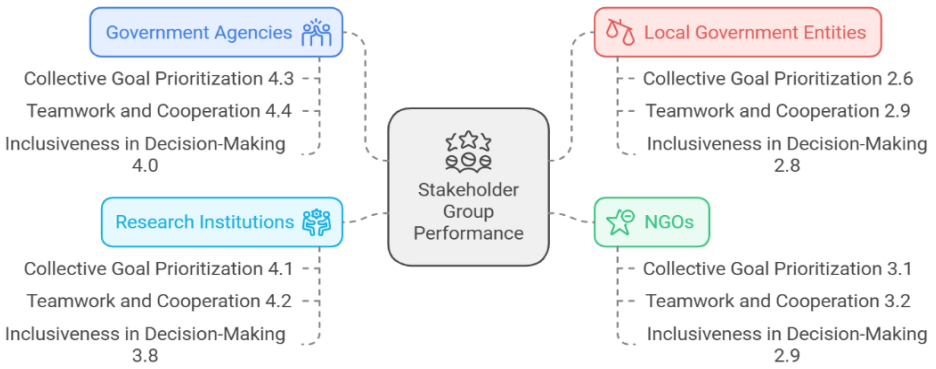

Fig 5. Major findings by stakeholders

Local government entities and NGOs scored the lowest in this dimension, with average scores of 2.7 and 3.0, respectively. These scores indicate a substantial misalignment between their short-term operational priorities and the broader, long-term objectives required for basin-wide management. Contributing factors include limited resources, sectoral fragmentation, and a lack of formalized structures for joint vision-setting, which ultimately hinders both vertical and horizontal collaboration.

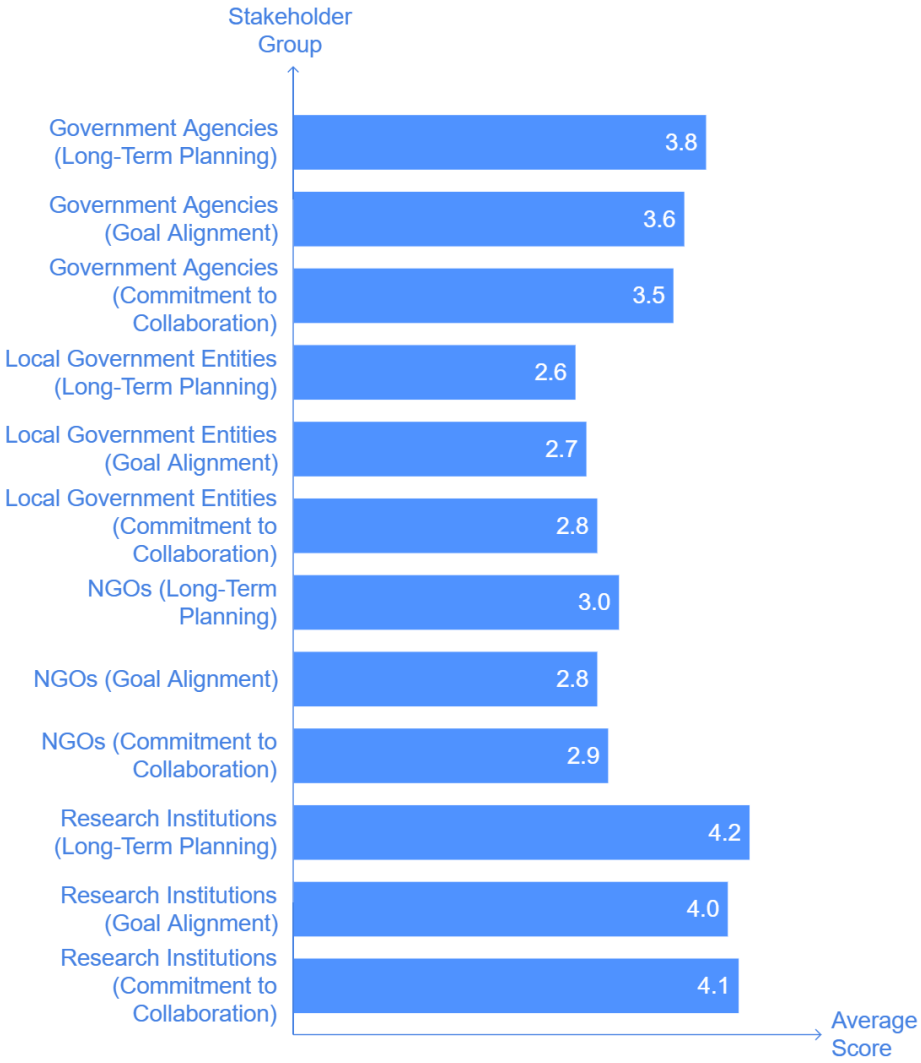

Figure 6. Average scores for shared vision and goal alignment by stakeholder group

Trust and Reciprocity (SC8)

Trust and reciprocity are central to collaborative governance, as they facilitate open communication, enhance credibility, and foster goodwill among stakeholders. This dimension evaluates power distribution, the openness to feedback, and the perceived fairness of decision-making processes.

Scores for trust and reciprocity were notably low across stakeholder groups, with government agencies and research institutions scoring slightly higher (4.8 and 4.6) than local entities and NGOs (3.5 and 3.7).

Conflict Resolution and Adaptive Management (SC9)

Conflict resolution and adaptive management capabilities are critical for navigating the complexities of transboundary water cooperation. This dimension assesses stakeholders' comfort with ambiguity, tolerance for risk and innovation, and the effectiveness of adaptive responses to environmental changes or conflicts. Scores for conflict resolution and adaptive management were also low, with government agencies scoring the highest at 5.0, while local entities and NGOs scored an average of 3.9 and 4.1. The low scores highlight the challenges in establishing adaptive governance systems.

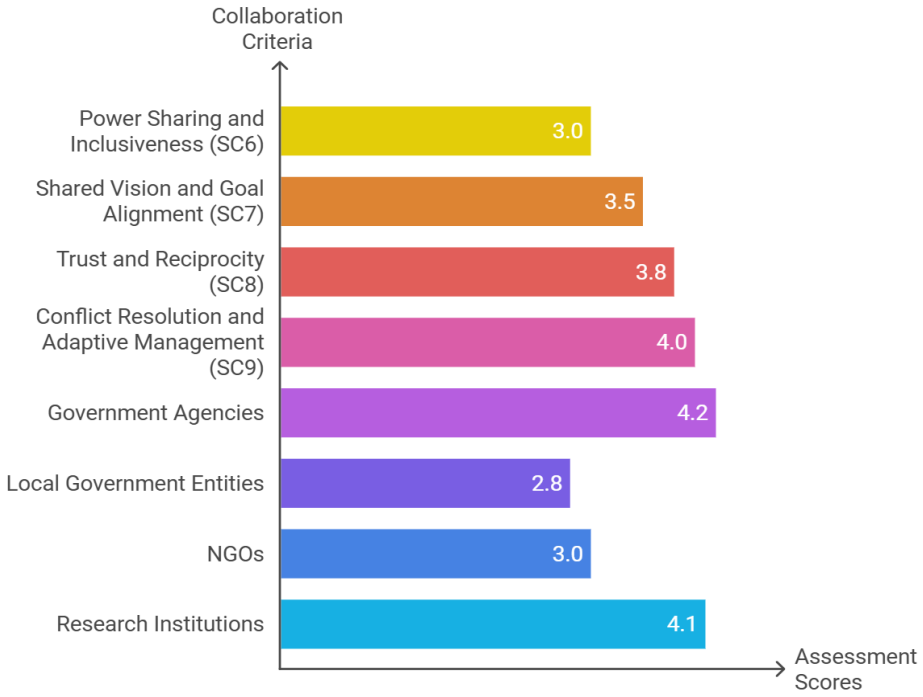

Figure 7. Shareholder collaboration assessment

The assessment of collaborative governance within the Ethiopian Juba-Shebelle Basin reveals generally low scores across all dimensions. Government agencies and research institutions show moderate levels of engagement, especially in long-term vision and goal alignment, yet these remain below the optimal threshold for effective basin-wide collaboration. Local entities and NGOs, facing challenges in power sharing, trust, and conflict resolution, require greater inclusion and support to engage actively in governance processes.

3.2 Characteristics of the Ethiopian KID Supply Chain

3.2.1 Overview

This section delineates the core sub-constructs that define the KID supply chain's collaborative dynamics: Improved Water Resource Management, Goal Congruence, Decision Synchronization, Incentive Alignment, Resource Sharing, Collaborative Communication, and Joint Knowledge Creation. Each sub-construct is assessed through carefully selected measurement items, employing a 7-point Likert scale to capture stakeholders' perceptions and experiences with nuance and precision. The analysis provides insights into the strengths and deficiencies of collaborative practices, informing strategies to enhance basin-wide cooperation.

Improved Water Resource Management assesses stakeholders' ability to share data, ensure timeliness, and manage resources effectively. Goal Congruence evaluates the alignment of objectives across stakeholder groups, critical for unified action. Decision Synchronization examines the timeliness and effectiveness of joint decision-making processes. Incentive Alignment measures the presence of equitable reward structures that motivate collaboration. Resource Sharing focuses on the equitable distribution of water-related resources and data. Collaborative Communication assesses the quality of stakeholder interactions, including transparency and conflict resolution. Joint Knowledge Creation evaluates collaborative efforts in research and innovation to address water challenges. These sub-constructs collectively form the backbone of the KID supply chain, as visualized in Figure 8, which illustrates their interrelationships and role in fostering collaborative advantage.

The assessment of these sub-constructs draws on stakeholder surveys and interviews, capturing perspectives from federal and regional governments, local government entities, NGOs, and research institutions. The Likert scale responses provide quantitative insights into collaborative performance, revealing disparities across stakeholder groups and highlighting areas for improvement. For example, low scores in data-sharing timeliness may indicate deficiencies in IT infrastructure, while high scores in joint knowledge creation among research institutions suggest robust collaborative networks (Mentzer et al., 2001). By grounding the analysis in a rigorous measurement framework, this study contributes to the literature on supply chain collaboration and offers actionable recommendations for enhancing water governance in the Juba-Shebelle Basin.

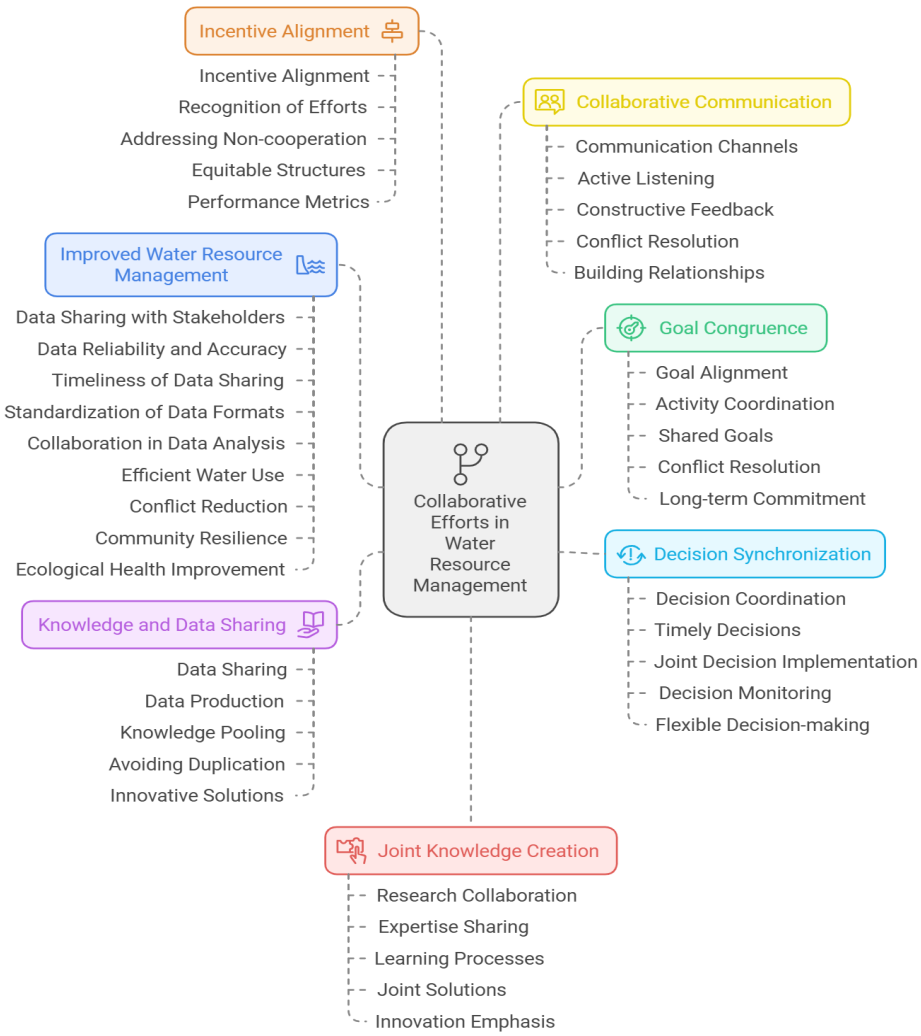

Figure 8. The core constructs and sub-constructs of the character aspects of the KID supply chain

The following table (table 3.2) summarizes the mean scores for the Ethiopian KID supply chain characteristics, assessed through a survey of various stakeholder groups. Stakeholders include the federal government, regional government, local government, NGOs, and research institutions. Each group was rated on the 7-point Likert scale across several constructs that reflect critical aspects of collaboration, knowledge sharing, decision-making, and resource alignment within the KID supply chain.

Table 3.2: Mean Scores for Characteristics of KID by Stakeholder Group

Supply Chain Characteristics and Sub-Constructs	Federal Government	Regional Government	Local Government	NGOs	Universities and Research Institutions
Improved Water Resource Management (SC12)					
Data Sharing with Stakeholders	3.4	3.1	2.2	2.5	3.8
Data Reliability and Accuracy	3.6	3.0	2.3	2.4	3.9
Timeliness of Data Sharing	3.2	2.8	2.0	2.3	3.6
Standardization of Data Formats and Protocols	3.3	3.0	1.8	2.2	3.7
Collaboration in Data Analysis and Interpretation	3.5	2.9	2.2	2.4	4.0
Efficient Water Use	2.8	2.5	2.0	2.3	3.1
Conflict Reduction	3.1	2.7	2.2	2.4	3.3
Community Resilience to Shocks	2.9	2.4	2.1	2.5	3.4
Ecological Health Improvement	2.8	2.6	2.2	2.4	3.5
Average Score for SC12	3.1	2.8	2.1	2.4	3.5
Goal Congruence (SC13)					
Goal and Objective Alignment	3.0	2.6	1.9	2.2	3.4
Coordination of Activities and Efforts	3.1	2.7	2.0	2.3	3.6
Collaboration for Shared Goals	3.2	2.8	2.1	2.3	3.7
Conflict Resolution Effectiveness	3.0	2.5	1.9	2.0	3.5
Commitment to Long-term Collaboration	3.3	2.9	2.0	2.4	3.8
Average Score for SC13	3.1	2.7	2.0	2.2	3.6
Decision Synchronization (SC14)					

Coordination of Decision-making	3.2	2.9	2.2	2.3	3.7
Timeliness of Collaborative Decisions	3.3	2.8	2.1	2.2	3.8
Effectiveness of Joint Decision Implementation	3.4	3.0	2.0	2.3	3.9
Monitoring and Evaluation of Decision Outcomes	3.1	2.8	2.1	2.4	3.6
Flexibility and Adaptability in Decision-making	3.2	2.9	2.0	2.3	3.7
Average Score for SC14	3.2	2.9	2.1	2.3	3.7
Knowledge and Data Sharing (SC15)					
Sharing Water and Climate Data	3.4	3.1	2.2	2.5	4.0
Collaboration in Data Production and Distribution	3.3	3.0	2.1	2.3	3.8
Pooling Knowledge and Data Resources	3.2	2.8	2.1	2.4	3.9
Avoidance of Duplication	3.1	2.7	2.0	2.3	3.7
Development of Innovative Solutions	3.2	2.9	2.1	2.3	3.8
Average Score for SC15	3.2	2.9	2.1	2.4	3.8
Incentive Alignment (SC16)					
Incentive Alignment with Other Stakeholders	3.0	2.6	2.0	2.1	3.4
Reward and Recognition of Collaborative Efforts	3.1	2.7	2.1	2.2	3.6
Addressing Non-cooperative Behaviors	3.0	2.6	2.0	2.1	3.5
Fair and Equitable Incentive Structures	3.2	2.8	2.1	2.2	3.6

Performance Metrics for Collaborative Efforts	3.3	2.9	2.1	2.3	3.7
Average Score for SC16	3.1	2.7	2.1	2.2	3.6
Collaborative Communication (SC17)					
Effectiveness of Communication Channels	3.3	3.0	2.3	2.4	3.8
Active Listening	3.2	2.8	2.2	2.3	3.7
Constructive Feedback	3.3	2.9	2.2	2.4	3.8
Conflict Resolution through Communication	3.1	2.7	2.1	2.2	3.6
Building Relationships with Stakeholders	3.4	3.1	2.3	2.5	3.9
Average Score for SC17	3.3	2.9	2.2	2.4	3.8
Joint Knowledge Creation (SC18)					
Collaboration in Research and Development	3.4	3.1	2.2	2.3	4.0
Knowledge and Expertise Sharing	3.5	3.0	2.3	2.4	3.9
Effective Learning Processes	3.3	2.9	2.1	2.3	3.8
Developing Joint Solutions	3.2	2.8	2.2	2.3	3.9
Emphasis on Innovation and Creativity	3.4	3.0	2.1	2.3	3.9
Average Score for SC18	3.4	3.0	2.2	2.3	3.9

3.2.2 Overall Findings by Core Constructs

This section synthesizes the performance of stakeholders in the Ethiopian Juba-Shebelle Basin across the core constructs of the Knowledge, Innovation, and Development (KID) supply chain, emphasizing their implications for effective transboundary water management. The analysis highlights disparities in collaborative capabilities, particularly at the local government level, and underscores the need for targeted interventions to foster cohesive governance.

Improved Water Resource Management reveals moderate capacity among federal government agencies, with regional governments performing slightly lower, and local governments exhibiting significant deficiencies. Local entities struggle with data sharing and timeliness, limiting their ability to engage in informed decision-making. In contrast, research institutions excel in data reliability and collaboration, positioning them as critical knowledge hubs. These disparities hinder integrated water management, necessitating enhanced data-sharing frameworks to bridge silos.

Goal Congruence reflects partial alignment among federal and regional governments, but local governments face pronounced challenges in aligning with basin-wide objectives. Weak conflict resolution mechanisms further exacerbate misalignment, undermining collaborative efforts. Research institutions and NGOs demonstrate stronger coordination, suggesting their potential to guide stakeholders toward shared goals. Strengthening inclusivity and conflict resolution is essential to foster unified objectives.

Decision Synchronization shows moderate federal capacity, with regional governments lagging due to coordination issues. Local governments face systemic barriers, struggling with timely and effective decision implementation. Research institutions and NGOs perform better, indicating their ability to facilitate synchronized processes. Improved IT infrastructure and coordination mechanisms are critical to enhance decision-making responsiveness across governance levels.

Knowledge and Data Sharing is moderately robust among federal agencies but severely limited at the local level, where barriers to data production and distribution impede collaboration. Research institutions lead in innovative data utilization, while local governments require support to access and leverage knowledge effectively. Standardized protocols and enhanced IT resources are vital to improve data-sharing efficacy.

Incentive Alignment is moderately developed among federal agencies but weak at the local level, where inadequate reward structures and non-cooperative behaviour management hinder collaboration. Research institutions benefit from stronger incentive systems, suggesting a model for broader application. Fair and equitable incentives are necessary to motivate collective action across stakeholders.

Collaborative Communication is adequate among federal agencies but deficient locally, where limited channels and poor conflict resolution undermine engagement. Research institutions and NGOs excel in relationship-building, highlighting their role as communicators. Strengthening communication frameworks, particularly for local entities, is crucial to enhance transparency and trust.

Joint Knowledge Creation is strong among federal agencies and research institutions, driven by collaborative research and expertise sharing. Local governments, however, struggle to participate in innovative initiatives, reflecting

resource and capacity constraints. Research institutions' leadership in this domain offers opportunities to mentor local entities, fostering basin-wide innovation.

The analysis reveals significant collaborative gaps, particularly at the local government level, driven by deficiencies in IT resources, governance, and incentive structures. Federal agencies and research institutions demonstrate stronger capacities, but local entities' challenges undermine basin-wide cohesion. To enhance resilience, stakeholders must prioritize inclusive communication, coordinated goal alignment, robust data-sharing systems, and equitable incentives. These efforts will strengthen collaborative governance, enabling sustainable and equitable water resource management in the Juba-Shebelle Basin.

3.2.3 Findings by Stakeholder Groups

This section examines the performance of stakeholder groups within the Knowledge, Innovation, and Development (KID) supply chain in the Ethiopian Juba-Shebelle Basin, focusing on their collaborative capabilities across key characteristics. The analysis reveals distinct strengths and challenges among federal government agencies, regional governments, local government entities, NGOs, and research institutions, highlighting the influence of antecedent constructs such as IT resources, inter-organizational systems (IOS) appropriation, and collaborative governance on their performance. These findings underscore the need for targeted interventions to enhance vertical and horizontal collaboration for sustainable water management.

Federal government agencies demonstrate moderate collaborative capacity, driven by access to resources and established processes, yet they face challenges in data-sharing timeliness and decision-making flexibility. Inconsistent data protocols hinder their ability to foster seamless vertical collaboration with regional and local entities. Strengthening IT infrastructure and standardizing data-sharing frameworks could enhance their role in coordinating basin-wide initiatives.

Regional governments exhibit slightly weaker performance, constrained by challenges in goal alignment, data standardization, and cross-sectoral coordination. Their limited effectiveness in conflict resolution and incentive alignment further impedes collaboration with other governance levels. Implementing robust data-sharing systems and clearer coordination mechanisms would improve their contribution to both vertical and horizontal collaboration, fostering a more cohesive approach to water management.

Local government entities face the most significant barriers, with limited IT resources and inadequate data-sharing protocols restricting their participation in large-scale KID initiatives. Misalignment with basin-wide objectives and weak long-term commitment exacerbate these challenges. Investments in IT infrastructure and capacity-building, coupled with standardized communication channels, are essential to elevate their role in integrated water management.

NGOs show moderate engagement, with strengths in knowledge sharing and communication but limitations in incentive alignment and goal congruence. The absence of formalized structures and reward mechanisms hinders their sustained collaboration with government bodies. Establishing clear incentive frameworks and dedicated data-sharing platforms would strengthen their integration into the KID supply chain, enhancing both horizontal and vertical collaboration.

Research institutions emerge as the strongest performers, excelling in knowledge creation, data sharing, and innovation due to their robust networks and expertise. Their high goal congruence and incentive alignment position them as key knowledge hubs. By leveraging their capabilities to support capacity-building for other stakeholders, particularly local entities and NGOs, they can enhance the overall effectiveness of the KID supply chain.

3.2.4 Analysis by Sub-Constructs (SC12–SC18)

The KID supply chain characteristics, shaped by antecedent constructs such as IT resources, IOS appropriation, and collaborative governance, are critical for effective transboundary water management in the Juba-Shebelle Basin. This analysis explores the interplay between these antecedents and the supply chain characteristics, revealing how foundational gaps impact vertical and horizontal collaboration.

Improved water resource management is hindered by limited IT resources and poor IOS appropriation, which restrict timely and reliable data sharing. Federal and regional governments show moderate capacity, but local entities struggle due to inconsistent data protocols, impeding vertical collaboration. Research institutions excel in horizontal collaboration within their networks, while NGOs and local entities face fragmented data practices, limiting their cooperative efforts.

Goal congruence is undermined by weak collaborative governance, particularly in power sharing and shared vision. Federal and regional governments exhibit partial alignment, but local entities' low scores reflect their exclusion from basin-wide objectives, hampering vertical collaboration. Research institutions demonstrate strong horizontal alignment, whereas NGOs and local entities struggle due to inadequate incentive structures.

Decision synchronization suffers from limited IT flexibility and expertise, restricting timely joint decision-making. Federal and regional entities show moderate coordination, but local governments face structural constraints, weakening vertical collaboration. Research institutions lead in horizontal synchronization, while NGOs and local entities are constrained by poor coordination mechanisms.

Knowledge and data sharing are limited by inadequate IT infrastructure and low trust, particularly affecting local entities. Federal and regional governments achieve modest vertical sharing, but inconsistencies hinder broader integration. Research

institutions excel horizontally, while NGOs and local entities lack shared platforms, reducing their collaborative capacity.

Incentive alignment is weakened by poor governance structures, with federal and regional entities showing partial alignment but failing to engage local entities effectively. Research institutions benefit from consistent reward systems, while NGOs and local entities face barriers due to insufficient recognition of collaborative efforts.

Collaborative communication is constrained by limited communication tools and low trust. Federal and regional governments demonstrate moderate vertical communication, but local entities face barriers due to inadequate infrastructure. Research institutions excel in horizontal communication, while NGOs and local entities struggle with inconsistent channels.

Joint knowledge creation is limited by weak IT resources and collaborative culture, particularly at the local level. Federal and regional governments engage moderately in vertical research, but local entities lack the capacity for innovation. Research institutions lead in horizontal knowledge creation, while NGOs and local entities are constrained by resource limitations.

In conclusion, the KID supply chain's effectiveness is closely tied to its antecedent constructs. Vertical collaboration is limited by local entities' capacity constraints, while horizontal collaboration is strongest among research institutions. Addressing gaps in IT infrastructure, governance, and incentive structures is critical to fostering cohesive collaboration for sustainable water management in the Juba-Shebelle Basin.

3.3 Consequences KID/ Collaborative advantage

3.3.1 Overview

The proposed Ethiopian Juba-Shabelle KID supply chain collaboration framework is rooted in a paradigm of collaborative advantage rather than individual country or stakeholder groups' competitive advantage. Collaborative advantage in this context emphasizes mutual, relational benefits that arise when stakeholders in the basin—such as government entities, NGOs, research institutions, and local communities—work together to manage shared water resources. This approach contrasts with a competitive advantage, which encourages individualistic, resource-seeking behaviours aimed at maximizing benefits for single entities.

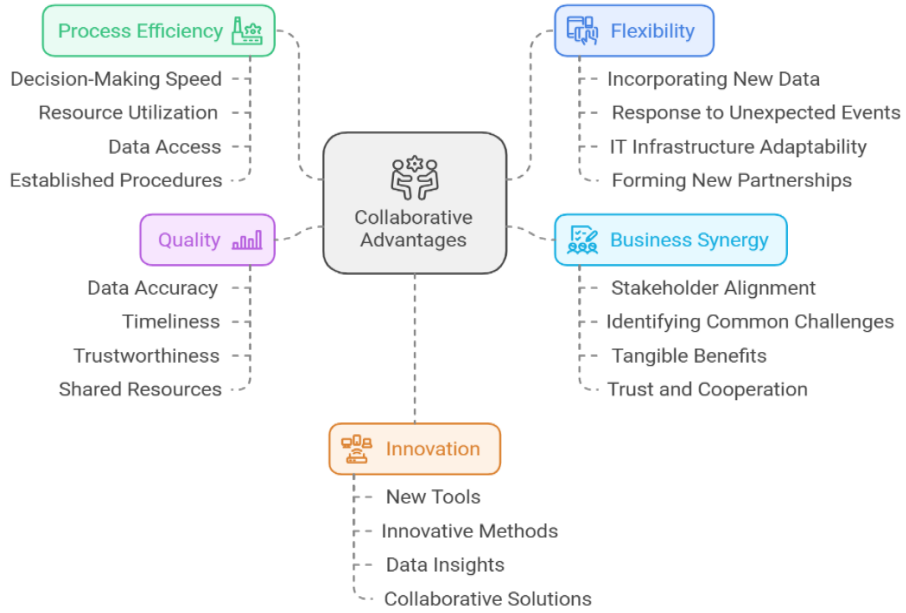

Figure 9. The collaborative advantage constructs and sub-constructs

The collaborative advantage perspective allows KID supply chain partners to approach water resource management as a positive-sum game rather than a zero-sum game. Rather than striving to secure exclusive access to water and data resources, stakeholders view collaboration as an opportunity to generate shared benefits for sustainable resource management, increased resilience, and enhanced national, regional and local cooperation. Despite its acknowledged importance in transboundary resource management literature, the concept of collaborative advantage has yet to be fully operationalized in the context of KID supply chain collaboration. In this research, we define and operationalize collaborative advantage and its impact on collective performance within the Ethiopian Juba-Shebelle KID supply chain. In this study five key sub-constructs of collaborative advantage and 20 sub-construct measurement items (indicators) are used are used to assess the views of the stakeholder groups. There is amble evidence that collaborative advantage is the consequence (outcome) of successful KID supply chain collaboration, meaning successful KID supply chain collaboration is the pre-conditions for operationalizing collaborative advantage.

The findings for each of the five collaborative advantage sub-constructs—process efficiency, offering flexibility, business synergy, quality, and innovation—are presented based on a 7-point Likert scale responses collected from organizations involved in water management within the Juba-Shebelle Basin, which are the potential member of the Ethiopian Juba-Shebelle KID supply chain. Scores reflect stakeholder performance and perceived benefits of KID supply chain collaboration across federal and regional government entities, local government, NGOs, and University and research institutions.

Table 3.3: The mean score of collaborative advantage by stakeholders group

Collaborative Advantage Sub-Constructs	Federal Government	Regional Government	Local Government	NGOs	Universities and Research Institutions
Process Efficiency	3.2	2.9	2.1	2.3	3.4
Offering Flexibility	3.1	2.8	2.0	2.2	3.5
Business Synergy	3.0	2.7	1.9	2.1	3.6
Quality	3.3	2.9	2.2	2.4	3.8
Innovation	3.2	3.0	2.2	2.3	3.9
Average Score for Collaborative Advantage	3.1	2.9	2.1	2.3	3.6

3.3.2 Key Findings by Sub-Construct

This section presents a refined analysis of the key sub-constructs—Process Efficiency, Offering Flexibility, Business Synergy, Quality, and Innovation—underpinning the collaborative advantage within the Knowledge, Innovation, and Development (KID) supply chain in the Ethiopian Juba-Shebelle Basin. The findings highlight varying performance across stakeholder groups and elucidate how deficiencies in antecedent constructs and supply chain characteristics foster a competitive rather than cooperative orientation, undermining basin-wide collaboration.

Process Efficiency

Process efficiency within the Juba-Shebelle Basin varies significantly across stakeholder groups. Federal government entities demonstrate moderate efficiency, driven by access to resources and standardized processes, while regional governments exhibit slightly lower performance due to coordination challenges. Local governments and NGOs face pronounced inefficiencies, stemming from delayed data sharing and inadequate KID supply chain infrastructure, which hinder streamlined operations. Research institutions, leveraging established data analysis and collaboration practices, achieve the highest efficiency, underscoring their role as knowledge hubs. However, the overall lack of interoperable systems limits basin-wide coordination, pushing stakeholders toward isolated, competitive workflows.

Offering Flexibility

Flexibility in adapting goals and reallocating resources is moderately developed among federal and regional governments, supported by some technical infrastructure, though constrained by local limitations. Local governments and

NGOs exhibit minimal flexibility, bound by rigid mandates and short-term priorities, which restrict their responsiveness to basin-wide needs. Research institutions demonstrate notable adaptability in research and data initiatives, offering potential benefits to cross-stakeholder projects. Yet, the absence of cohesive frameworks for real-time adjustments fosters a competitive mindset, as stakeholders prioritize internal operational needs over collective adaptability.

Business Synergy

Business synergy, reflecting aligned goals and resource-sharing, is moderately achieved by federal and regional governments, though gaps in multi-stakeholder partnerships persist. Local governments and NGOs struggle significantly, operating within silos due to limited inter-organizational support, which hampers alignment with broader basin objectives. Research institutions excel in synergy, capitalizing on academic networks and partnerships to drive knowledge-sharing. However, the lack of basin-wide alignment encourages stakeholders to prioritize individual objectives, reinforcing competitive dynamics over collaborative potential.

Quality

The quality of collaborative efforts is moderately robust among federal and regional governments, though challenged by inconsistent data protocols and limited monitoring. Local governments and NGOs face greater difficulties, grappling with data standardization issues and resource constraints that compromise reporting and management standards. Research institutions lead in quality, producing reliable data and high-calibre analysis, yet their contributions are not fully integrated across the basin. This variability in quality drives stakeholders to safeguard internal standards, fostering a competitive approach rather than unified excellence.

Innovation

Innovation capacity is moderately developed among federal and regional governments, with some progress in adaptive data solutions, though constrained by budgetary and administrative hurdles. Local governments and NGOs exhibit limited innovation, lacking the resources and support to drive creative solutions. Research institutions stand out, excelling in developing adaptive research methods and technological solutions for water management. However, the broader collaborative network's inability to integrate these innovations, due to poor data sharing and trust deficits, pushes stakeholders toward independent efforts, prioritizing internal gains over collective advancement.

Assessment of Constructs Contributing to Competitive Advantage

The persistent weaknesses in antecedent constructs—particularly IT resources, inter-organizational systems (IOS) appropriation, and collaborative governances significantly undermine collaborative advantage. Limited IT infrastructure and expertise, especially at the local level, result in delayed data sharing and reliance on

isolated datasets, as highlighted by regional officials who noted the absence of interoperable systems restricts access to federal or neighbouring data. Similarly, low trust and inadequate power-sharing foster perceptions of exclusion, particularly among local governments, driving a focus on localized objectives over basin-wide goals. These challenges encourage a competitive mindset, as stakeholders prioritize self-reliance over cooperative data exchange.

Supply chain characteristics further exacerbate this competitive orientation. Inconsistent data reliability and timeliness, as noted by research institutions, hinder cohesive data-sharing environments, prompting stakeholders to focus on internal processes. Misaligned goals and poor decision synchronization, reported by NGOs as a disconnect between local and governmental objectives, reduce motivation for collective action, reinforcing siloed efforts. The lack of incentive alignment, coupled with quality and innovation constraints, limits joint innovation and adaptation, as stakeholders protect their own resources and standards. Federal representatives expressed frustration over misaligned priorities, while local officials and NGOs emphasized immediate, localized needs, and research institutions highlighted data inconsistencies that force independent verification. These dynamics collectively foster competitive advantage orientation, where stakeholders prioritize individual performance over basin-wide collaboration.

The findings underscore that deficiencies in IT infrastructure, trust, and supply chain characteristics—such as data sharing, goal congruence, and decision synchronization—drive competitive behaviours that undermine collaborative advantage. To enhance cooperation, stakeholders must prioritize interoperable systems, standardized data protocols, and inclusive governance frameworks to align objectives and foster trust, enabling Ethiopia to strengthen its role in sustainable basin management and regional collaboration.

Intra-Country Performance and Stakeholder Dynamics

3.3.3 Overview

The pursuit of collaborative advantage and robust country performance represents the core outcomes of Knowledge, Innovation, and Development (KID) supply chain collaboration within the Juba-Shebelle Basin. This transboundary region, shared primarily by Ethiopia and Somalia, has long been characterized by competitive dynamics driven by the strategic importance of the Juba and Shebelle rivers. These rivers are vital lifelines, underpinning agriculture, water supply, and livelihoods in both nations. Historically, economic imperatives, political tensions, and differing national priorities have fostered a competitive approach to resource management, often at the expense of cooperative potential. However, the growing recognition of shared climate challenges—such as recurrent droughts, floods, and

ecosystem degradation—has spurred a gradual shift toward cooperative frameworks. Regional initiatives, spearheaded by organizations like the Intergovernmental Authority on Development (IGAD) and supported by international partners, have begun to foster dialogue, data sharing, and trust-building to promote sustainable management of the basin's resources. Despite these efforts, achieving effective and sustainable cooperation remains an ongoing challenge, constrained by entrenched competitive stances and systemic barriers.

In this study, country performance is defined as a nation's ability to achieve its water and climate resource management objectives, encompassing social, economic, and environmental goals, in comparison to its primary regional counterpart. For Ethiopia, this entails excelling in intra-country water and climate resource management, which involves coordinated actions to manage and allocate physical water resources while addressing climate impacts on ecosystems and human needs. The focus is on sustainable practices, including irrigation management, flood control, and drought preparedness, which require policy alignment, stakeholder agreements, and cohesive actions among government agencies, local authorities, and communities to ensure water availability and climate resilience. Central to this endeavour is the KID supply chain collaboration, which emphasizes the collection, sharing, processing, and dissemination of water- and climate-related knowledge, information, and data. This collaboration hinges on establishing robust data pipelines, often facilitated by digital platforms and inter-organizational information systems, to support informed decision-making and effective resource management.

The KID supply chain collaboration prioritizes technical infrastructure—such as sensors and remote monitoring systems—alongside knowledge-sharing protocols and tools to manage and distribute actionable information among stakeholders. By enabling better forecasting, planning, and adaptive management, effective knowledge supply chain collaboration empowers stakeholders with timely and reliable data to address complex water and climate challenges. In the Juba-Shebelle Basin, this collaborative framework is critical for aligning diverse stakeholders around shared objectives, fostering resilience, and enhancing Ethiopia's capacity to manage its water resources sustainably while contributing to regional cooperation with Somalia and other riparian nations. However, the findings indicate that persistent deficiencies in data-sharing protocols, stakeholder alignment, and technical capacity continue to limit the realization of these outcomes, underscoring the need for targeted interventions to strengthen intra-country performance and transboundary collaboration.

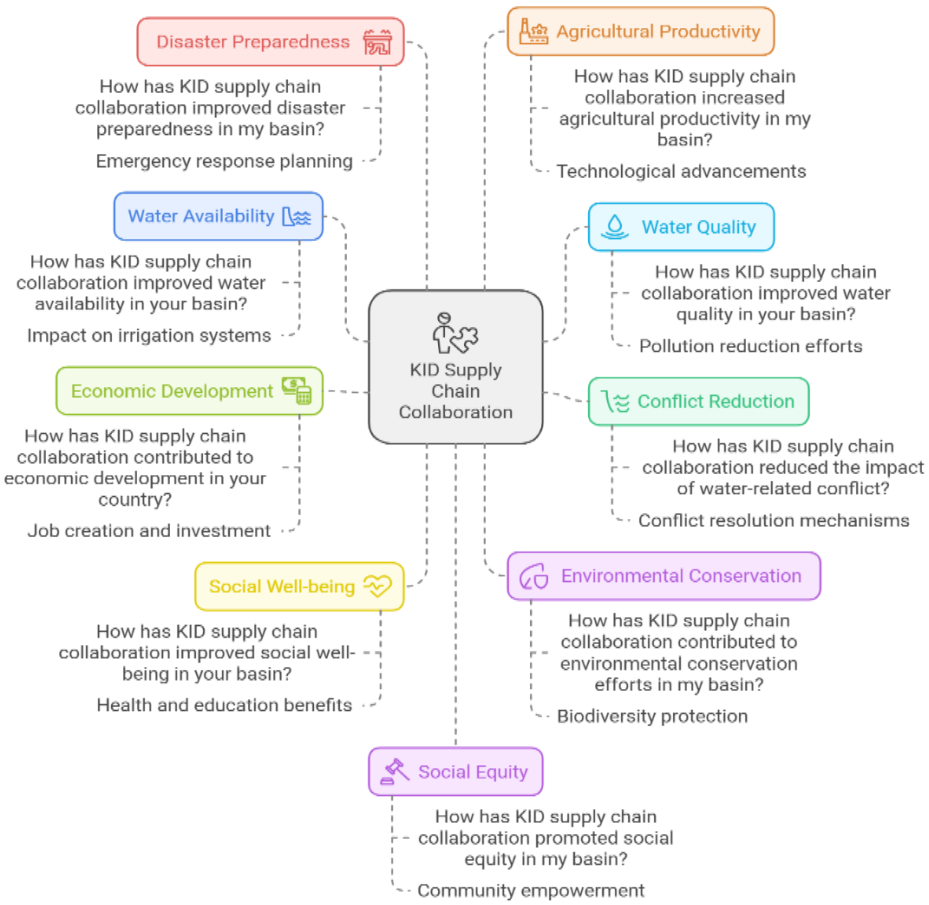

Figure 10. Country Performance constructs and sub-constructs

The findings are presented across four sub-constructs of country performance—resource-sharing, joint decision-making, conflict resolution, and adaptive response capacity—with Likert scale scores averaged for each stakeholder group. These scores reflect the extent to which the Ethiopian KID supply chain collaboration has translated into water and climate resources cooperative management across governance levels within Ethiopia.

Table 3.4: the mean score of country/stakeholders performance

Country Performance Sub-Constructs	Federal Government	Regional Government	Local Government	NGOs	University and Research Institutions
Resource Sharing	3.3	3.0	2.4	2.5	3.7
Joint Decision-Making	3.2	2.9	2.3	2.4	3.6
Conflict Resolution	3.1	2.9	2.2	2.5	3.5

Adaptive Response Capacity	3.3	3.1	2.5	2.6	3.8
Average Score for Enhanced Cooperation	3.2	2.9	2.3	2.5	3.6

3.3.4 Key Findings by Sub-Construct

This section presents a detailed analysis of the key findings related to the consequences of Knowledge, Innovation, and Development (KID) supply chain collaboration in the Ethiopian Juba-Shebelle Basin, focusing on the sub-constructs of Resource Sharing, Joint Decision-Making, Conflict Resolution, and Adaptive Response Capacity. The analysis elucidates the varying performance levels across stakeholder groups—federal and regional governments, local governments, NGOs, and research institutions—and explores the broader implications for enhanced cooperation, both domestically and with riparian nations. The findings reveal systemic weaknesses in the KID supply chain characteristics that directly undermine collaborative advantage and country performance, limiting Ethiopia's capacity to engage effectively in transboundary water management.

Resource Sharing

Resource sharing within the Juba-Shebelle Basin reflects a fragmented landscape, with notable disparities across stakeholder groups. Federal government agencies demonstrate a moderate capacity for resource sharing, achieving a score of 3.3, driven by their access to water management data and technological resources. Regional governments, scoring 3.0, exhibit similar capabilities but face constraints in coordinating with local entities, limiting the scalability of resource-sharing frameworks. In contrast, local governments and NGOs, with scores of 2.4 and 2.5 respectively, struggle significantly due to resource competition and insufficient frameworks for equitable distribution. This competition, particularly pronounced at the local level, exacerbates tensions and hinders intergovernmental cooperation. Research institutions, scoring 3.7, stand out as leaders in resource sharing, leveraging established networks with academic and research bodies to facilitate data and knowledge exchange. However, the absence of standardized protocols across organizations diminishes the efficiency and scale of these efforts, constraining the broader impact of resource-sharing initiatives. This widespread internal fragmentation in resource sharing, evidenced by an overall low country average, demonstrably limits Ethiopia's ability to propose and implement robust, verifiable resource-sharing agreements with downstream riparian states like Somalia. A fragmented internal position weakens Ethiopia's negotiating stance by raising concerns among external partners regarding the nation's capacity to guarantee resource commitments and ensure equitable allocation across its own sub-basin.

Joint Decision-Making

Joint decision-making capabilities reveal similar disparities, reflecting challenges in aligning stakeholders toward cohesive basin-wide strategies. Federal and regional governments, with scores of 3.2 and 2.9 respectively, demonstrate moderate capabilities, supported by access to data and institutional frameworks. However, delays in data transmission from regional bodies and misaligned water management goals impede efficiency. Local governments and NGOs, scoring 2.3 and 2.4, face significant barriers, with limited influence in national-level decisions and fragmented engagement in basin-wide strategies. This exclusion fosters a disjointed decision-making environment, undermining coordinated action. Research institutions, with a score of 3.6, excel in technical decision-making due to their expertise and partnerships, yet their role remains largely consultative, limiting their impact on policy and management decisions. The lack of inclusive decision-making processes across governance levels restricts Ethiopia's ability to implement unified water management strategies. The lack of inclusive, timely, and cohesive decision-making domestically (evidenced by the low average score of 2.9) compromises Ethiopia's diplomatic credibility in bilateral and multilateral forums. When internal governance mechanisms (vertical collaboration) are weak, external partners may perceive Ethiopia as unable to execute or enforce joint agreements effectively, thereby limiting the scope and ambition of future transboundary cooperation efforts with Somalia and Kenya.

Conflict Resolution

Conflict resolution presents a critical challenge, with stakeholder performance indicating limited capacity to manage disputes effectively. Federal and regional governments, scoring 3.1 and 2.9 respectively, exhibit moderate capabilities, but procedural delays and inconsistent priorities around water usage hinder progress. Existing conflict resolution mechanisms, while present, are underutilized, leading to unresolved tensions. Local governments and NGOs, with scores of 2.2 and 2.5, face even greater challenges, exacerbated by resource competition and the absence of formal dispute-resolution channels. These deficiencies are particularly acute at the local level, where water scarcity amplifies tensions. Research institutions, scoring 3.5, demonstrate stronger conflict resolution capabilities in technical and data-sharing contexts, but their advisory role limits their influence in mediating disputes among primary water management bodies. The overall weakness in conflict resolution mechanisms undermines trust and collaboration, both domestically and in transboundary contexts. The low overall score for Conflict Resolution (2.8 at the country level) directly exacerbates the risk of disputes escalating into transboundary tensions, undermining the foundation of trust required for regional water agreements.

Adaptive Response Capacity

Adaptive response capacity, critical for addressing dynamic climate and water management challenges, varies significantly across stakeholders. Federal agencies,

with a score of 3.3, show moderate responsiveness in adjusting policies based on new data or climate impacts, supported by access to resources and expertise. Regional governments, scoring 3.1, are less adaptable, constrained by funding limitations and inadequate infrastructure. Local governments and NGOs, with scores of 2.5 and 2.6, exhibit limited capacity to respond to changing conditions, citing insufficient support for monitoring climate impacts and developing adaptive infrastructure. Research institutions lead with a score of 3.8, excelling in developing predictive models and providing guidance on climate resilience. However, their contributions are not fully integrated into national strategies, limiting their impact on policy-level adaptation. This uneven adaptive capacity hinders Ethiopia's ability to respond effectively to basin-level challenges and coordinate with riparian nations on climate resilience.

Impact of Supply Chain Characteristics on Cooperation

The weaknesses in KID supply chain characteristics, particularly poor data sharing and standardization, low goal congruence, and limited decision synchronization—directly undermine enhanced cooperation outcomes. Inconsistent data reliability, quality, and timeliness create a fragmented information environment, constraining resource sharing and joint decision-making. Stakeholders often prioritize localized data over shared resources, limiting Ethiopia's ability to coordinate with regional partners or align decisions across governance levels. Similarly, low goal congruence results in misaligned objectives, reducing motivation for collective basin-wide strategies and fostering competitive rather than cooperative dynamics. This misalignment weakens Ethiopia's potential for integrated resource sharing with riparian countries, hindering bilateral and multilateral water agreements. Limited decision synchronization further exacerbates these challenges, slowing responses to dynamic basin conditions and impeding coordinated water management decisions, both domestically and transboundary.

Impact of Collaborative Advantage on Cooperation Outcomes

The limited realization of collaborative advantage, driven by low scores in process efficiency and business synergy, restricts Ethiopia's operational capacity to coordinate water resources, data sharing, and conflict resolution. Stakeholders' focus on competitive advantages and siloed initiatives undermines coordinated basin management, diminishing the potential for synergistic outcomes. Additionally, reduced quality and innovation capacity, despite contributions from research institutions, reflects a lack of structured mechanisms to integrate innovative solutions into policy. This gap limits Ethiopia's ability to adopt adaptive water management practices that address cross-boundary challenges and climate change impacts, further constraining collaborative outcomes.

3.4 Implications for Bilateral and Multilateral Cooperation

Ethiopia's underperformance in enhanced cooperation signals limited readiness for effective cross-border collaboration with Somalia and other riparian nations. A robust KID supply chain, characterized by strong data-sharing protocols, decision alignment, and process efficiency, is essential for building cooperative mechanisms to address shared water challenges. Without improvements in these areas, Ethiopia's collaborative advantage remains constrained, reducing its influence in multilateral negotiations. Insufficient conflict resolution mechanisms heighten the risk of disputes over water allocation, particularly during periods of scarcity, undermining Ethiopia's role as a cooperative partner. Similarly, limited adaptive capacity, especially at regional and local levels, restricts Ethiopia's ability to coordinate with neighbouring countries on climate resilience initiatives. Developing joint climate monitoring and adaptive response frameworks would strengthen cooperative resilience and enhance Ethiopia's regional leadership.

The findings underscore that the Ethiopian Juba-Shebelle KID supply chain has achieved only moderate success in fostering collaborative advantage, with performance scores consistently lower than those of the supply chain characteristics. The weaknesses in characteristics such as goal alignment and decision synchronization directly impair business synergy and collaboration quality. Misaligned objectives and slow decision-making processes reduce stakeholders' ability to generate relational benefits, fostering an environment where competitive priorities often overshadow cooperative goals. Challenges in data standardization and communication further constrain process efficiency and offer flexibility, limiting stakeholders' ability to coordinate responses to water management issues. While research institutions demonstrate some capacity for innovation, the broader collaborative network lacks mechanisms to integrate innovative solutions, reflecting deficiencies in knowledge sharing and trust. These interdependent weaknesses highlight the critical linkage between supply chain characteristics and collaborative advantage, emphasizing the need for targeted interventions to strengthen data sharing, align goals, and enhance decision-making processes to unlock Ethiopia's potential for effective transboundary water management.

3.4.1 Analysis of Stakeholder Cooperation in Transboundary Water Governance

This table summarizes the levels of vertical and horizontal cooperation among key stakeholder groups in the context of effective governance for environmental management, data sharing, and sustainable development.

Table 3.5. Vertical Cooperation: Interactions Across Hierarchical Levels

Stakeholder Group	Strengths	Weaknesses
1.1 Government Agencies	- **High IT Resources:** Strong in IT Infrastructure Flexibility (5.2) and Hydrological/Climate Information System Expertise (5.8), supporting data-driven governance and communication. - **Robust IOS Utilization:** High usage of IOS for Data Sharing (5.6) and Data Analysis (5.9), indicating readiness for information exchange.	- **Moderate Governance Constructs**: Lower scores in Trust and Reciprocity (4.8) and Power Sharing and Inclusiveness (5.2), suggesting potential frictions with lower government levels and other stakeholders. - **Hindered Buy-in**: Lack of inclusive practices can limit engagement from local governments and civil society.
1.2 Regional Government Entities	- **Similar Capacity:** Scores comparable to government agencies in IT resources and IOS utilization (around 5.0), demonstrating technical competence.	- **Lower Collaborative Governance Scores:** Even lower scores in Power Sharing (4.5) and Shared Vision (4.3), indicating challenges in engaging effectively with local government and NGOs. - **Limited Intermediary Role:** Absence of robust collaborative framework restricts their ability to link higher-level agencies with local entities.
1.3 Local Government Entities	- **Governance Engagement Potential:** Can play essential roles in implementing policies and engaging with local communities, despite overall lower scores.	- **Limited Resources & Capacity:** Average scores around 4, indicating lack of necessary technical resources and collaborative frameworks. - **Significant Barriers**: Low score for Power Sharing (3.8) limits participation in collective decision-making, leading to disconnected policies and reduced community impact.
Overall Observations on Vertical Cooperation	- **Technical Capability vs. Governance Gap:** Government agencies and regional entities possess technical capability, but deficiencies in collaborative governance (trust, shared vision, power sharing) hinder true vertical cooperation. - **Marginalization & Restricted Engagement:** Lower levels of government may feel marginalized, undermining holistic and community-driven environmental governance.	

Table 3.6. Horizontal Cooperation: Interactions Among Stakeholders at the Same Level

Stakeholder Group	Strengths	Weaknesses
2.1 Government Agencies & Regional Entities	- **Partial Cooperation**: Generally similar resource capabilities exist. (No specific strength scores provided, but implied from vertical analysis).	- **Hindered by Commitment Differences**: Effective horizontal cooperation is hindered by variations in commitment to collaborative governance, even with similar resources. Regional entities need to proactively engage to align efforts.
2.2 Non-Governmental Organizations (NGOs)	- **Strong Data Sharing Engagement**: High capability for data sharing (IOS scores averaging ~4.4), enabling effective collaboration with both government and research institutions. - **Community Liaison**: Act as vital links between local communities and governments, ensuring local voices are represented in governance.	- **Limited Technical Influence**: Lower capability in technical expertise compared to research institutions (lack of high analytical capacity scores). - **Restricted Policy Influence**: May lead to fewer opportunities for significantly influencing policy decisions, limiting their role in horizontal collaboration.
2.3 Research Institutions	- **Highest Technical Expertise & Resources**: Scored highest in almost all constructs, particularly IOS Use for Data Analysis (6.2) and Hydrological Information System Expertise (5.9). - **Catalysts for Collaboration**: Positioned as critical knowledge brokers who can drive initiatives, align stakeholder goals, and foster innovation in research and policy analysis.	- **Engagement Contingency**: Their significant expertise's influence depends on their engagement strategies. They must actively communicate insights to government entities and NGOs for substantial impact.
Overall Observations on Horizontal Cooperation	- **Stronger Foundation**: Interplay between NGOs and research institutions indicates stronger potential due to complementary strengths, particularly for community-driven efforts. - **Need for Structured Mechanisms**: Maximizing horizontal cooperation requires structured mechanisms (shared data platforms, workshops, joint trainings) to promote synergy between governmental and non-governmental sectors and enhance collective outcomes.	

3.5 Benchmark Analysis

3.5.1 Analysis of Deviations from the Benchmark Scores

The analysis of the KID supply chain collaboration among stakeholders in the Ethiopian Juba-Shabelle Basin reveals substantial deviations from the benchmark - ideal rating of "7" on a seven-point Likert scale. This significant gap indicates a systemic deficiency in critical antecedents necessary for effective collaboration in water resource management. A closer examination of the scores as they pertain to each sub-construct provides valuable insights into the capabilities and limitations of various stakeholder entities, particularly Local Government Entities.

In the construct of IT Resources, IT Infrastructure Flexibility emerges as a pivotal determinant of adaptability in technological environments. Government Agencies score 5.2, reflecting moderate flexibility, while Regional Government Entities are slightly behind at 4.8. However, Local Government Entities score only 3.9, revealing a staggering deficiency of 3.1 from the ideal score. This lack of flexibility stunts their ability to adapt to new technologies, limiting responsiveness to emerging data and environmental challenges. In contrast, Research Institutions achieve a score of 5.7, demonstrating their capability to innovate and integrate new systems. This disparity underscores the need for enhanced investments in IT infrastructure among Local Government Entities to foster a culture of adaptability and responsiveness essential for modern water management.

When considering Hydrological and Climate Information System Expertise, the scores reveal a concerning trend. Government Agencies (5.8) and Research Institutions (5.9) exhibit strong expertise, vital for informed decision-making. This proficiency enables these entities to effectively manage water resources amid climatic fluctuations. Contrarily, Local Government Entities, scoring only 4.3, display a noteworthy deficiency of 2.7. This shortfall indicates a lack of requisite skills to interpret hydrological data, significantly hampering their ability to make informed decisions at the local level. Strengthening expertise in these areas is essential, as it directly correlates with the capacity to devise contextually relevant, climate-responsive solutions.

Moving on to IOS Appropriation, the metrics paint a similarly troubling picture. The lowest score is found among Local Government Entities for IOS Use for Communication and Coordination, with a score of 4.3, translating to a substantial deviation of 2.7 from the ideal. This deficiency highlights barriers in facilitating effective communication and collaborative coordination, crucial for joint efforts in water management. Research Institutions lead with a score of 5.9, emphasizing their significant role as facilitators of data-sharing and collaboration among various stakeholders. The inability of Local Government Entities to utilize IOS effectively not only isolates them but may also exacerbate tensions and discrepancies in water management strategies among different governance layers.

Similarly, in IOS Use for Data Analysis and Modelling, the gap broadens. Government Agencies achieve a score of 5.9, indicating good analytical capabilities; however, Local Government Entities lag behind with a 4.3 score. This results in an alarming deviation of 2.7, underscoring their inadequate capacity to process and analyze data. The reliance on higher governmental layers for analysis can create dependencies that diminish local autonomy, preventing communities from actively engaging in decision-making processes.

In terms of Collaborative Governance, the deficiencies are starkly evident across sub-constructs. The lack of inclusiveness in Power Sharing is particularly troubling for Local Government Entities, which score as low as 3.8—exhibiting a deviation of 3.2 from the exemplary value of "7". Critically, this score of 3.8 suggests that LGEs face systemic marginalization, where they are excluded from collective decision-making, hampering true vertical collaboration and resulting in a strong presence of a top-down and fragmented approach. This deficiency can alienate local voices and perpetuate existing power dynamics, thus exacerbating conflicts and reducing the legitimacy of collaborative initiatives. This data highlights that the constraints faced by LGEs are not just performance shortcomings, but structural issues of governance. Stakeholders must prioritize developing governance frameworks that embed inclusivity to create more equitable opportunities for engagement and representation.

The lack of Shared Vision and Goal Alignment among stakeholders is also alarming. Local Government Entities scored only 3.7, indicating a substantial disconnect in pursuing unified objectives. This deviation of 3.3 reveals the potential for fragmentation in the collaborative landscape, where entities prioritize individual goals over collective aims, ultimately leading to inefficacies in water resource management.

While Government Agencies scored reasonably well in Trust and Reciprocity (4.8), Local Government Entities faced a notable deficit with a score of 3.9, yielding a deviation of 3.1. This lack of trust could hinder transparent communication channels, complicating collaborative processes as stakeholders may be hesitant to share sensitive data, which is critical for combined efforts.

Furthermore, the scores for Conflict Resolution and Adaptive Management reflect a concerning trend. Although Government Agencies scored reasonably with 5.0, Local Government Entities lag significantly with a score of 4.0, producing a deviation of 3.0. The inadequate mechanisms for managing disputes limit the ability to address conflicts constructively, potentially escalating tensions and diminishing the overall effectiveness of governance initiatives.

In conclusion, the analysis of deviations from ideal scores highlights critical shortfall in fulfilling's their respective goals and common goals. The deficiencies in the antecedents of KID supply chain collaboration among stakeholders in the Ethiopian Juba-Shebelle Basin. The evident shortfalls, particularly among Local

Government Entities, necessitate urgent remedial action through targeted capacity-building initiatives, tailored training programs, and enhanced communication frameworks. By addressing these deficiencies, stakeholders can create a robust collaborative environment that is essential for effective transboundary water governance and climate change adaptation in the region. Only through a concerted effort to overcome these challenges can the stakeholders hope to achieve a more sustainable and equitable management of the region's vital water resources.

The detailed findings across the constructs reveal a clear need for strengthening collaboration among various stakeholder groups within the KID supply chain in the Ethiopian Juba-Shebelle Basin. Research Institutions consistently excel across all dimensions, suggesting a strong foundation for collaborative endeavours. Local Government Entities face significant challenges, particularly in IT flexibility, data sharing, and collaborative governance. There is a compelling argument for targeted capacity-building initiatives and interventions to enhance the operational readiness and collaboration potential of these entities, aiming to create a more integrated and effective approach to transboundary water management. By addressing these gaps and fostering a more equitable collaborative culture, all stakeholders can work together more effectively to achieve sustainable water governance in the region.

3.5.2 Key Insights from benchmark analysis

1. Limited Long-term Orientation:

- Local government entities and NGOs showed the lowest scores for long-term planning, with averages of 3.6 and 4.0, respectively. This indicates that these organizations are primarily focused on immediate, organization-specific issues, often due to limited funding, short-term mandates, and limited staffing capacity.
- This short-term focus limits horizontal collaboration among local entities and NGOs, as they may lack the resources and incentive to engage in basin-wide initiatives that require long-term commitment. Without a unified, future-oriented framework, their efforts may remain isolated and have limited impact on broader water management objectives.

2. Absence of a Cohesive Vision:

- The absence of a cohesive vision for water management across sectors, including agriculture, energy, and urban development, contributes to low goal alignment. With average scores of 4.6 for government agencies and 3.7 for local entities, it is clear that stakeholders often operate under fragmented priorities, reducing opportunities for integrated planning.
- This lack of an agreed-upon vision negatively impacts vertical collaboration between national and local levels. Without shared goals, local entities may feel disconnected from national strategies, leading to inconsistent and uncoordinated actions across governance levels.

3. Low Commitment to Collaboration:

- The scores for commitment to collaborative efforts were consistently low, averaging around 4.5 for government agencies and dropping to 3.9 for NGOs and 3.8 for local entities. This reflects a lack of perseverance and resilience in collaborative efforts, with stakeholders potentially prioritizing their individual objectives over joint, basin-wide initiatives.
- This low commitment to collaboration limits both vertical and horizontal integration within the KID supply chain. Without strong, mutual dedication to shared goals, stakeholders may face challenges in maintaining ongoing joint projects, data-sharing initiatives, and resource allocation efforts necessary for effective transboundary water management.

Image 2. Tributary watershed. Source: Anna Tengberg.

Consequences of Low Shared Vision and Goal Alignment

The lack of a shared vision and aligned goals among stakeholders has significant implications for both vertical and horizontal collaboration within the KID supply chain. The primary consequences include:

1. Reduced Vertical Collaboration:

- Inconsistent Strategic Planning: The lack of goal alignment across governance levels leads to inconsistencies in strategic planning. Local entities may implement projects that do not align with national priorities, resulting in fragmented efforts that reduce overall impact.

- Challenges in Policy Implementation: When local and national stakeholders do not share a common vision, policies implemented at the national level may fail to be effectively adopted at the local level. This hinders the basin-wide coordination necessary for sustainable water management.
- Reduced Resilience: Vertical collaboration is essential for responding to crises, such as droughts or floods. The absence of a shared vision and goal alignment reduces the basin's capacity for unified action, which may impair resilience and crisis response capabilities.

2. Weak Horizontal Collaboration:

- Fragmentation Across Sectors: The lack of a cohesive vision across sectors like agriculture, energy, and urban development results in fragmented approaches. Stakeholders may pursue individual sectoral goals without considering their impacts on shared water resources, leading to inefficient resource use and potential conflicts.
- Duplication of Efforts: Low goal alignment and poor communication can lead to redundant projects and wasted resources, as local entities and NGOs independently pursue similar objectives without coordinated planning.
- Missed Opportunities for Innovation: Horizontal collaboration enables knowledge exchange and innovation. However, without a shared vision, organizations may miss out on opportunities to collaborate on innovative solutions for sustainable water management.

3.5.3 Country Level Benchmark Analysis

We can conduct a country-level analysis of the antecedents, characteristics, and consequences of Knowledge, Information, and Data (KID) supply chain collaboration in the Ethiopian Juba-Shebelle Basin by examining the aggregated responses from various stakeholder groups.

1. Antecedents of KID Supply Chain Collaboration

The study identifies four fundamental constructs as antecedents crucial for successful KID supply chain collaboration:

- IT Resources: This includes IT Infrastructure Flexibility and Hydrological and Climate Information System Expertise. The average scores across all stakeholder groups are 4.76 and 5.08, respectively. These scores indicate a moderate level of IT resources available at the country level to support collaboration.
- **IOS Appropriation**: This refers to the use of Inter-Organizational Systems for Data Sharing and Interoperability, Data Analysis and Modelling, and Communication and Coordination. The aggregated scores are 5.02, 5.16, and 4.98, respectively. These suggest a moderate to good level of adoption and utilization of IOS for water management purposes across the country.

- **Collaborative Culture:** Explicitly provide an aggregated score for "Collaborative Culture" as a single construct, it examines related aspects under "Collaborative Governance." The average scores for sub-constructs like Power Sharing and Inclusiveness (4.52), Shared Vision and Goal Alignment (4.34), and Trust and Reciprocity (4.42) indicate moderate challenges in establishing a strong collaborative culture across the country.
- The **"Supply Chain Collaboration** defines collaborative culture with subcomponents like collectivism, long-term orientation, power symmetry, and uncertainty avoidance, suggesting a more nuanced understanding of this antecedent.
- **Trust:** Similar to collaborative culture, the assesses **Trust and Reciprocity** under "Collaborative Governance," with an average score of **4.42**, suggesting a moderate level of trust among stakeholders.

In summary, the country-level analysis of antecedents reveals moderate levels of IT Resources, IOS Appropriation, and Trust, along with moderate challenges in establishing a strong Collaborative Culture for KID supply chain collaboration in Ethiopia.

2. Characteristics of the KID Supply Chain:

Here we assess the characteristics of the KID supply chain through seven sub-constructs related to collaboration:

- Data and Information Sharing: Average score of 2.78.
- Goal Congruence: Average score of 2.62
- Decision Synchronization: Average score of 2.60.
- Incentive Alignment: Average score of 2.58.
- Resource Sharing: Average score of 2.84
- Collaborative Communication: Average score of 2.72
- Joint Knowledge Creation: Average score of 3.02.

These consistently low average scores across all seven characteristics indicate significant weaknesses in the KID supply chain collaboration within Ethiopia at the country level. This suggests a lack of effective information flow, shared objectives, coordinated decision-making, and mutual support among stakeholders.

3.6 Consequences of KID Supply Chain Collaboration

This chapter evaluates the consequences of Knowledge, Innovation, and Development (KID) supply chain collaboration in the Ethiopian Juba-Shebelle Basin, focusing on Collaborative Advantage and Country Performance in water resource management. A detailed country-level deviation analysis from an ideal benchmark (a score of 7 on a seven-point Likert scale) reveals significant gaps in

both antecedents and characteristics, underscoring systemic challenges that hinder effective collaboration and impede sustainable water governance.

3.6.1 Consequences of KID Supply Chain Collaboration

The consequences of KID supply chain collaboration are assessed through two primary lenses: Collaborative Advantage and Country Performance. These metrics provide insight into the efficacy of stakeholder interactions and their impact on achieving national water and climate resource management objectives.

Collaborative Advantage

Collaborative Advantage is evaluated through five sub-constructs: Process Efficiency (2.78), Offering Flexibility (2.80), Business Synergy (2.76), Quality (2.88), and Innovation (2.82). These scores, averaging approximately 2.81, indicate only moderate success in generating substantial collaborative advantages at the country level. The relatively low scores reflect systemic inefficiencies in stakeholder coordination, limiting the ability to achieve synergistic outcomes that surpass the capabilities of individual actors.

- **Process Efficiency (2.78)**: Inefficiencies in collaborative workflows, such as delays in decision-making and resource allocation, hinder streamlined operations.
- **Offering Flexibility (2.80)**: Limited adaptability in addressing diverse stakeholder needs restricts the basin's ability to respond to dynamic water management challenges.
- **Business Synergy (2.76)**: Weak alignment among stakeholders results in missed opportunities for leveraging collective strengths, undermining cooperative potential.
- **Quality (2.88)**: While quality shows a slightly higher score, inconsistent standards across collaborative efforts diminish overall effectiveness.
- **Innovation (2.82)**: The low score reflects a lack of mechanisms to foster creative solutions, critical for addressing complex transboundary water issues.

These modest scores suggest that while collaboration exists, it falls short of delivering transformative outcomes, primarily due to misaligned objectives and inadequate coordination mechanisms.

Country Performance

Country Performance in water resource management is measured across four dimensions: Resource Sharing (3.0), Joint Decision-Making (2.9), Conflict Resolution (2.8), and Adaptive Response Capacity (3.1). With an overall average score of 2.95, these metrics highlight significant challenges in achieving national water and climate management goals through collaborative efforts. Notably, Conflict Resolution exhibits the lowest score, signalling a critical weakness in managing disputes among stakeholders.

- **Resource Sharing (3.0)**: Moderate success in pooling resources indicates some level of cooperation, but inefficiencies in equitable distribution persist.
- **Joint Decision-Making (2.9)**: Fragmented decision-making processes undermine timely and cohesive action, eroding collaborative efficacy.
- **Conflict Resolution (2.8)**: The lowest score reflects inadequate mechanisms for resolving disputes, fostering mistrust and hindering cooperation.
- **Adaptive Response Capacity (3.1)**: While slightly higher, this score still indicates limited ability to respond dynamically to environmental and social changes.

The low average performance underscores a disconnect between collaborative efforts and tangible outcomes, particularly at the national level, where systemic barriers impede progress toward sustainable water management.

3.6.2 Country-Level Deviation Analysis from the Benchmark

A deviation analysis from the ideal benchmark score of 7 highlights substantial gaps in the antecedents and characteristics of KID supply chain collaboration, particularly at the local government level. These gaps illuminate the structural and relational challenges that constrain effective collaboration and contribute to the moderate outcomes observed in Collaborative Advantage and Country Performance.

Antecedents

The antecedents of KID supply chain collaboration—IT Resources, IOS Appropriation, Collaborative Governance, and Trust—exhibit significant deviations from the benchmark, with local government entities consistently representing the weakest link.

- **IT Resources**: Local government entities lag significantly in IT Infrastructure Flexibility (score: 3.9, deviation: 3.1) and Hydrological and Climate Information System Expertise (score: 4.3, deviation: 2.7). These gaps reflect limited access to advanced tools and expertise, constraining their ability to contribute to basin-wide initiatives. In contrast, research institutions and universities demonstrate stronger capabilities, highlighting an uneven technological landscape that undermines equitable collaboration.
- **IOS Appropriation**: The deviation in IOS Use for Data Analysis and Modelling is stark, with local government entities scoring 4.3 (deviation: 2.7) compared to government agencies' 5.9 (deviation: 1.1). This disparity indicates a critical capacity gap in processing and analyzing data, limiting local entities' ability to engage in data-driven decision-making. Similar deviations likely persist across other IOS sub-constructs, further hampering collaborative efficacy.
- **Collaborative Governance**: Local government entities score 4.0 in Conflict Resolution and Adaptive Management, resulting in a deviation of 3.0 from the benchmark. This shortfall reflects inadequate mechanisms for managing

disputes and adapting to changing conditions, which reverberates across the national collaborative framework. Other stakeholder groups may exhibit smaller deviations, but the local-level gap significantly undermines overall governance effectiveness.

- **Trust**: While not explicitly detailed in the deviation analysis, the average score for Trust and Reciprocity (4.42, deviation: 2.58) across stakeholders indicates a substantial gap. The lack of trust fosters scepticism and reluctance to share resources, further exacerbating collaborative challenges.

These deviations underscore the need for targeted interventions to bolster local government capacities and foster a more cohesive collaborative environment.

Characteristics of the KID Supply Chain

The characteristics of the KID supply chain exhibit consistently low scores across all stakeholder groups, with significant deviations from the benchmark, signalling systemic weaknesses that hinder collaboration.

- **Data and Information Sharing (2.78, deviation: 4.22)**: Low scores in data reliability, standardization, and timeliness prevent the establishment of a cohesive data-sharing environment, undermining informed decision-making.
- **Goal Congruence (2.62, deviation: 4.38)**: Misaligned objectives among stakeholders create silos, reducing cooperative potential and fostering competitive dynamics.
- **Decision Synchronization (2.60, deviation: 4.40)**: Inconsistent decision-making processes lead to delays and inefficiencies, eroding trust and collaborative momentum.
- **Incentive Alignment (2.58, deviation: 4.42)**: Lack of aligned incentives discourages stakeholders from prioritizing collective goals, further fragmenting efforts.
- **Resource Sharing (2.84, deviation: 4.16)**: Limited equitable resource distribution hampers collaborative efficiency and collective problem-solving.
- **Collaborative Communication (2.72, deviation: 4.28)**: Ineffective communication channels impede stakeholder coordination and shared understanding.
- **Joint Knowledge Creation (3.02, deviation: 3.98)**: The highest among the characteristics, yet still significantly below the benchmark, this score reflects limited success in fostering innovative solutions through collective expertise.

These substantial deviations highlight a critical gap between the current state of KID supply chain collaboration and the ideal benchmark, particularly at the local government level, where capacity constraints exacerbate systemic weaknesses.

3.6.3 Synthesis and Implications

The country-level analysis reveals that KID supply chain collaboration in the Ethiopian Juba-Shebelle Basin is not effectively translating into significant Collaborative Advantage or Country Performance outcomes. The moderate scores in Collaborative Advantage (average: 2.81) and Country Performance (average: 2.95) reflect systemic inefficiencies, particularly in conflict resolution and decision synchronization. The deviation analysis further illuminates the root causes of these shortcomings, with local government entities facing pronounced gaps in IT resources, IOS appropriation, and collaborative governance. These deficiencies, combined with low trust and misaligned characteristics, create a fragmented collaborative landscape that stifles innovation and limits adaptive capacity.

To address these challenges, stakeholders must prioritize:

- **Prioritizing Goal Congruence and Incentive Alignment:** The largest gaps in KID Supply Chain Characteristics—Goal Congruence (deviation: 4.38) and Incentive Alignment (deviation: 4.42)—must be treated as the critical practical impediments undermining long-term commitment and fostering a competitive mindset.
- **Implementation of Specific Incentive Structures:** To counter the competitive behaviours and fragmented priorities observed, the report recommends establishing formal, equitable incentive structures. These must include financial support for local entities participating in joint data-sharing projects, public recognition of cooperative successes, and the implementation of performance metrics that explicitly reward collaboration, shared risk-taking, and long-term commitment to basin-wide goals.
- **Capacity Building for Local Governments:** Invest in IT infrastructure and training to enhance local entities' ability to engage in data-driven collaboration.
- **Refined IOS Metrics:** Develop precise, context-specific tools to evaluate and improve IOS appropriation, particularly for data analysis and modelling.
- **Strengthened Governance Mechanisms:** Establish robust frameworks for conflict resolution and adaptive management to foster cohesive collaboration.
- **Trust-Building Initiatives:** Promote transparency and highlight cooperative successes to enhance trust and reciprocity among stakeholders.
- **Alignment of Characteristics:** Streamline data sharing, goal congruence, and decision synchronization through structured coordination mechanisms.

By addressing these critical gaps, stakeholders can transform the KID supply chain into a dynamic, inclusive, and innovative framework, unlocking the full potential of collaborative water management in the Juba-Shebelle Basin.

The transboundary water cooperation is greatly dependent on country-level analysis, particularly country-level analysis of the characteristics of the KID supply chain collaboration most directly determine a country's capacity for transboundary water cooperation:

- **Directly Reflect Collaborative Practices:** The characteristics of the KID supply chain, such as data and information sharing, goal congruence, and decision synchronization, are the actual mechanisms through which transboundary cooperation would occur. A country with strong characteristics in these areas demonstrates an existing capacity to engage in the essential collaborative behaviours needed for effective water management with other nations.
- **Foundation for Transboundary Action:** While antecedents like IT resources and trust are crucial enablers, the characteristics reveal how effectively these foundations are being utilized in practice. For example, even if a country has good IT resources (an antecedent), if its data sharing practices (a characteristic) are weak, its capacity for transboundary data exchange will be limited.
- **Impact on Cooperation Outcomes:** The study explicitly links weaknesses in KID supply chain characteristics to unmet cooperation objectives. Low scores in areas like data sharing, goal congruence, and decision synchronization directly restrict a country's ability to engage effectively with neighbouring riparian countries.
- **Specific Areas of Weakness:** The analysis of characteristics in the Ethiopian Juba-Shebelle Basin highlights specific areas of concern, such as poor data sharing and standardization, low goal congruence, and limited decision synchronization. These weaknesses directly translate to a reduced capacity for effective cross-border collaboration.

In summary, while the antecedents provide the necessary building blocks and the consequences reflect the outcomes, it is the characteristics of the KID supply chain collaboration that reveal the existing capabilities and limitations in the specific collaborative processes essential for successful transboundary water cooperation. A country demonstrating strength in these characteristics is better positioned to engage effectively in sharing resources, making joint decisions, and resolving conflicts with other riparian nations.

4. Conclusions

This chapter synthesizes the findings from the analysis of Knowledge, Innovation, and Data (KID) supply chain collaboration in the Ethiopian Juba-Shebelle Basin, offering a comprehensive evaluation of its antecedents, characteristics, and consequences in the context of transboundary water management. The conclusions illuminate the intricate interplay of technological, cultural, and relational dynamics that shape effective collaboration, while underscoring persistent challenges that constrain the realization of collaborative advantage.

Phased Intervention Strategy: Linking Foundational Weaknesses to Actionable Solutions The report concludes that the most effective pathway to enhanced collaboration must follow a phased intervention strategy, addressing foundational antecedents before attempting to fix operational characteristics.

Phase 1: Addressing the Trust and Technology Deficit (Antecedents to Action)

The antecedents—IT Resources, IOS Appropriation, Collaborative Culture, and Trust—form the critical scaffolding for stakeholder engagement. The analysis revealed that low organizational trust (average score 4.42, deviation 2.58) is a cornerstone weakness directly driving competitive behaviours.

To translate this foundational weakness into constructive action, IT acquisition must be explicitly linked to measurable trust-building outcomes (H2).

- IOS Implementation as a Trust Mechanism: Strategic investments must focus on implementing standardized, transparent data platforms (IOS) that mandate open data exchanges and consistent information quality across all governance levels. This technological implementation serves as a trust-building metric, as the consistent availability of reliable, shared data reduces scepticism and fosters openness, directly mitigating the low trust deficit.
- Refining Metrics for Trust Efficacy: The appropriation of IOS is currently hindered by imprecise metrics. Refined IOS metrics must be developed to assess integration and communication effectiveness, specifically focusing on the frequency of data access by local government entities and the timeliness of joint reporting, using these metrics to demonstrate and reward transparent data reciprocity, thereby strengthening relational trust.

Phase 2: Fixing Operational Impediments (Characteristics)

Once foundational trust and transparent technological infrastructure are established, interventions must target the severely compromised characteristics of

the KID supply chain. Goal Congruence (deviation 4.38) and Incentive Alignment (deviation 4.42) are the most significant operational barriers.

- Aligning Goals and Incentives: Misaligned goals and poor decision synchronization foster inefficiencies, stifling innovation and perpetuating a competitive environment. Addressing this requires prioritizing formal agreements that align organizational objectives (Goal Congruence) with a clear reward system (Incentive Alignment). This necessitates detailing specific incentive structures, such as funding priority for joint projects or formal inclusion of local officials in high-level planning, to ensure sustained commitment and counter the tendency toward siloed, short-term priorities.

Refined IOS Metrics

The appropriation of IOS is hindered by imprecise metrics for assessing integration and communication, obscuring stakeholders' ability to evaluate collaborative efficacy. To address this, the report proposes developing refined IOS metrics that move beyond simple system usage rates. Specifically, these metrics must measure:

- Data Reliability and Standardization: Metrics should track the percentage of data exchanged across the IOS platform that adheres to common protocols and standards (Data and Information Sharing, deviation 4.22), ensuring consistent quality for all users.
- Two-Way Flow and Inclusivity: New metrics must assess the frequency and responsiveness of data contribution from local government entities (LGEs), ensuring that IOS implementation supports vertical collaboration and empowers marginalized groups, rather than merely facilitating top-down communication.
- Decision-Efficacy Linkage: Metrics should evaluate the timeliness of data delivery preceding joint decision-making instances (Decision Synchronization, deviation 4.40), directly linking IOS performance to critical operational outcomes in the basin.

Framework Validation and Priority Recommendations

In conclusion, the findings underscore the critical need to address technological disparities, refine IOS metrics, cultivate a collaborative culture, and build trust to strengthen KID supply chain collaboration in the Juba-Shebelle Basin. To ensure the operationalization of the framework and translate theory into practical outcomes, the final validation process necessitates three immediate, high-priority recommendations:

1. Adopting Localized Data Collection Methods: Implementation must prioritize methods, such as community-based monitoring, to ensure the framework's adaptability to the diverse socio-cultural and environmental contexts of the basin.

2. Targeted Capacity-Building Initiatives: Immediate investment is required to launch capacity-building initiatives to empower local stakeholders, particularly within Ethiopia's under-resourced local governments, enabling them to effectively generate, utilize, and appropriate IOS data.
3. Establishing Robust Conflict Resolution Guidelines: Given the historical mistrust and competing interests within the Juba-Shebelle Basin, robust conflict resolution guidelines must be adopted.

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Annex 1: Proposed Framework Validation Report

The validation of the IOS-Enabled Knowledge, Information, and Data (KID) Supply Chain Collaboration Framework represents a rigorous evaluation of its seven core constructs, 27 sub-constructs, and over 256 measurement items, assessed against stakeholder expectations within the transboundary Juba-Shebelle Basin. This process not only affirms the framework's robustness but also illuminates pathways for refinement, establishing a comprehensive foundation for advancing collaborative water resource management in a region marked by climatic variability and socio-political complexity. Grounded in an exhaustive synthesis of academic literature, empirical studies, case analyses, and practical applications, the validation underscores the framework's alignment with global best practices while highlighting context-specific opportunities to enhance its efficacy in fostering equitable and sustainable water governance.

The validation process draws on a multidisciplinary evidence base, integrating theoretical insights from scholars such as Murray-Rust et al. (2016), who emphasize the role of integrated governance in transboundary basins, and empirical findings from Becker et al. (2020), which highlight the importance of data-driven collaboration in mitigating water-related conflicts. Case studies from analogous basins, such as the Mekong and Nile, further contextualize the framework's applicability, demonstrating how structured collaboration can address shared challenges (MRC, 2005; NBI, 2020). This triangulation of sources ensures that the framework is both theoretically sound and practically viable, tailored to the Juba-Shebelle Basin's unique socio-ecological dynamics, where erratic rainfall and competing water demands necessitate adaptive management (FAO, 2020).

At the framework's core, Information Sharing and Transparency encapsulate the extent to which stakeholders exchange accurate, timely, and accessible water-related data. Sub-constructs such as data accessibility, transparency, and quality are measured through items evaluating the frequency of data exchanges, the reliability of shared information, and the ease of access to digital platforms. Empirical evidence underscores that transparent data sharing fosters trust and reduces conflict risks, as demonstrated in the Indus Basin, where open data protocols mitigated tensions among riparian states (Rogers et al., 2017). The KID framework's emphasis on data quality aligns with these findings, positioning it as a critical mechanism for building cooperative relationships among Ethiopian, Somali, and Kenyan stakeholders.

Goal Congruence, another pivotal component, reflects a shared commitment to water management priorities across diverse stakeholders. Sub-constructs assess the alignment of objectives and the presence of mutual agreements, with measurement items probing the extent of consensus on resource allocation and climate adaptation strategies. Research by Brouwer et al. (2017) confirms that shared objectives enhance collaborative efficacy, as seen in the Rhine Basin, where aligned goals facilitated joint flood management initiatives. The KID framework's focus on goal congruence addresses the Juba-Shebelle Basin's fragmented governance, where divergent priorities—such as Ethiopia's upstream hydropower ambitions versus Somalia's downstream agricultural needs—hinder cooperation (World Bank, 2021).

Joint Knowledge Creation integrates scientific, traditional, and local knowledge systems to enrich decision-making processes. Sub-constructs evaluate the incorporation of diverse data sources, while measurement items assess the frequency of collaborative research and the inclusion of indigenous insights. The Nile Basin Initiative's success in blending scientific and local knowledge to inform water allocation decisions exemplifies the value of this approach (NBI, 2020). By fostering inclusive knowledge production, the KID framework enhances adaptive capacity in the Juba-Shebelle Basin, where local pastoralist observations can complement hydrological models to address drought risks (IWMI, 2023).

Decision Synchronization ensures cohesive action through coordinated decision-making. Sub-constructs measure the timeliness and alignment of decisions, with items evaluating the effectiveness of joint planning processes. Studies by Haas (2009) demonstrate that synchronized decisions, as implemented in the Danube Basin, improve resource management outcomes by minimizing delays and conflicts. The KID framework's emphasis on synchronization addresses the basin's challenges, where asynchronous decision-making between Ethiopian federal agencies and local authorities exacerbates inefficiencies (UNEP, 2022).

Collaborative Communication, a cornerstone of stakeholder engagement, facilitates transparent dialogue and adaptive governance. Sub-constructs assess communication frequency and clarity, with measurement items probing the use of shared platforms and feedback mechanisms. The Danube River Basin Initiative's success in leveraging communication networks to enhance stakeholder trust validates this component (Bakker, 2012). In the Juba-Shebelle Basin, where historical mistrust between Ethiopia and Somalia persists, the framework's focus on communication offers a pathway to rebuild relational dynamics (World Bank, 2021).

Practical validation is reinforced by non-academic evidence from global water governance initiatives. The Global Water Partnership advocates for integrated data platforms and adaptive governance, principles mirrored in the KID framework's emphasis on IOS-enabled data sharing and decision synchronization (GWP, 2019). The Mekong River Commission's use of shared monitoring systems to manage flood risks provides a compelling precedent, demonstrating how collaborative

platforms can foster cooperation in politically sensitive basins (MRC, 2005). Similarly, the Nile Basin Initiative's data-sharing protocols have reduced tensions among riparian states, offering a model for the Juba-Shebelle Basin (NBI, 2020).

Despite its robust design, the validation process identifies critical areas for enhancement. Localized data collection methods are essential to ensure the framework's adaptability to the basin's diverse socio-cultural and environmental contexts. Evidence from the Zambezi Basin highlights the efficacy of community-based monitoring in tailoring solutions to local needs (O'Hare et al., 2021). Capacity-building initiatives are equally critical to empower local stakeholders, particularly in Ethiopia's under-resourced local governments, to generate and utilize data effectively. The Okavango Basin's training programs for local water managers illustrate the transformative impact of such efforts (GWP, 2019). Additionally, robust conflict resolution guidelines are vital to address disputes arising from data asymmetries or competing interests, as demonstrated in the Colorado River Basin, where structured mediation reduced litigation (Susskind & Cruikshank, 2006).

In conclusion, the validation of the IOS-Enabled KID Supply Chain Collaboration Framework establishes its potential as a transformative model for transboundary water governance in the Juba-Shebelle Basin. By integrating advanced technologies, participatory methodologies, and adaptive governance, the framework addresses the basin's multifaceted challenges while fostering stakeholder alignment. The evidence-based validation, drawing on global best practices and basin-specific insights, confirms its theoretical and practical robustness, though targeted refinements in localized data collection, capacity building, and conflict resolution will enhance its impact. A forthcoming technical report will provide detailed strategies for implementing the framework, recognizing that the basin's sustainable future depends on robust KID collaborations that unify stakeholders across its sub-basin.

Annex 2: Lists of Framework Survey Organizations

Government agencies

Federal Governmental Agencies:

1. Ethiopian Ministry of Water and Energy
2. Ethiopian Environmental Protection Authority
3. Ethiopian Ministry of Peace
4. Ethiopian Ministry of Foreign Affairs
5. Ethiopian Ministry of Irrigation and Low Lands
6. Ethiopian Ministry of Agriculture
7. Ethiopian Ministry of Health (Water, Sanitation, and Hygiene Division)
8. Ethiopian Ministry of Urban Development and Construction
9. National Disaster Risk Management Commission
10. Federal Water Resources Development Authority
11. Awash Basin office

Regional Government agencies:

12. Somali Regional Environmental Protection Bureau
13. Somali Regional Water Bureau
14. Somali Regional Bureau of Agriculture and Natural Resources
15. Somali Regional Pastoral and Agro-pastoral Bureau
16. Somali Regional Bureau of Education (Water, Sanitation, and Hygiene in Schools)
17. Somali Regional State Planning and Development Commission
18. Somali Regional State Office of Disaster Prevention and Preparedness
19. Somali Regional Bureau of Women, Children, and Youth Affairs (Community Development Focus)
20. Somali government state administration office

Local Government Entities (Somali Regional State District Offices):

Kebri Dehar District

21. Kebri Dehar District Administration Office
22. Kebri Dehar District Water Office
23. Kebri Dehar District Health Office (WASH initiatives)
24. Kebri Dehar District Education Office (WASH programs in schools)
25. Kebri Dehar District Pastoral and Agro-pastoral Development Office
26. Kebri Dehar District Disaster Risk Reduction Office

Gode District
27. Gode District Administration Office
28. Gode District Water and Sanitation Office
29. Gode District Health Office (Water and sanitation projects)
30. Gode District Education Office (school-based WASH initiatives)
31. Gode District Pastoral and Agro-pastoral Development Office
32. Gode District Disaster Risk Reduction Office

Ferfer District
33. Ferfer District Administration Office
34. Ferfer District Water Office
35. Ferfer District Health Office (focus on community health and sanitation)
36. Ferfer District Education Office (WASH education in schools)
37. Ferfer District Pastoral and Agro-pastoral Development Office
38. Ferfer District Disaster Risk Reduction Office

Dollo Ado District
39. Dollo Ado District Administration Office
40. Dollo Ado District Water Office
41. Dollo Ado District Health Office (community hygiene and sanitation)
42. Dollo Ado District Education Office (WASH in school initiatives)
43. Dollo Ado District Pastoral and Agro-pastoral Development Office
44. Dollo Ado District Disaster Risk Reduction Office

Mustahil District
45. Mustahil District Administration Office
46. Mustahil District Water Office
47. Mustahil District Health Office (sanitation and hygiene)
48. Mustahil District Education Office (WASH awareness in schools)
49. Mustahil District Pastoral and Agro-pastoral Development Office
50. Mustahil District Disaster Risk Reduction Office

Fik District
51. Fik District Administration Office
52. Fik District Water Office
53. Fik District Health Office (public health and hygiene programs)
54. Fik District Education Office (school-based sanitation efforts)
55. Fik District Pastoral and Agro-pastoral Development Office
56. Fik District Disaster Risk Reduction Office

Danan District
57. Danan District Administration Office
58. Danan District Water Office
59. Danan District Health Office (WASH and hygiene programs)
60. Danan District Education Office (water conservation education)
61. Danan District Pastoral and Agro-pastoral Development Office

62. Danan District Disaster Risk Reduction Office

Warder District
63. Warder District Administration Office
64. Warder District Water Office
65. Warder District Health Office (focus on sanitation and hygiene)
66. Warder District Education Office (WASH programs for students)
67. Warder District Pastoral and Agro-pastoral Development Office
68. Warder District Disaster Risk Reduction Office

Kebri Beyah District
69. Kebri Beyah District Administration Office
70. Kebri Beyah District Water Office
71. Kebri Beyah District Health Office (public health with WASH focus)
72. Kebri Beyah District Education Office (WASH education in schools)
73. Kebri Beyah District Pastoral and Agro-pastoral Development Office
74. Kebri Beyah District Disaster Risk Reduction Office

Shekosh District
75. Shekosh District Administration Office
76. Shekosh District Water Office
77. Shekosh District Health Office (community hygiene initiatives)
78. Shekosh District Education Office (focus on WASH for school children)
79. Shekosh District Pastoral and Agro-pastoral Development Office
80. Shekosh District Disaster Risk Reduction Office

Afdem District
81. Afdem District Administration Office
82. Afdem District Water Office
83. Afdem District Health Office (sanitation and health improvement programs)
84. Afdem District Education Office (WASH education)
85. Afdem District Pastoral and Agro-pastoral Development Office
86. Afdem District Disaster Risk Reduction Office

Degehabur District
87. Degehabur District Administration Office
88. Degehabur District Water Office
89. Degehabur District Health Office (WASH and hygiene projects)
90. Degehabur District Education Office (school sanitation programs)
91. Degehabur District Pastoral and Agro-pastoral Development Office
92. Degehabur District Disaster Risk Reduction Office

Non-Governmental Organizations (NGOs)

93. World Vision Ethiopia (Water, Sanitation, and Hygiene Projects)
94. Oxfam Ethiopia (Water Resource Management Program)
95. CARE Ethiopia (Integrated Water Resource Management)
96. Save the Children Ethiopia (WASH programs)
97. WaterAid Ethiopia
98. Forum for Environment
99. SOS Sahel Ethiopia (focused on natural resource management)
100. Mercy Corps Ethiopia (WASH initiatives)
101. Pastoralist Concern Ethiopia
102. African Wildlife Foundation Ethiopia (Basin Biodiversity)
103. Ethiopian Orthodox Church Development Commission (Community Water Initiatives)
104. Farm Africa Ethiopia (Water and Land Use for Agriculture)
105. Rift Valley Institute (Water and Development Studies)
3. Research Institutions & Universities
106. Addis Ababa University, Institute of Water and Environment
107. Haramaya University, College of Agriculture and Environmental Sciences
108. Ethiopian Institute of Agricultural Research (Water-Related Research Division)
109. Jigjiga University, Water Resources Management Program
110. Ethiopian Institute of Water Resources
111. Ethiopian Biodiversity Institute
112. Agricultural Transformation Agency (Research on Sustainable Water Use)
113. International Water Management Institute (IWMI) Ethiopia Office
114. Ethiopian Water Technology Institute
115. Ethiopian Metrology Institute

Explanation of Selections

This list encompasses a variety of organizations with direct or indirect stakes in water resource management, ecological preservation, and socioeconomic activities relevant to the Ethiopian Juba-Shebelle Basin.

- Governmental Agencies and Local Government Entities (including district offices) are prioritized for their regulatory roles, especially Somali regional state and district government offices that manage resources, environmental protection, and community needs within the basin.
- NGOs play significant roles in implementing water, sanitation, and hygiene (WASH) initiatives, natural resource management, and community development, all critical for sustainable basin management.
- Research Institutions & Universities: provide critical insights through research on water resource management, environmental health, and sustainable development specific to the basin context.

This list is tailored to ensure relevance to the Juba-Shebelle Basin and reflects a comprehensive range of stakeholders engaged in, influencing, or impacted by water management in the Ethiopian segment of this transboundary basin.