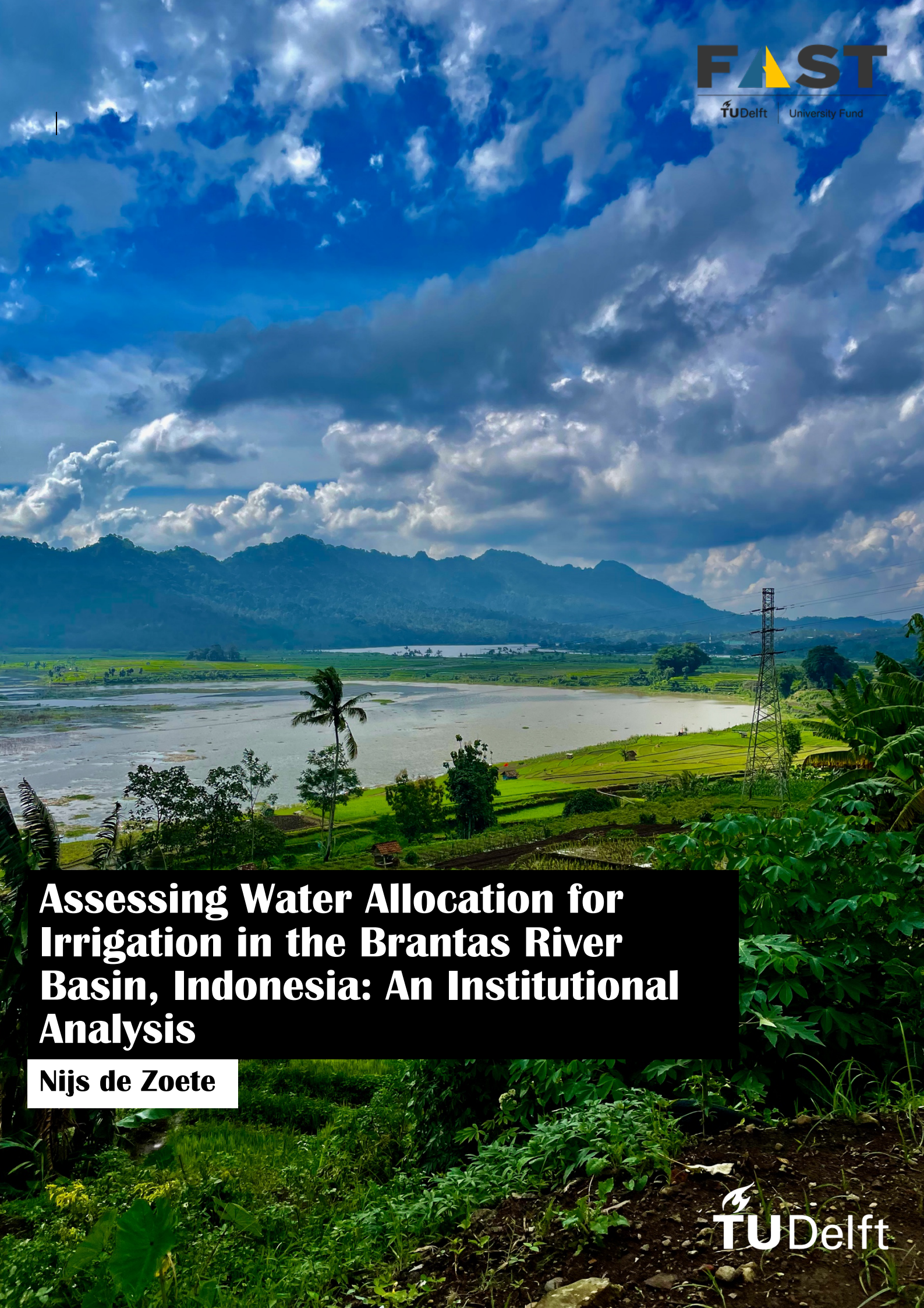

Assessing Water Allocation for Irrigation in the Brantas River Basin, Indonesia: An Institutional Analysis

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Executive Summary

Already for decennia, water is a scarce resource in Java. The tropical climate, uneven water distribution amongst the islands in place and time, rapidly growing population, and climate change have been and continue to be significant contributors to this issue. As Java is Indonesia's economic and population center and a major food producer, addressing the island's experienced water stress is crucial for its sustainability and continued development.

The Indonesian government has been trying to alleviate water stress by building more and more infrastructure to capture surface water. However, this strategy has repeatedly shown to cause secondary issues and conflict, leaving significant challenges unresolved. These effects should inspire policymakers to find additional solutions to relieve the country's water stress.

One such option is institutional analysis. Polski & Ostrom (1999) define institutions as a widely understood rule, norm, or strategy that incentivizes behavior in repetitive situations. The study of the institutions related to Common Pool Resources has shown that well-functioning institutions contribute to significant improvements in the sustainability of the resource. As surface water is such a resource due to its high extractability and low excludability, an institutional analysis could provide substantial insights that could help support future improvements.

Since the agricultural sector accounts for four-fifths of the water demand, this research focuses on the allocation institutions and practices for irrigation. This brings us to the following research question:

How do the formal and informal institutions influence irrigation surface water allocation practices in the Brantas river basin in Indonesia?

The institutional analysis and development (IAD) framework is used to answer the research question. This approach enables a comprehensive analysis of the irrigation water allocation institutions, identifying overarching themes and exploring their influence on one another.

The results of this research are divided into two main sections: (1) the formal institutions and formally arranged connections between organizations related to irrigation surface water allocation are analyzed and summarized in a formal chart, and (2) the local water allocation practices are identified and analyzed with the use of action arenas. Within the IAD framework, action arenas provide the foundation for the analysis of local irrigation water allocation practices. In these action arenas, numerous actors interact with one another, shaping irrigation surface water allocation outcomes. Here, exogenous variables such as the biophysical/material conditions, socio-economic factors, and rules-in-use

(institutions) define the context in which the actors operate. Each actor's actions are influenced by their values, resources, and perceptions.

Data for this analysis was gathered through interviews: ten with experts active in (governmental) organizations and four group interviews with farmers and field practitioners actively involved in irrigation. These interviews provided insights into field-based connections between actors and their respective values, resources, and perceptions, allowing for the sketching and analysis of action arenas.

The formal framework of the irrigation water allocation system within the Brantas River Basin is shaped by a series of rules and regulations. The foundation for these rules stems from the 1945 Constitution of the Republic of Indonesia, which declares that "the land and the water, as well as the natural resources therein, are controlled by the state and utilized for the optimal welfare of the people." This statement not only outlines the guiding principles for the use of water resources but also emphasizes the government's responsibility toward its citizens.

The current primary legal framework for managing water resources is outlined in Law No. 17/2019 on Water Resources (Al'Afghani, 2022). Combined with decentralization laws and regulations, this framework establishes three levels of governance responsible for water allocation: (1) national, (2) provincial, and (3) local. At the national level, multiple ministries oversee water management, all reporting to the president. A governor leads the provincial level and involves provincial counterparts of the ministries, known as "Dinas", working alongside other organizations such as River Basin Organizations (RBOs). BBWS Brantas is the RBO responsible for the water allocation and management in the Brantas River Basin. The PJT1 is responsible for implementing these water allocation plans and other operational tasks. The local level mirrors the provincial structure, with leadership by district heads (*Bupati*) or municipal heads (*Walikota*) and local counterparts of the ministerial organizations, also referred to as "Dinas."

Additionally, the irrigation areas are divided into three subsections: (1) Irrigation areas larger than 3000 hectares or interprovincial or national strategic irrigation areas are placed under the responsibility of the central government, which in turn delegates these tasks in the Brantas River basin to the River Basin Organization responsible for water allocation and management within the Brantas River basin (BBWS Brantas); (2) irrigation areas between 1000 and 3000 hectares or inter-district or -city irrigation areas are under the responsibility of the provincial government, which delegates this task to the Provincial Agency of Water Resources of East Java (Dinas PU SDA); and (3) irrigation areas smaller than 1000 hectares are under the responsibility of the district/city government. These organizations are responsible for the operation and maintenance of the primary and secondary irrigation infrastructure, cropping plan, and water allocation plan. Only the operation of the tertiary water infrastructure is in the hands of the Water Users Farmers Associations.

The action arenas identified and analyzed in this research are: (1) farmers deciding which crops to cultivate; (2) reaction to sudden water scarcity within one of the irrigation areas; (3) tertiary water infrastructure maintenance, and (4) working culture in organizations related to water allocation. Out of the analysis of the action arenas, two common themes are identified: (1) a mismatch between water demand and supply expectations regarding different data used in the calculations, and (2) organizations filling in the practical vacuum left by the formal network or other organizations. Additionally, three different approaches by actors within the action arena have been observed: (1) the conservative approach, mainly focusing on the tasks assigned by the formal framework (i.e. BBWS Brantas, Dinas PU SDA); (2) the proactive approach, where organizations try to fill an undefined void or a void left by others (i.e. Ministry of Agriculture); and (3) the coordination approach, where actors coordinate, discuss and inform each other to shape water allocation institutions (i.e. UPT and the Water Users Farmers Associations)

This study found three main insights in the institutional analysis regarding irrigation water allocation practices.

The first key insight is regarding the presence of nested enterprises across various levels of governance in the irrigation water sector. The decentralization laws provide a solid base for organizations on different levels to accommodate their needs. In practice, however, there is overlap between different levels. This can best be seen in the organizations responsible for the three different irrigation area sizes. Here, provincial-level organizations have local responsibilities, such as the BBWS Brantas and the Dinas PU SDA. This structure makes sense on paper but creates a split focus for provincial and local tasks of underfunded organizations, conflicting tasks, and interests.

The second key insight is the existence of public participation mechanisms at multiple levels of governance. These mechanisms have been observed at both the local and provincial levels. Locally, the Water Users Farmers Associations structure in the Brantas River basin creates various problem-solving and conflict-resolution arenas at different scales within an irrigation area. These Water Users Farmers Associations (also referred to as (I/G)Hippas) are a multilayered structure to accommodate solutions and conflict resolution mechanisms on various levels inside an irrigation area (from smallest to largest: Hippa -> Ghippa -> Ihippa). Provincially, the Coordination Team for Water Resources Management (TKPSDA) provides a platform for multiple organizations to coordinate their actions. The TKPSDA functions as an intergovernmental coordination team that involves stakeholders in the water resources management sector and is tasked with the creation of the master plans of the river basin (*Pola* and *Rencana*). However, this research is unable to draw definitive conclusions about the effectiveness of the TKPSDA, as decision-making authority often remains with individual organizations.

The third key insight is that some of the observed organizational roles are underemphasized in the formal structure of the water allocation framework. Observed examples of these roles are the roles of the Ministry of Agriculture and the local technical operations unit

(*UPT*). This Ministry of Agriculture's officially defined role and the tasks it performs in practice. While its formal responsibilities are limited to certain aspects of irrigation, the Ministry has additional involvements in other parts of the water allocation process, even though it lacks formal jurisdiction. These additional roles have been taken on due to the close relationship between water and agriculture. For instance, this Ministry provides subsidies in periods of sudden water scarcity to help resolve local conflicts and also plays a role in rehabilitating tertiary water infrastructure. This involvement by the Ministry of Agriculture arises from an institutional and practical gap, but also creates friction with other responsible organizations. The UPT has been observed to play an important role in the local water allocation practices whilst formally only being responsible for the operation of the irrigation area's infrastructure. They collaborate closely with the irrigation area's Water Users Farmers Associations to create internal water allocation plans, provide information about the conditions of the infrastructure, and aid in emergency solutions.

With these insights, three policy recommendations have been proposed to strengthen the irrigation water allocation system, along with two recommendations for further scientific research.

The first policy recommendation is to assign the responsibilities of the national government regarding irrigation areas to another organization. The River Basin Organization responsible for water allocation and management within the Brantas River basin (BBWS Brantas) fulfills a crucial role regarding the water allocation of the Brantas river and also additional roles regarding the operation and maintenance of the water infrastructure within irrigation areas inside their jurisdiction and the creation of the annual crop rotation plans (RTTGs) for these irrigation areas. These roles seem to create a conflict of interest. Formally assigning these roles to another organization relieves these conflicting roles.

The second policy recommendation is to find solutions that improve farmers' living standards and increase their participation in surface water management. Combining these two elements will raise farmers' awareness of surface water management and reduce their need to take risks that lead to a higher water demand.

The third policy recommendation is to align adjustments to the annual water allocation plan with each irrigation area's access to an alternate water source. Some irrigation areas suffer heavily due to a sudden decrease in water availability, while others are unaffected due to their access to alternate water sources. Implementing this policy would increase water security for heavily affected farmers whilst leaving others unaffected.

While addressing water allocation disparities is crucial, it is equally important to advance research efforts. Therefore, the first recommendation for further research is to increase the coupling between institutional analysis and the already existing quantitative models to bridge the gap between qualitative insights and measurable outcomes.

The second recommendation for further research is to enhance measurement tools and techniques for identifying informal institutions within interview data collection methods. Informal institutions are unconscious and conscious rules, making it difficult to identify such unconscious rules through interviews. Extracting more of such rules can significantly improve the depth and accuracy of the analysis.

Several aspects of this research warrant reflection. Firstly, there was some deviation from the stepwise approaches recommended by Hermans & Cunningham (2018) and McGinnis (2012). The somewhat unstructured process led to gaps in addressing elements of the action arenas and left certain aspects of the irrigation water system unexplored, affecting the overall robustness and completeness of the analysis.
Limitations also arose from the interview process, specifically due to the nature of semi-structured interviews. These interviews reflect only one version of reality and are constrained by the knowledge and willingness of the interviewees, which significantly limited the research. Furthermore, neither the researcher nor the interviewees were native English speakers. As the interviews were conducted in English, this created a language barrier, especially as interviews became more localized. The need for a translator increased as the English proficiency of interviewees decreased, likely resulting in miscommunications and misunderstandings.

Additionally, not all relevant actors were interviewed, which narrowed the scope of the analysis and left several key areas unexamined. There was an overrepresentation of one organization, the Ministry of National Development Planning (BAPPENAS), which skewed the analysis towards their perspective.
This thesis presented several challenges, such as the introduction of new concepts: institutions, governmental structures, qualitative data collection, and coding methods. This shift from executing predefined processes to creating and executing my own process was a significant learning experience, though it left some stones unturned.

Conducting research in a foreign country brought its own set of challenges. Beyond the practical differences in government structures and laws, cultural differences were also evident. Indonesia's hierarchical structure influenced interview dynamics, and the language barrier became more pronounced as the locations became more local. Although I made an effort to learn Indonesian (Bahasa), which helped foster connections during interviews, the need for a translator was inevitable.

Despite these challenges, the overall experience of this research has been positive. I am deeply grateful for the opportunity to conduct this research and for the warmth, hospitality, and enriching experiences I encountered in Indonesia. It has been a heartwarming and unforgettable journey that I will always cherish.

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List of Abbreviations

Abbreviation	Description	Indonesian
Bappeda	Regional agency of development planning	Badan Perencanaan Pembangunan Daerah
Bappenas	Ministry of National Development Planning	Badan Perencanaan Pembangunan Nasional
(B)BWS	National or provincial river basin organization responsible for water allocation and management within one or more river basin territories	(Balai) Besar Wilayah Sungai
BMKG	Meteorology, Climatology, and Geophysics Agency	Badan Meteorologi, Klimatologi, dan Geofisika
CPR	Common Pool Resources	
Dinas PKP	Provincial Agriculture and Food Security Office of East Java	Dinas Pertanian dan Ketahanan Pangan Provinsi Jawa Timur
Dinas PU	Agency of Public Works working under the provincial or district government	Dinas Pekerjaan Umum
Dinas SDA	Agency of Water Resources working under the provincial or district government	Dinas Sumber Daya Air
ESDM	Ministry of Energy and Mineral Resources	Kementerian Energi dan Sumber Daya Mineral
IAD framework	Institutional Analysis and Development framework	
IC	Irrigation Commission	Komisi Irigasi
(I/G)Hippa	The structure of Water Users Associations (P3a) / Water Users Farmers Associations within one irrigation area as described in Section 4.3.	
MoA	Ministry of Agriculture	Kementerian Pertanian
PJT1	State-owned enterprise and river basin organization responsible for the operation of primary and secondary water infrastructure	Perum Jasa Tirta I
PUPR	Ministry of Public Works and Housing	Kementerian Pekerjaan Umum dan Perumahan Rakyat
RAAR	10 to 15 day water allocation plan which is specific for each river basin area	Rencana Alokasi Air Rinci
RAAT	Annual water allocation plan specific for each river basin area	Rencana Alokasi Air Tahunan
RBO	River Basin Organization	
RBT	River Basin Territory	Wilayah Sungai

RPJMN	Medium-term water allocation development plans	Rencana Pembungunan Jangka Menengah Nasional
RPJPN	Long-term water allocation development plan	Rencana Pembungunan Jangka Panjang Nasional
RTTG	Annual cropping plan specific for each irrigation area	Rencana Tata Tanam Global
TKPSDA	Coordination team for Water Resources Management	Tim Koordinasi Pengelolaan Sumber Daya Air
UPT	Technical implementation unit operative in regencies	Unit Pelaksana Teknis
WUFA	Water Users Associations (P3A) / Water Users Farmers Associations	Perkumpulan Petani Pemakai Air
WUA	Water Users Association	Perkumpulan Pemakai Air
WUFA	Water Users Farmers Association / WUA (P3A)	Perkumpulan Petani Pemakai Air

Glossary

Action arena	is the center of the Institutional Analysis and Development framework, and is the conceptual space in which actors inform themselves, consider alternative courses of action, make decisions, act, and experience the consequences of these actions (Polski & Ostrom, 1999)
Actor	refers to individuals, organizations or groups capable of autonomous and intentional actions that have an impact on a problem or system of interest (Hermans & Cunningham, 2018)
Common pool resources	is a collective name for resources that have a high subtractability and in which it is difficult to exclude actors from use (Ostrom et al., 1994)
Institutions	are a widely understood rule, norm or strategy that creates incentives for behavior in repetitive situations (Crawford & Ostrom, 1995)
Formal institutions	are explicitly communicated agreements between actors. Formal institutions therefore refer to laws, orders, verbal agreements, and promises between friends.
Formal chart	portrays hierarchic structures and physical, data, and or legal (inter)dependencies between organizations
Ghippa	The middle Water Users Association (P3a) or Water Users Farmers Association in East Java within irrigation areas. This organization works under the Ihippa and coordinates Hippas when interhippa conflict or to resolve larger problems occurs within its influence
Hippa	The lowest level Water Users Association (P3a) or Water Users Farmers Association in East Java within irrigation areas. This organization works under the Ghippas solves member conflict or to resolve problems occurs within its influence.

IAD framework	Institutional Analysis and Development framework helps analysts comprehend complex social situations and compartmentalize the elements into manageable sets of practical activities (Polski & Ostrom, 1999)
Indohippa / Ihippa	The largest parent Water Users Association (P3a) or Water Users Farmers Association in East Java is located within irrigation areas. The number of Ihippas (either none, one, or several) in an irrigation area depends on the specific characteristics of that irrigation area.
Informal institutions	are not consciously designed nor clearly defined institutions, but are implied rules that we are expected to follow (North, 1990; Lowndes, 1996; Williamson, 1998; Polski & Ostrom, 1999). Informal institutions therefore refer to behavioral customs, cultural norms, and social expectations (Lowndes, 1996).
Rencana	River Basin Territory master plan
Pola	River Basin Territory strategic plan

1. Introduction: Current Issues in Water Allocation in Java

Indonesia is renowned for its vast archipelago, stunning scenery, and rich biodiversity and culture. After declaring its independence in 1945, the country experienced significant transformations, including tremendous economic and populational growth. Today, the archipelago of the Republic of Indonesia is one of the most populous countries in the world, inhabited by around 280 million people and spread over more than 17,000 islands.

Java is home to over half of the country's population, making it the most densely populated island in the archipelago. As a result, Java faces challenges, particularly in water resource management. With increasing demands from for example agriculture, industry, and increased private water consumption, the issue of equitable and sustainable water allocation has been a critical concern for decennia. With irrigation being by far the largest consumer of (surface) water in the country, this research delves into the complexities of the current irrigation water allocation system on Java Island.

1.1. Socio-Economic Forces Driving Water Management in Java

Since its independence, Indonesia has experienced tremendous changes. The two most significant are the economic and population growth of the country. The country's population has increased by 420% in the last 75 years, which is expected to continue to rise over the coming 30 years (Statistica, 2021; United Nations population, 2024).

As the world's most populous island, Java is housing over 55% of the country's population (Statistica, 2020). This equates to more than 150 million people living on a relatively small island, resulting in an astonishing population density of over 1100 people per square meter (Lindner, 2024). With water being essential for life, such a densely populated region can face immense demands for water and food, leading the island to struggle with water scarcity for decennia.

Additionally, Java plays a major role in the national economy, generating over half of Indonesia's GDP. Currently, half the country's GDP is produced in areas experiencing 'high' or 'severe' water stress and is expected to grow to two-thirds by 2045 (World Bank, 2021). Given the strong link between GDP growth and the reduction of water stress, addressing this issue should be a top priority for the government (World Bank, 2021).

Managing the water is already crucial for Java, as the predictions are that water demand will increase by over 30% between the years 2015 and 2045, making the issue only more pressing (Indonesian Central Bureau of Statistics (Badan Pusat Statistik), 2016). The largest consumer of water is the irrigation sector, which accounts for 74% of total water use, followed by personal consumption (16%), industries (7%), and urban usage (3%) (World Bank, 2021).

A major driver of this high water demand is Java's critical role in Indonesia's agricultural sector. Thanks to the island's fertile volcanic soil, enriched by its 112 volcanoes (35 of which are still active), Java's irrigation sector is highly productive. Although the island accounts for only 40% of Indonesia's irrigated land, it produces 70% of the nation's food supply (Samekto, 2008; World Bank, 2021). These high yields explain the importance of Java's irrigation, but this success comes at a cost. The intensive cultivation requires large amounts of water, driving up the demand of the sector.

Indonesia's water supply is dominated by two different water sources: surface water and groundwater. Each source seems to mainly support different uses. The largest source of raw water is surface water, which mainly supplies irrigation and municipal demands. The surface water originates from rainfall, which is captured and stored in rivers. This water is mainly distributed amongst irrigation areas whilst also being used for industries and as urban water supply. Another significant water source is groundwater, which provides only 15% of the water supply. Groundwater is mainly used for household supplies, especially in major cities like Jakarta (USAID & Sustainable Water Partnership, 2021). Due to this large distinction between water source and the industries they supply, it is important to take this into account in research.

The continued economic growth of Indonesia also brings increasing water demands. Indonesia has re-earned itself a place in the upper-middle income countries and is also still growing and developing (World Bank, 2023). Households in developing economies tend to increase their private water consumption and Indonesia is no exception.
Even though the incrementation is small for each household each year, the sheer size of the population on an island still has a big impact.

1.2. Understanding Climate and Hydrology's Impact on Java's Water Availability

Almost contradictory, Indonesia belongs to the top 10 richest countries in terms of renewable water resources (World Bank Group, 2024). In theory, Indonesia should be swimming in water. Unfortunately, the majority of the rainfall is concentrated within the rainy season, as is typical for tropical climates. Such a climate is characterized by having two seasons: the rainy and the dry season (BMKG; CCKP World Bank, 2021). During the rainy season, the country experiences daily heavy rainfall. This results in the majority of the rainfall pouring down within this season (CCKP World Bank, 2021). In this season, water is abundant and the rivers are full of water. On the contrary, the dry season is characterized by periods of absent rainfall, with the occasional downpour of water. Especially during the height of dry season, August and September, the country experiences extended periods of droughts, which are responsible for drastically depleting water levels in the rivers (Asian Development Bank, 2016).

Impacting the severity of the dry season is the occurrence of El Niño. El Niño typically lasts nine to twelve months and occurs every two to seven years (National Ocean Service, 2024). The occurrence of this phenomenon expresses itself all across the Pacific Ocean and it affects the Indonesian climate by decreasing rainfall and increasing temperatures (Iskandar et al., 2019). In short, its presence amplifies the effects of the dry season, putting extra strain on the country's water resources. Unfortunately, a shift in the global climate makes the occurrence of El Niño more frequent than before (Cai et al., 2014).

In addition to the rainfall not being evenly distributed over time, rainfall is also not even distributed in space, resulting in different islands receiving different amounts of rainfall. Islands such as Sumatra, Kalimantan, and Papua receive 25 to 30% of the national rainfall, creating an island-specific surface water abundance (World Bank, 2021). Unfortunately, the situation in Java is different. Java only contains 4% of the country's surface water and only 6% out of the 6% of the total water availability (Asian Development Bank, 2016; World Bank, 2021). The combination of such a large population, water-intensive agriculture, and uneven distribution in space and time make it difficult for governmental organizations to capture and store a sufficient amount of water to create a fulfilling water supply during scarce periods.

In the past, water infrastructure construction in Indonesia has caused serious alternative issues such as protests regarding the construction of new infrastructure, generational poverty under affected farmers, and increasing maintenance costs of the already overdue infrastructural maintenance (Aribowo & Yudhistira, 2021; Barahamin, 2022; Asnawi, 2023; Iqbal, 2023; Crisis24, 2024). Despite this, the Indonesian government has repeatedly expressed its interest in constructing more infrastructure to increase the water supply (Asnawi, 2023; Tri Murti, 2023). While the growing number of water storage facilities helps to alleviate some issues, the critical question remains whether constructing more infrastructure will also address the additional and underlying problems.

1.3. Emphasizing the Need to Improved Water Allocation Institutions in Indonesia

Water scarcity has been a persistent issue in Java for decades. It is primarily driven by the misalignment of a large population and inconsistent rainfall (USAID & Sustainable Water Partnership, 2021). As a response to this growing challenge, the Indonesian government has undertaken a series of initiatives to develop and revise laws and regulations surrounding water allocation. Since 2005, these efforts include the creation of national, provincial, and local long- and medium-term water allocation development plans (*Rencana Pembangunan Jangka Panjang/Menengah Nasional* – RPJPN/RPJMN) and the government has implemented measures such as mitigating flood risks, increasing raw water capacity, and promoting community involvement in water management.

Despite these efforts, gaps remain in the institutional framework governing water allocation in Java. Local water shortages continue to occur across the island, leading to conflicts among water users (Al'Afghani, 2023; Samekto, 2008; Waskito et al., 2024). These ongoing conflicts are symptomatic of deeper issues within the current institutional arrangements. The persistence of such conflicts indicates that the institutional mechanisms in place may not be adequately addressing the needs and rights of all stakeholders, leading to inequities in water access and usage.

The increasing pressures of climate change are enhancing the severity of these challenges. Java has been experiencing more frequent and severe weather events, such as droughts and floods, straining the already limited water resources even more. These changes underscore the urgency of re-evaluating and strengthening the current water allocation institutions. Without a robust and adaptable institutional framework, Java's water management systems are likely to face even greater difficulties in the future.

The necessity for a comprehensive analysis of Java's water allocation institutions is clear. By identifying and addressing the weaknesses in the current system, it may be possible to develop more effective strategies for managing water resources, reducing conflicts, and ensuring equitable access for all users. This is not only crucial for meeting the island's immediate water needs but also for building resilience against the long-term impacts of climate change. The development of stronger institutions is therefore an urgent priority for sustaining water resources in Java and beyond.

1.4. Highlighting the Necessity of Well-Functioning Water Allocation Institutions and Their Applicability in Java

To ensure sustainable use of a highly demanded natural resource, careful and coordinated management is necessary (Ostrom et al., 1994). In situations where these resources are abundant, users might initially exploit them without much concern for depletion. However, as the resource becomes overused and mismanaged, the strain on water supplies intensifies, leading to scarcity (Ostrom, 1990; Ostrom et al., 1994). In this instance, water scarcity not only threatens ecosystems and livelihoods but also necessitates the establishment of robust mechanisms to govern water use effectively. The need for well-developed and respected agreements becomes paramount in ensuring the sustainable utilization of water resources, particularly in regions where common pool resources (CPRs) like water are under significant pressure.

Elinor Ostrom's work on the governance of CPRs highlights the essential role institutions play in managing resources sustainably. Ostrom et al. (1994) emphasize that as resources become scarce, stakeholders must collaborate to establish rules and guidelines for resource use. These rules, when respected and upheld by all users, can prevent further depletion and even promote the recovery of already strained resources. Empirical evidence supports this notion; in areas where CPRs were notably depleting, the introduction of

effective institutions allowed these resources to stabilize and even recover over time (Asprilla-Echeverria, 2024; Loos et al., 2022; Ostrom, 1990; Ostrom et al., 1994). Therefore, institutions are not just about creating agreements but ensuring their implementation. This approach reduces conflict, increases compliance, and ultimately contributes to the long-term sustainability of the resource.

The limited availability of usable water on Java Island, coupled with a high and growing demand, underscores the necessity for a strong institutional framework. Without such institutions, the risk of over-exploitation and the consequent depletion of water resources becomes significantly higher, threatening the long-term sustainability of the water supply on the island. Despite advancements in infrastructure and technology aimed at reducing water demand, Java still faces a severe challenge in meeting its water needs due to a combination of factors including population growth, groundwater depletion, and climate change.

1.5. Structure of this Research

This thesis consists of a case study regarding irrigation surface water in the Brantas River basin, located in the East Java province in Indonesia. This research consists of an analysis of the formal water allocation institutions and their resemblance to the researched local irrigation water allocation practices. The structure of this thesis is outlined below. Chapter 2 provides a literature research including the necessary definitions, framework, and a review of previous related research. Chapter 3 defines the research questions and methodology, such as the data gathering methods and processing plan, and provides an overview of the interviewee's organizations participating in this research. Chapter 4 comprises an overview of the legal landscape of the surface water allocation sector in Indonesia, portraying the relevant actors in a formal chart. Chapter 5 contains the analysis of the chosen action arenas, including a situation sketch, actor identification and analysis, arena explanation, arena visualization, and arena observations and conclusions. Chapter 6 performs a joint analysis of the previous result chapters and the research discussion, linking this research's findings to existing literature. At last, Chapter 7 provides a research conclusion, policy and science recommendations, and a reflection regarding this research.

2. Literature Review: Institutions and Water Allocation

"For the next several decades, the most important question related to water resource development is that of institutional design rather than engineering design" Ostrom (1993)

Chapter two delves into the foundational literature and frameworks that inform the analysis of water allocation institutions. It begins by exploring previous research on water allocation. The chapter also highlights the role of institutions in water allocation systems. By introducing key concepts like formal and informal institutions and discussing the Institutional Analysis and Development (IAD) framework, this chapter provides the theoretical grounding necessary for understanding how institutional arrangements influence water allocation practices.

2.1. Research on Water Allocation

A quick search on the literature search engine 'Scopus' shows that more than half of the papers regarding water allocation focus on modeling. These models often analyze the river's water fluxes and estimate the river's robustness and resilience to water scarcity (for instance, Dake Xu, 2024; Neumann et al., 2013; Santikayasa et al., 2017). Some of these models are built upon geographical data to predict the location of the water and its demand to find optimal solutions for the allocation of water within a certain predefined area.

A modeling approach can provide insight into the underlying meteorological or geological situation to eventually find optimal solutions for water allocation. Building a model generates a technical understanding of the system's working and intricacies, but often overlooks the smaller, intricate, parts of the system that affect its implementation. These more intricate and overlooked parts are built on the collaboration of people and their interactions, which is in short: the institutions.

2.2. Investigation Previous Research on Water Allocation Institutions in Indonesia

As mentioned in the introduction of this chapter, more than half of the water allocation research is focused on models. In the case of Indonesia, this is no different. Most studies investigate the optimization of water allocation or estimate water supply and demand using various modeling techniques (Mullick et al., 2015; Santikayasa, 2016; Santikayasa et al., 2017; Farriansyah et al., 2018; Limantara & Narulita, 2019; Margini et al., 2024).

Fortunately, also research has been conducted on formal water allocation institutions (for instance: UNESCO-IHE, 2008; Wieriks, 2011; World Bank, 2021; Roestamy & Fulazzaky, 2022; Al'Afghani, 2022, 2023). These institutional analyses can generally be categorized

into two different groups: (1) law and regulation overview and analysis (Al'Afghani, 2023; Al'Afghani, 2022), and (2) an organizational and policy analysis of the water allocation system in Indonesia (Roestamy & Fulazzaky, 2022; UNESCO-IHE, 2008; Wieriks, 2011).

Multiple pieces of research focus on the analysis of water management systems of formal institutions (the laws and regulations), making this domain very well analyzed (Al'Afghani, 2022; UNESCO-IHE, 2008; Wieriks, 2011; World Bank, 2021). On the contrary, a lack of research is conducted on the in-field implementation of these formal structures in Indonesia.

2.3. Analyzing the Role of Institutions in Water Allocation Systems

"Institutions help to understand the physical, economic, and cultural procedures that lead to incentive systems" Ostrom (1993). Institutions structure social, political, and economic interactions in our society and their analysis has repeatedly shown their crucial role in the process leading to outcomes. It is no surprise that institutionalism is emerging across various fields, i.e., political science, economics, politics, and many more (North, 1990; Lowndes, 1996; Mulé, 1999).

2.3.1. Defining Institutions

Across these different fields, different definitions and philosophies of the origin and purpose of institutions started to develop. Polski and Ostrom (1999), building on the earlier work of Crawford and Ostrom (1995) on the "Grammar of Institutions," aimed to capture the complexity of the term 'institutions', irrespective of philosophical orientation. This led them to the following definition: "Institutions are a widely understood rule, norm or strategy that creates incentives for behavior in repetitive situations". As a result, institutional analysis can range from laws to cultural behaviors, as long as it creates an incentive system of repeated interaction. This means that an institutional analysis can have numerous interpretations: i.e. law, responsibility, structural, network, decision-making systems, outcome analysis, etc. (North, 1990; Ostrom, 1990; Gomes & Hermans, 2018a).

2.3.2. Differentiating Between Formal and Informal Institutions

Institutions are classified into two different groups: formal and informal. Formal institutions are seen as explicitly communicated agreements between actors, such as laws, orders, verbal agreements, and promises between friends. Informal institutions on the other hand are not consciously designed nor clearly defined, but are implied rules that we are expected to follow (North, 1990; Lowndes, 1996; Williamson, 1998; Polski & Ostrom, 1999). Informal institutions therefore refer to behavioral customs, cultural norms, and social expectations (Lowndes, 1996).

Institutional analysts generally agree on the definitions of formal and informal institutions, but they differ in their views on the origins and roles of these institutions. Are institutions

solutions to problems from the past or do they improve the comprehensiveness of our interactions (March & Olsen, 1989; Marsh & Rhodes, 1992, p. 196; Lowndes, 1996)? Does their presence lead to higher communicative efficiency or social stability (Williamson, 1998; North, 1990; Lowndes, 1996)?
For an institutional analysis, the origin is not so relevant. Only if someone seeks to initiate institutional reform, does the origin and purpose of institutions become a starting point for change. Even though there are different perceptions of the origins and purpose, there is a consensus that informal institutions are the hardest to change (Lowndes, 1996; Mulé, 1999; North, 1990; Williamson, 1998).

2.3.3. Evaluating Water Allocation Institutions

Institutions are delicate. They are considered effective if they operate in the correct space, time, and function, and manage and balance different interactions (Song et al., 2024). While some posed institutions are crucial for and have improved the management and condition of CPRs, as mentioned in Section 1.3 (Loos et al., 2022; Ostrom, 1990; Wabela et al., 2024; Asprilla-Echeverria, 2024; Ostrom, 1990; Ostrom et al., 1994).

Cosens (2011) identified five adaptive governing principles regarding river governance in the face of uncertainty, which are: (1) multiple overlapping levels of control with one level of control or strong coordination at the relevant social-ecological scale; (2) horizontal and vertical flow of information and coordination of decision-making; (3) meaningful public participation; (4) local capacity building; and (5) authority to respond to changes across a range of scenarios. In addition to Cosen's work, Green et al. (2013) added two more principles after their research regarding water allocation regulation of the EU: (6) monitoring and system feedback, and (7) enforcement.

From an agricultural perspective and with significant overlap with Cosens' and Green et al.'s adaptive governing principles, Ostrom (1993) formulated eight design principles that characterize long-lasting irrigation systems. Instead of focusing on the formal institutional arrangements, focus these design principles on local involvement, namely increasing participation in the management of the CPR and the operation and maintenance of the needed infrastructure. Long-lasting irrigation systems refer to operating systems that have been and still are active for several generations. During such periods, the systems experience all types of stress, needing the flexibility to adapt to changing environments over long periods of time (Ostrom, 1993). The eight principles that are referred to are: (1) Clearly defined boundaries, (2) Proportional equivalence between benefit and costs, (3) Collective-choice arrangements, (4) Monitoring, (5) Graduated sanctions, (6) Conflict resolution mechanisms, (7) Minimal recognition of rights to organize, and (8) Nested Enterprises encompassing values of appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities. In line with the fourth design principle, Asprilla-Echeverria (2024) conducted research on community engagement and the effectiveness of CPR conservation. This research found a stronger positive effect on the

conservation of the CPR if the participants received updated information on the system's progress, creating a feedback loop of information on the community's progress.

2.4. The Institutional Analysis and Development Framework

Frameworks are useful tools to identify elements and relationships, organize information and structure, and compare theories (Ostrom, 2011). The Institutional Analysis and Development (IAD) framework is created to help analysts comprehend complex social situations and compartmentalize the elements into manageable sets of practical activities (Polski & Ostrom, 1999). Which, in this case, is the analysis of institutions and their influence on the outcomes.

2.4.1. Introducing the Institutional Analysis and Development Framework

The IAD framework was first created by Ostrom, Gardner, and Walker in 1994. Since then, the IAD framework has been widely adopted by social scientists to investigate the processes by which institutions emerge and change over time (Cole et al., 2019). Currently, it is widely recognized as one of the leading frameworks in policy science and has seen numerous implementations in the management of CPR (Cole et al., 2019; Weible & Sabatier, 2018). Since its origins in 1994, the framework has seen some structural adaptations, expanding on the initial ideas (Ostrom, 2005). Occasionally has this framework been used in addition to others, such as the Social-Ecological Systems Framework, to offset the weaknesses of both these frameworks. In the case of the IAD framework, it lacks the analysis of specific social and ecological variables that influence social interaction (Cole et al., 2019).

The framework sketches actors who have repeated interactions and try to shape outcomes. This repetition allows the actors to adapt their strategies to yield more positive (in the actor's eyes) outcomes. As this framework analyses the context in which the actors operate, plus their values, norms and motives, the outcomes of the framework are a snapshot of the institutional situation. Out of the snapshot, fallacies, gaps, and ambiguities can be found and changed to provide more efficient, equitable, and sustainable outcomes (Garrick et al., 2018; Gomes & Hermans, 2018b; Nigussie et al., 2018; Ostrom, 2005, 2011; Sifundza et al., 2019).

2.4.2. Outlining the Institutional Analysis and Development Framework

At the center of the IAD framework is the action arena, which consists of the participants and the space in which these participants interact. In Figure 1, the structure of the IAD framework can be seen. The action arena is the conceptual space in which actors inform themselves, consider alternative courses of action, make decisions, take action, and

experience the consequences of these actions (Polski & Ostrom, 1999). In the action situation, participants interact with one another and as a result, it produces outcomes.

These actors are influenced by the exogenous variables that sketch the contextual conditions of the action arena. These variables are: (1) the biophysical/material conditions, (2) the socio-economic conditions, and (3) the rules-in-use. The biophysical/material conditions are related to the physical and human resources providing goods and services, such as climate, technology, condition of infrastructure, sources of finance, etc. Socio-economic conditions are the social ties within each interaction, such as demographic features of the community, social norms, etc. And the rules-in-use relate to the rules that restrict individual behavior, such as laws, regulations, social norms, etc.(Cole et al., 2019; Polski & Ostrom, 1999). These elements influence the actor's perceptions and options and also shape the action arena in which repeated interaction takes place. The outcomes are produced by the repeated interactions of the actors within the action arena, which can be evaluated by evaluative criteria. The outcomes, again, shape the exogenous variables and, therefore, the future participant's behavior.

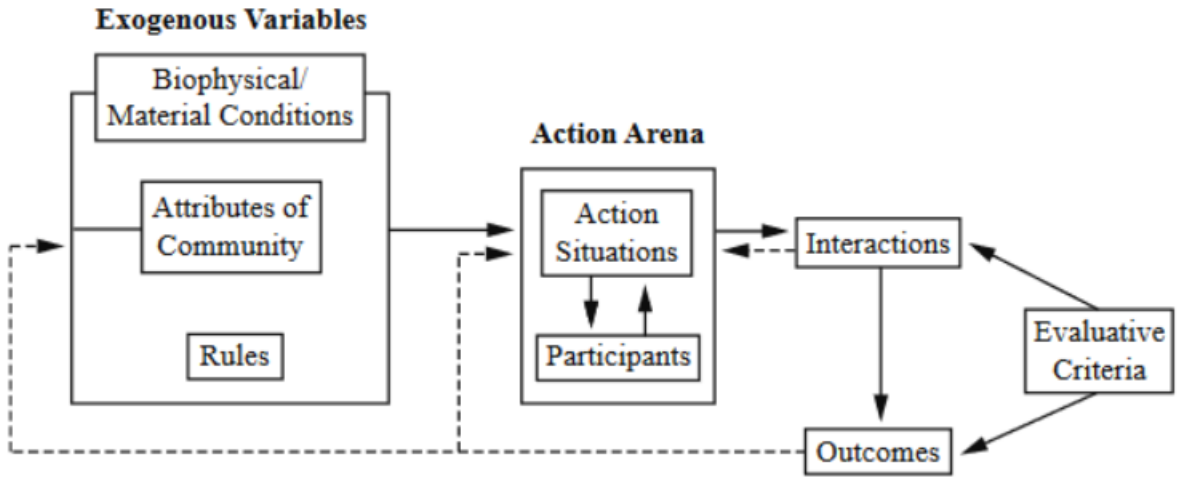

Figure 1. The basic components of the adapted IAD framework. Source from Ostrom (2005, p. 15)

2.4.3. Conceptualizing the Action Arena

Action arena literature was created before the creation of the IAD framework. The first descriptions of the action arena are found in the work of Ostrom (1986). This action arena developed to be the central element of the IAD framework and has seen alternative developments over the years (Hermans & Cunningham, 2018; Janssen & Anderies, 2023; Ostrom, 2005; Polski & Ostrom, 1999).

One way of analyzing the action areas is posed by Hermans & Cunningham (2018). Hermans & Cunningham (2018) put more emphasis on the participants inside the action arena, merging some of the components posed by Ostrom (2005). This makes a

comprehensive situation sketch at the beginning of the analysis very important so that there is no important information missing.

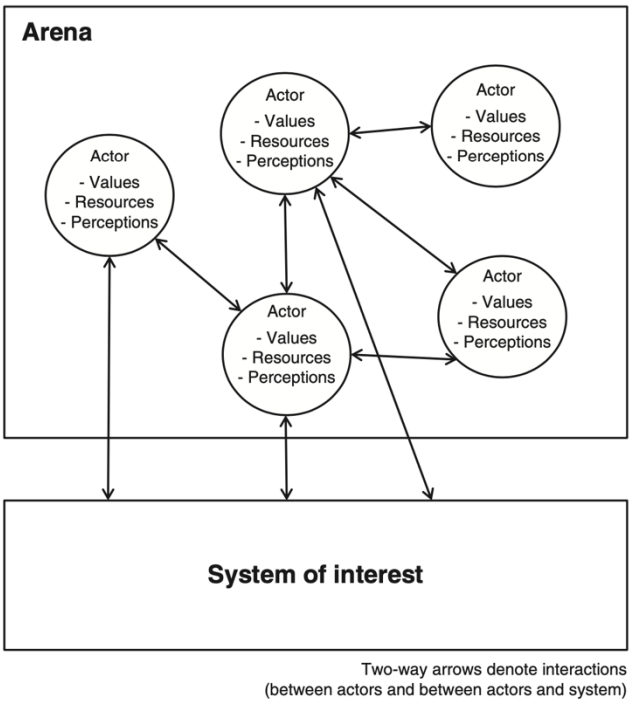

Figure 2. Conceptual framework for action arenas, source: Hermans & Cunningham (2018)

An action arena is divided into two different concepts: the actor level and the network level (Hermans & Cunningham, 2018). The actor level describes the individual components of the actor that are of influence on the action arena: values, resources, and perceptions. The network level focuses on the boundaries that define the action arena, the relationships between the actors, and the rules that influence the behavior of the actors (Hermans & Cunningham, 2018). Here, the relations between actors are based on the interactions of different actors, i.e. legal obligations, sharing information, funds, and resources (Hermans & Cunningham, 2018). Additionally, relations are often based on existing patterns of behavior. Merging the network and actor levels reveals the action arenas in which actors interact and make decisions to influence the outcomes/system of interest. An example of the visualization of an action arena can be seen in Figure 2.

2.4.4. Actors level

As mentioned in the previous paragraph, the actor level consists of multiple components that influence the outcomes of the system. These components are: values, resources, and perceptions. Each of these components portrays a vital part of the interplay of the actors. Let's look deeper into each of these elements to understand their involvement in the action arena and define their concepts.

Values

Each actor's values form the intention and/or motivation behind their actions (Hermans & Cunningham, 2018). Understanding the values of an actor can help to understand their aims and goals, linking reason to action. Unfortunately, values are abstract concepts. Discovering the relevant values can be difficult, even for the actors themselves. To make values more concrete, the focus is put on their expression in the real world. As the actor's objectives are the expressions of the values, this will be used in further analysis (Hermans & Cunningham, 2018).

Resources
Resources are used by the actors to influence their surroundings and other actors. The actor's resources therefore encompass everything that an actor can use to change their outcomes. This includes but is not limited to: physical resources, geographical position, information, networks, social status, legal mandate, financial resources, and (access to) specialized knowledge or skills (Hermans & Cunningham, 2018). The distribution of resources across various actors within the action arena is uneven, providing each actor with a unique set and various degrees of resources.

Perceptions
How participants perceive the world, the problem, and each other greatly affects behavior and decisions. These experiences and views are captured in the 'perceptions' of the actor. These perceptions link the actor's potential actions to their perceived outcomes. The information available to and perceptions of each actor are closely linked. The perceptions are developed by a(n) (un)conscious filter, which interprets the information according to the filter. This filter can highlight or interpret certain information, strengthening the already existing perceptions (Hermans & Cunningham, 2018; Ostrom, 2005; Sabatier & Weible, 2007). On the contrary, perceptions are not permanent and can change. New information can also modify perceptions and change the frame in which an actor perceives and thinks about the outside world (Hermans & Cunningham, 2018). In practice, it is difficult to determine which perceptions are of influence on the decision-making of a participant. the perceptions mentioned can vary widely.

2.4.5. Interconnectedness of the Action Arenas

Action arenas are not only formed in chronological order but can coexist simultaneously. The same actor can therefore also be part of multiple action arenas at the same time, not needing to occupy the same position. Actors can meet each other in different and/or repeating action arenas (De Bruijn & Ten Heuvelhof, 2018). This means that the actors can meet and influence one another in one action arena, affecting and influencing the other. This interaction links action arenas (McGinnis, 2011; Ostrom, 2005). The interconnectedness of these action arenas increases their complexity. Outcomes and/or rules from one action arena can influence another, enhancing complexity whilst simultaneously providing more solutions for posed dilemmas by, for example, drawing on resources or forming coalitions (McGinnis, 2011).

2.4.6. Limitations of the IAD Framework

In addition to the usefulness of the IAD framework, there are also some limitations of the framework.

1. All individuals taking part in an action arena are different, each has their unique values, resources, and perceptions. Mapping all the individual's values, resources, and perceptions can be too time-consuming for research, too vulnerable to

changes, and too complex for analysis. A solution for these problems is to categorize and unify certain participants under an umbrella term, such as organizations, nations, provinces, municipalities, departments, NGOs, etc. Hermans & Cunningham (2018) refer to actors encompassing multiple individuals as 'composite actors'. This categorization is a trade-off, reducing complexity, but increasing comprehensibility and resilience to changes. Introducing organizations as participants can influence the action arena. There are instances where the personal preference of the individual in theory shouldn't matter due to the assumption of neutrality, e.g. law firms vs lawyers. Oppositely, when a group referenced as one is divergent in opinion, it influences the outcome. Such an example is the overarching term of the urban voters for an election. They could be categorized as one group 'urban voters', this group exists of numerous sub-groups, all with their preferences influencing their eventual vote. To categorize all urban voters in one group negatively influences the analysis of the action arena, not capturing their diversity. Therefore, unifying individuals depends on the action situation that is being analyzed and should be carefully considered.

2. The analysis of outcomes poses two different challenges: (1) the method used to predict outcomes to changes that occur in the action arena and (2) the method of evaluation of these predicted outcomes. To begin with the first challenge. No matter the nature of these changes, alternate realities cannot be observed. This means that the only option to deal with this uncertainty of the outcomes of other possible actions is to create experiments and observe them carefully. Unfortunately, even then, the timeline or size can put limitations on the actual outcomes of wide implementation. Second of all, the evaluation outcomes in this regard refer to the overall analysis, not to the perceptions of the participants. Outcomes can be different and differently measured, all affecting the perceptions of the action arena outcomes. The method of ranking significantly influences the outcome of the ranking. Thus, it also influences the perception of the effectiveness of the action (Janssen & Anderies, 2023). Additionally, some outcomes can reveal themselves after implementation, unexpectedly influencing the system.

3. Research Methodology

This chapter introduces the main research question along with its sub-questions, providing the foundation of the study. It also describes the scope of this research, detailing the boundaries and focus areas, followed by an explanation of the research approach and methodology. The subsequent sections delve deeper into the specific research methods.

3.1. Formulating the Research Questions and Scope

The connection between Indonesia's formal institutional structure (laws and regulations) and their on-ground application still has many unknowns. The purpose of this research is to provide new insights into the connection between a formal institutional structure and irrigation surface water allocation practices with the use of the IAD framework as a means of analysis. This is accomplished by analyzing the current formal institutions shaping irrigation surface water allocation and sketching local irrigation water allocation practices to unravel institutions and the connection with these practices. Afterward, the connection between institutions and local water allocation practices will be analyzed, and an answer to the research question can be formulated. This leads to the following research questions:

Main research question:

How do the formal and informal institutions influence irrigation surface water allocation practices in the Brantas River basin in Indonesia?

Sub-questions:

1. *What are the formal institutions that scope the irrigation water allocation playing field inside the Brantas river basin?*
2. *How do different actors interact to shape irrigation water allocation practices and outcomes?*
3. *How are these irrigation water allocation practices influenced by formal and informal institutional factors?*
4. *What are suitable recommendations for policy and science?*

This research focuses on the agricultural sector due to its significant use of surface water resources in Indonesia and its primary reliance on surface water. This research aims to analyze the irrigation surface water allocation institutions through a case study in the Brantas River located in East Java, Indonesia. Additionally, it aims to uncover, understand, and find suitable recommendations for institutional barriers that may hinder the outcomes in irrigation water resources management. In addition, this study identifies various actors and mentions their involvement in basin management. This approach is essential since the issues of the Brantas River are not solely hydrological, but are also embedded in the current institutional framework. This requires alignment between formal structure and actual practices to ensure the effectiveness of future policies and interventions in the management of surface water.

3.2. The Case Study in the Brantas River Basin

The Brantas River basin is a river basin located inside the East Java province, which can be seen in Figure 3. The river flows clockwise between Mount Arjuno and Mount Kelud. From there it stretches to Surabaya (Roestamy & Fulazzaky, 2022). The river basin's agriculture has been one of the most productive and advanced food producers in Indonesia, almost tripling its rice production in the past 50 years (Aldrian et al., 2008; Roestamy & Fulazzaky, 2022).

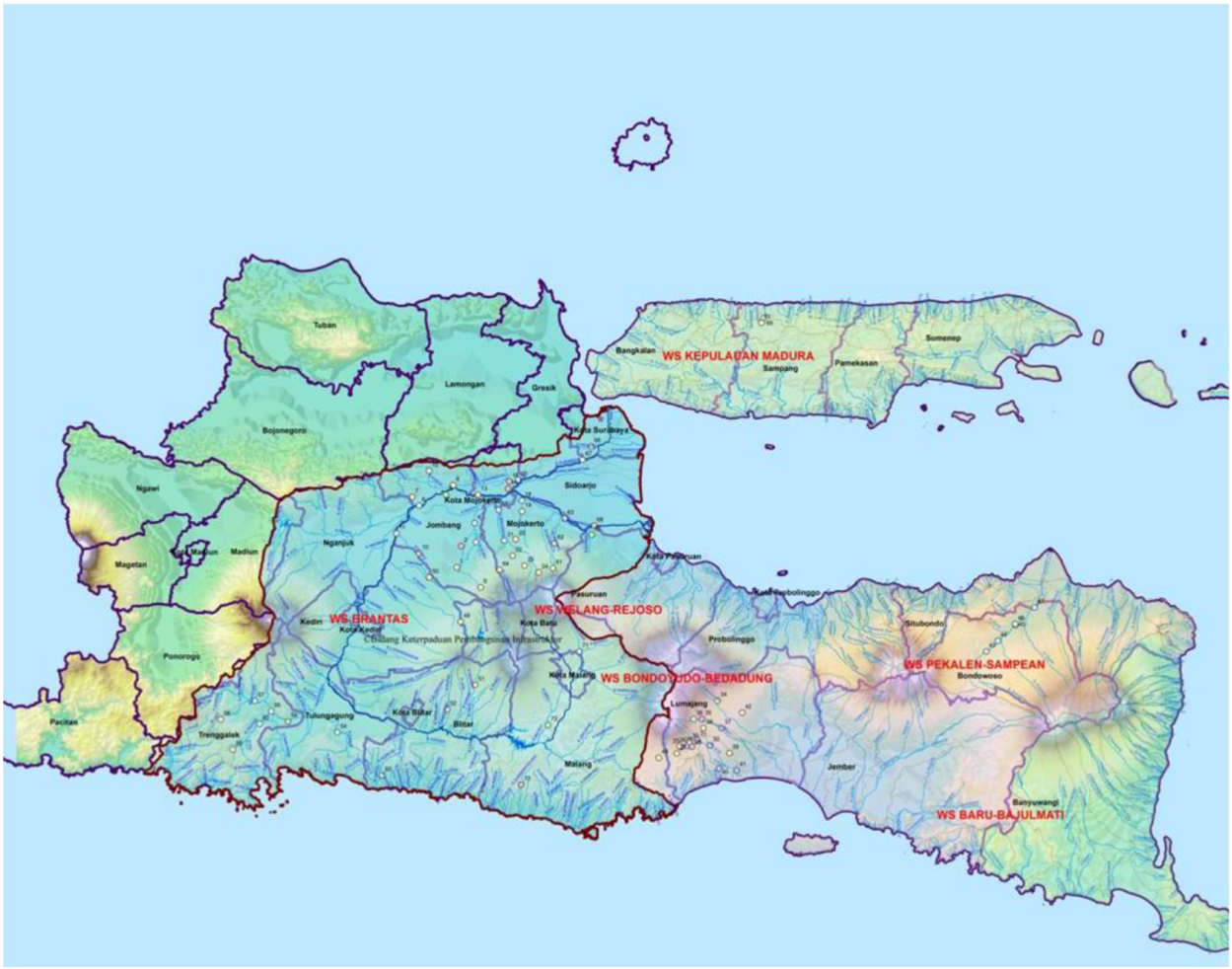

Figure 3. Brantas River basin (shown as WS Brantas) in the East Java province. Source: BBWS Brantas Hydrology Information System (2020)

The Brantas River basin, just like Indonesia, has seen significant population growth in the past decennia. Currently, the river basin contains more than 15 million inhabitants, covering over 40% of the province's population. For more than 50 years, the Brantas River basin has seen numerous physical and institutional changes, including the introduction of various actors as well as an increase in stakeholder participation (Roestamy & Fulazzaky, 2022).

In addition to these regulatory changes, the physical environment has changed, causing solutions and problems in the process. The construction of at least 14 large hydro dams

since 1970 has significantly reduced floods and increased water availability significantly. Unfortunately, the river basin has also seen deforestation and degradation of the upper watershed, lack of sufficient available water resources to fulfill the water needs in the basin, degradation of water quality, increased flood risks, and deterioration and degradation of the infrastructure (M. A. Fulazzaky & Abdul Gany, 2009; M. Fulazzaky, 2014; Roestamy & Fulazzaky, 2022).

3.3. Data Collection Methods

As mentioned in the previous chapters, the focus of this research is on the analysis of institutions. As described in Section 3.2., Institutions can be categorized into two different types: formal and informal. As part of the formal institutional analysis, a formal chart of the actors in the Brantas River Basin will be created as stated by Hermans & Cunningham (2018). This chart helps to understand the role and position of important actors in the irrigation water allocation system within the Brantas River basin. This formal chart therefore portrays hierarchic structures and physical, data, and or legal (inter)dependencies between organizations. Other researchers, such as UNESCO-IHE (2008) & Wieriks (2011), have already created such a formal chart for the Indonesian water sector. The formal chart created in this research is therefore inspired by the previously mentioned ones, is specific to the East Java province, and contains updated information.

Informal institutions, as described in Section 3.2., refer to the implicit rules that individuals are expected to follow. Actors may be conscious or unconscious of these rules, making them difficult to identify. Qualitative data collection methods are an effective way to gain insight into these institutions. Semi-structured interviews are one of these methods and provide a degree of structure while allowing the flexibility to explore contextual details when required. However, this flexibility can result in potential challenges, such as inconsistent and unrepeatable interviews, since each interview may vary even when using the same questions with the same participants at different times. General interview questions were prepared in advance of the interview. These questions form the basis of the structure of the conversation, creating similarities between the interviews and ensuring the usability of the data regarding the IAD framework.

3.4. Qualitative Data Collection and Analysis

The data is collected in the form of semi-structured interviews. This research distinguishes two types of interviewees: (1) experts within the water allocation sector and (2) active field practitioners. The distinction between the two groups is based on a different purpose, as described below. This distinction in purpose led to different questions asked in the interviews. An overview of these questions can be found in Appendix A and B.

The interview methods and interviewee selection process will be elaborated in the next two sections. Common aspects between these different groups were the preparation of the

questions before the interviews, and each interview of the same group had the same interview questions and structure. Additionally, all interviews were conducted in the environment where the participants preferred to meet, which was often from the comfort of their own office, the house of one of the field practitioners, or on top of water infrastructure buildings.

3.4.1. Interviewing Experts

Interviewee selection methods
Regarding the interviews with experts, the interviewees were selected based on two different methods. The first method identifies key organizations within the water allocation sector and experts in their respective water-related fields were asked to participate in the interview. Additionally, some interviewees were selected via the 'snowball method'. In this method, experts would refer to other experts in the field.

Interview methodology:
The interviews were always planned to be one-on-one interviews of around 60 minutes, which often took 90 minutes. The experts interviewed are employees active in various key organizations regarding the water allocation in East Java.

Interview goals
These experts are interviewed due to their broad knowledge of the irrigation water allocation system. These interviews focus on understanding the overall structure and approach of their organization regarding the water allocation system, the organization's participation in the water allocation sector, and obtaining their values, resources, and perceptions. The interview questions for the experts in the water allocation sector can be found in Appendix A.

The goal of the interviews was to gain an understanding of the organization's perspectives on:

- The organization's responsibilities and role within the water allocation sector;
- The organization's collaborations with other organizations and the grounds of this collaboration;
- The dependencies on and of their organization;
- The problems that the organization encounters regarding water allocation implementation;
- The water allocation system in East Java / the Brantas River basin;
- Water scarcity in East Java / Brantas River basin.

These goals were chosen to gain an understanding of the respective organization's formal and informal positions in the water allocation sector and their perceptions regarding their position.

3.4.2. Interviewing Field Practitioners

The selection of field practitioners was different from the experts. During the interviews with the experts, the regional governmental organizations were asked which areas in the province were facing consistent water scarcity. Afterward, these places are approached to organize a group discussion with active field practitioners. These interviews are scheduled to be around 90 minutes.

Irrigation area selection method:
This research specifically searches for irrigation areas in the Brantas River basin. To find irrigation areas to interview, another section has been made based on assumptions. This research assumes that irrigation areas struggling with water availability require local cooperation, leading to developed or still developing decision-making mechanisms/institutions that disincentivize local conflict. Another assumption of this research is that low levels of local conflict originate from well-developed local water decision-making institutions. This assumption is based on the reasoning that, during challenging periods, there is a need for quick access to action arenas to resolve conflicts in a manner that results in satisfactory outcomes for all involved actors. Such access to rapid and effective action arenas can be considered good institutions. These assumptions could provide interesting insights applicable to other locations. This led to the following selection criteria for irrigation areas:

- Consistent struggle with water availability
- Low levels of conflict

If such irrigation areas cannot be found in researched literature, this research has to resort to other means of data gathering. The method employed is to ask, during the interviews with the 'provincial' governmental organizations, the interviewees which irrigation areas in the Brantas River basin struggle with water security and have low levels of conflict. If the interviewees are 'unaware' of the conflict indices of the irrigation areas, they are asked to mention irrigation areas that are consistently known to struggle with water scarcity. The irrigation areas that eventually were selected to participate in this research were selected on: (1) the presence of local conflict, (2) location (within the East Java province), and (3) reachability within the remaining time frame of the project.

Interviewee selection
To gain the most understanding of the internal decision-making processes of the irrigation areas, the field practitioners active in these processes were interviewed. Additionally, to obtain a better perspective of the different layers within these processes, partitioners from different layers in these processes were also included in these interviews. These selection criteria led to the partitioners from the following organizations within each irrigation area:

- Farmers
- Active partitioners or chiefs of multiple levels of water user farmer associations (as described in Section 4.3.

- Operational team members of the irrigation infrastructure

Unfortunately, the researcher was not in control of whom attended these interviews, resulting in participants with other functions joining as well. Another addition to the lack of control was that all field practitioners interviewed were male. As male and female practitioners fulfill different roles, run into different problems, and have different perceptions of the situation, the interviews conducted only paint a partial picture of the total situation/institutions.

Interview methodology:
The interviews were always scheduled to be group interviews of a diverse set of field practitioners active in different on-field organizations. The interviews were scheduled to be around 90 minutes. Often, these interviews extended to a 120 to 150 minutes interview. Some participants arrived late or left after the intended 90 minutes. They also received a small financial compensation for their efforts.

Interview goals
The interviews with field practitioners of irrigation areas focus on understanding some of the local irrigation water allocation practices, in addition to their values, resources, and perceptions. To create some structure in uncovering the local water allocation practices, extra attention was given during the field practitioner interviews to the local internal water allocation plan, irrigation area decision-making mechanisms and structure, responses to sudden water amount changes, and irrigation system maintenance. The interview questions for the field practitioners can be found in Appendix B.

The goal of the interview was to gain knowledge within the respective irrigation area of:

- The interviewees and their roles;
- Characteristics of the irrigation area (size & crops);
- Available water sources;
- The irrigation area-specific irrigation water allocation decision-making structure, dynamics, and participants;
- The internal yearly water allocation plan;
- Mechanisms to respond to changes;
- Their involvement in water allocation decision-making on the river basin level, and their satisfaction with their involvement;
- Their perceived value on attributes related to water management.

These goals structured the interviews in three steps: (1) obtaining general knowledge of the interviewed irrigation area and its agricultural practices; (2) gaining an understanding of their internal decision-making mechanisms and their perceived involvement in the water allocation process at the river basin scale; and (3) understanding their priorities and whether these priorities lean more toward the formal or informal side.

3.4.3. Data Collection Methods

The data collection is divided into two different sections. First of all, the formal institutions shaping irrigation surface water allocation, such as laws and regulations, are analyzed. The result of the relevant laws and regulations shape the framework in which different (governmental) organizations participate. These organizations, together with their connections, are then visualized by a formal chart similar to the ones posed by UNESCO-IHE (2008) and Wieriks (2011).

The other data collection method used is semi-structured interviews. These interviews are aimed at unraveling potential action arenas and gathering data to complete the conceptual framework as described in Section 2.4. A semi-structured interview format was chosen to provide direction for the interviewer while allowing flexibility to deviate from the predetermined questions. This approach helps guide the topics covered during the interviews while also allowing for follow-up questions to obtain more in-depth responses.

The data necessary for the actor-level analysis is described in Section 2.4.4. by the conceptual framework could have been gathered with help from a survey. However, to ensure correct interpretation of the questions and the lack of existing knowledge of this research on potential action arenas creates the need for a more in-depth information-gathering method, such as semi-structured interviews.

Accompanied by gathering data involving human subjects, TU Delft protocols relating to human research ethics have been followed. The Human Research Committee (HREC) of the TU Delft has accepted the application related to this research and the research has been carried out following its application.

3.4.4. Data Coding & Action Arena Selection

Interviewee responses were recorded and written down by the interviewer for later analyses. Saldaña (2009) categorizes the data coding process into two rounds. The first round focuses on the coding of the individual interviews, creating statements and/or categories within the interviews, whilst the second round focuses on the connection between the interviews, revealing overarching themes between interviews.

The first round of data coding was executed following the ‘descriptive method’ as described by Saldaña (2009, p. 70). In this method, individual statements are grouped into categories. The data belonging to the same category is placed together to create structure in the data. The first round of data coding, previously referred to as the ‘interview summary,’ was sent to the interviewee to verify the accuracy of the information and its categories. Interviewees were also given the opportunity to provide additional information, as well as the option to retract specific statements or withdraw their entire interview from the research.

During the second round of data coding, various categories were collected into a central Excel file, following the 'pattern method' as described by Saldaña (2009, p. 152). Since this research separates the interviews into two categories, expert and active field practitioner interviews, due to the differences in guiding questions (as shown in Appendix A and B), data was analyzed within each respective category. The semi-structured nature of the interviews resulted in the data entered into the Excel file primarily consisting of overarching responses to the guiding questions, along with additional overlapping themes identified across the interviews.

Out of the central Excel file, ten potential action arenas were identified. The final selection of action arenas was based on several criteria: (1) the locality of the action arena, (2) the involvement of organizations across multiple layers of government, and (3) the quantity and quality of the data of the action arena. Using these criteria, three action arenas were chosen that reflect local water allocation practices and one speculative action arena was identified regarding the overall functionality of certain governmental organizations.

3.4.5. Interviewed Participants

A total of 14 interviews were conducted for this research, consisting of 10 interviews with larger overseeing relevant organizations such as governmental organizations and four group interviews with active field practitioners. An overview of these interviews can be seen in Table 1. In the field practitioner interviews, some participants held multiple roles simultaneously. Each individual was assigned a number, and all of their roles were represented under that same number.

To ensure the anonymity of the interviewees, only the organizations employing the interviewees are mentioned. The only exemption to this rule is the Ministry of National Development Planning (Bappenas). Due to its overrepresentation and broad role of the organization (which can be read in Section 4.1.4.), this research has chosen to mention the current interviewees' departments to show the diversity of the interviews. More information on the anonymity process can be seen in Section 3.5.5. All the interviewees partake in an active role in shaping irrigation surface water allocation.

Table 1. An overview of the interviewed organizations & field practitioners per irrigation area

Interview	Organization	Department
Organizational interviewees		
1	Ministry of National Development Planning (Bappenas)	Water Allocation
2	Global Water Partnership & Water Stewardship Indonesia	-
3	Ministry of National Development Planning (Bappenas)	Food & Agriculture
4	Ministry of National Development Planning (Bappenas)	Water Allocation
5	Ministry of National Development Planning (Bappenas)	Water Allocation
6	Ministry of Public Works and Housing (PUPR)	-

7	Ministry of Agriculture (MoA)	-
8	RBO active in the Brantas River basin (BBWS Brantas)	-
9	East Java's provincial department of Public Works in Water Resources (Dinas PU SDA Provinsi Jawa Timur)	-
10	Water Services Corporation (PJT1)	-
Field practitioner interviewees		
11	1. Chief of irrigation area and farmer 2. Field coordinator water distribution 3. Member of water distribution team (UPT) 4. 5 out of the 7 chiefs of the second level of irrigation area sub-divisions of the Water Users Farmers Association (WUFA) within the irrigation area (Chiefs of Ghippas) and all are farmers too	
12	1. Chief of the second level of the WUFA within the irrigation area (Chiefs of Ghippas) and farmer 2. Coordinator of technical operational team (UPT) and a third tier division of the WUFA within the irrigation area (Hippa) 3. Member of the operations unit of East Java's provincial department of Public Works in Water Resources (Dinas PU SDA Provinsi Jawa Timur) 4. Member of the survey team of East Java's provincial department of Public Works in Water Resources (Dinas PU SDA Provinsi Jawa Timur) 5. District policy coordinator	
13	1. Chief of third tier of the WUFA within the irrigation area (Chief of Hippa) and farmer 2. Member of third tier of the WUFA within the irrigation area (member of Hippa) 3. One of the chiefs of the first tier WUFA within the irrigation area (chief of Ihippa) and farmer	
14	1. Part of first tier of the WUFA within the irrigation area (Ihippa), head of the second tier of the WUFA within irrigation area (Ghippa), and farmer 2. Head of local weir operations 3. 3 members of the technical operations unit (UPT)	

3.4.6. Ensuring Interviewee Anonymity

To ensure the anonymity of the interviewees, several measures have been taken. First of all, to mitigate the chances of reidentification of the organizational interviewees, it has been chosen to exclude their current department and role within the organization. Regarding the field practitioners, this research mentions the occupation of individuals present in these group interviews, and excludes the names of the irrigation areas. These could function as identifiers when combined with more area-specific information in the rest of this research.

Another method has been taken to ensure the anonymity of the interviewees. All interviewees are assigned a random value. The key to this value is known by the researcher of this thesis and its responsible supervisor. There is a division between the organizational interviews and the field practitioner group interviews. The interviews with (governmental) organizations have obtained a random and mutually exclusive value between 1 and 10, whilst the field practitioner interviews have received a random and mutually exclusive value between 11 and 14.

In Chapter 5, an exception has been made to the use of the randomly assigned numbers to relate to the interviews in Tables 5, 6, and 7. Only the names of the organizations are mentioned concerning statements about the values, resources, or perceptions of the organization itself. This precaution prevents matching randomly assigned numbers to the respective organizations, unraveling the key of randomly assigned numbers.

4. Analyzing the Formal Institutions of the Brantas River Basin Irrigation Water Allocation System

As part of an answer to the main research question, the formal structure that sketches the irrigation water allocation playing field should be analyzed. After Indonesia's independence, the country has been developing its laws and regulations regarding water allocation. In this chapter, a small overview of the history is given, followed by an explanation of the current water allocation laws and their implications. Not all involved laws and organizations will be mentioned and/or analyzed in this chapter, but the ones relevant to irrigation surface water allocation in Java are. Additionally, organizations active in the irrigation water allocation sector are introduced. These actors and the links between them are put into a formal chart in Figure 4 (Section 4.6.), which was adapted from UNESCO-IHE (2008) and Wieriks (2011).

4.1. Indonesian Water Laws and Their Role in Governance

It is essential to understand the context in which Indonesia's water law has developed. This key piece of legislation establishes the foundation for water use in the country and outlines the central government's responsibilities in its regulation and distribution. To gain a deeper understanding, this section will first examine the evolution of this law over time. Afterward, other important laws are introduced and their implications on the irrigation water allocation system.

4.1.1. Tracing the Evolution of Indonesia's Water Law and the Role of Central Government

The Constitution of the Republic of Indonesia in 1945 is the first document in which the responsibility of the Indonesian government regarding water is mentioned. It states that ' the land and the water, as well as the natural resources therein, are controlled by the state and utilized for the optimal welfare of the people'.
To classify the use, distribution, and operations of the water inside their domain to use for the welfare of the people, numerous water resources laws and regulations have been implemented and revised. First, Law #11/1974 On Water Resources was created to act as a framework law that established the principles and objectives of water management, as well as conservation and development (Republic of Indonesia, 2020). This law was revoked after a revision and implementation of Law #7/2004 on Water Resources. After interference of the Constitutional Court in 2005, Law #11/1974 was reinstated from 2015 until the installation of the current Law No.17/2019 on Water Resources. This new law is currently still active and poses the primary framework of the Management of Water Resources (Al'Afghani, 2022) and forms the basis of most aspects of the water resources management in Indonesia.

4.1.2. Defining Water Priorities

In the Court's decision to reinvoke Law #11/1974 in 2015, the Court also established six basic principles of water resources management. These six basic principles form the basis for the prioritization of the different uses of water (Al'Afghani, 2022; Republic of Indonesia, 2023). These prioritizations are summarized as followed by Al'Afghani (2023): (1) basic daily needs, (2) irrigated agriculture, (3) use of water resources for businesses to meet daily basic needs through the Drinking Water Supply System (for example bottled water companies). Only in case of sufficient water availability, water can be allocated to the following: (4) the use of water resources to meet non-business activities in the public interest, and (5) the use of water resources for other business needs that have been licensed.

These priorities show a strong focus of water utilization for the public by points 1, 2, and 3, by investing water in its daily use and food production.

4.1.3. Managing Surface and Groundwater

Indonesia has divided the management of surface and groundwater between different organizations. The Ministry of Public Works and Housing (PUPR) carries responsibility for the management of surface water, whilst the Ministry of Energy and Mineral Resources (ESDM) carries this responsibility for groundwater. According to the regulation of the PUPR (Permen PUPR No.6 2021), the head of the geological agency (ESDM) or their respective regional agencies (usually "Dinas" ESDM) approves the "technical prerequisites". This means that the head of the (regional) ESDM needs to make decisions regarding groundwater management, including permits (Al'Afghani, 2022; World Bank, 2021).

4.1.4. Identifying Governance Levels in the Water Sector

Indonesia recognizes three different levels of administration and governance: (1) national, (2) provincial, and (3) local (Al'Afghani, 2022; Wieriks, 2011). These various levels are separated, and their authorities and responsibilities are defined by a combination of Law No.17/2019 on Water Resources and several decentralization laws and regulations stemming from 1999 and 2004, as well as existing laws prior to 1999 (Wieriks, 2011).

National

In Indonesia, the responsibility of the central government rests on the shoulders of the president of the country, who delegates tasks over to the ministries. The primary ministry in the water sector is the Ministry of Public Works and Housing (Bahasa: *Pekerjaan Umum dan Perumahan Rakyat*, hence called PUPR)(Al'Afghani, 2022). The PUPR is split into several directorates, all having separate tasks. The tasks related to the water sector include regulation of water services in general, regulation and management of (some) of the water resources (including surface water), overseeing National Level River Basin Organizations or (B)BWS (Bahasa: *Balai Besar Wilayah Sungai*). The tasks of the PUPR are mainly directed to

their Directorate of Water Resources. The previously mentioned (B)BWSs are in charge of managing various river basin territories and construction, operation and maintenance of the water infrastructure within their jurisdiction (Al'Afghani, 2022; World Bank, 2021).

Apart from the PUPR, there are other ministries also partaking in the water sector, which are the Ministries of: (1) National Development Planning (BAPPENAS), (2) Environment and Forestry, (3) Agriculture (MoA), (4) Energy and Mineral Resources (ESDM), (5) Ministry of Health, and (6) Home Affairs (Al'Afghani, 2022; Wieriks, 2011; World Bank, 2021).
The Ministry of National Development Planning (hence called BAPPENAS) is in charge of the overall planning and intersectoral coordination of and between ministries, the ministries of Environment and Forestry mainly oversee the "water quality", the Ministry of Health sets standards for and monitors drinking water quality, and the Ministry of Energy and Mineral Resources (hence called ESDM) manages the deep groundwater reservoirs (Permen PUPR No.6 2021, 2021; Al'Afghani, 2022).

Provincial
Similarly to the national level, the provincial level also has a responsible person at the top. At the provincial level, it is the governor, who delegates its tasks to the agencies of the provincial government, which are called "Dinas" (World Bank, 2021). Different Dinases have different portfolios, possibly holding different water-related tasks under their portfolio. Two examples of provincial Dinases that have water resources under their portfolio are Dinas PU and Dinas SDA (*Sumber Daya Air* – Water Resources Management). Each Dinas is divided into directorates working on problems within their responsibilities such as planning, operation and maintenance, etcetera. The distinction of authorization between the Dinas PU and Dinas SDA is not always clearly defined (Wieriks, 2011).

Similarly to the role of Bappenas, the Provincial Development Planning Agency (BAPPEDA - *Badan Perencanaan Pembangunan Daerah*) overlooks other Dinases under the governor. They are responsible for developing (spatial) planning and intergovernmental agency coordination on a provincial level (UNESCO-IHE, 2008). They are involved in the irrigation water allocation sector by formulating the technical policy of the Dinases related to water resources management and they prepare the planning and programming, monitoring, and evaluation of the provincial development planning for the water resources (Djoeachir, 2008). At last, provincial Agriculture and Food Security Offices (*Dinas Pertanian Dan Ketahanan Pangan* – Dinas PKP) support the governor in carrying out governmental affairs in the field of agriculture and food in the province. They formulate the technical policies, implementation of these policies, and the evaluation and reporting in the field of agriculture and food (Dinas Pertanian dan Ketahanan Pangan Provinsi Jawa Timur, 2024). Additionally, they provide consultation to the provincial Irrigation Commission (as later described in 4.4.3.) to match the expected water supply and the according crop.

Local
This level can be split up into two different categories: districts and municipalities. The mayor (*Walikota*) is the head of the municipality, which often encompasses towns and

large urban areas. Districts on the other hand are headed by a head of district (*Bupati*). These districts encompass rural areas and multiple towns. Often the districts deal with irrigation policy and forestry issues whilst municipalities deal with urban water problems and sanitation (Wieriks, 2011). Similar to the provincial level, local agencies under the head of the district or the mayor are called "Dinas" and BAPPEDA. These organizations carry out tasks similar to those of their provincial counterparts but operate at the district level.
In addition to the two different categories stated in this section, one organization can cover multiple districts and/or municipalities. This organization is the local operations unit (*Unit Pelaksana Teknis* – UPT). One UPT unit can cover namely between 2 and 5 different regencies.
Again, similarly to the role of the provincial Agriculture and Food Security Offices (*Dinas Pertanian Dan Ketahanan Pangan* – Dinas PKP), a district Agriculture and Food Security Office is supporting the Walikota/Bupati in carrying out governmental affairs in the field of agriculture and food within the region. They formulate the technical policies, implementation of these policies, and the evaluation and reporting in the field of agriculture and food. Additionally, they provide consultation to the district Irrigation Commission (as later described in 4.4.3.) to match the expected water supply and the according crop.

Responsibilities of different levels of government regarding irrigation areas
Under PUPR Regulation No. 14/PRT/M/2015 (Articles 9, 10, and 11), different sizes of irrigation areas are uncovered by different responsible levels of governments and parties. This can be seen in the table below:

Table 2. Water management arrangements of irrigation area sizes, the exceptions portrayed in 'level', regarding their responsible authority. Table adapted from Al'Afghani (2022, p. 38).

Irrigation Size	Level of jurisdiction	Responsible authority
>3000 ha	Primary and secondary, inter provincial, national strategic irrigation areas	Central government
Between 1000 and 3000 ha	Primary and secondary, inter district / city irrigation areas	Provincial government
<1000 ha	Within one district/city	District/City government
-	Tertiary Network	Water User Farmers Association (*Perkumpulan Petani Pemakai Air* - P3A)

Table 2 shows the different irrigation sizes and their responsible level of authority. The authorities have to manage and maintain the water infrastructure and develop the irrigation systems under their jurisdiction (PUPR Regulation No. 14/PRT/M/2015). Regarding the same regulation, the party responsible for the operation and maintenance of the irrigation systems receives additional authority to open or close weirs, formulate the cropping plan,

formulate the water allocation plan, etc (Al'Afghani, 2022). Usually, the provincial and district/city governments entrust this task to their *Dinas(es)*.

In addition to the responsibility for the operation and management of the irrigation systems to governments, Water Users Farmers Associations (WUFA) also have tasks regarding the irrigation network. WUFAs are tasked with the management and development of tertiary irrigation systems. This is the infrastructure system that links the water from the larger rivers directly to the farmers.

The central government and/or regional government may delegate their tasks regarding these irrigation areas and the responsibility for the water allocation, and operation and management to a River Basin Organization (RBO).

4.2. The Roles of the River Basin Organizations in Water Management

River Basin Organizations (RBOs) are another piece of the puzzle in the water sector in Indonesia. Each River Basin Territory (RBT or *Wilayah Sungai*) is managed by a RBO (Hatmoko, 2010). Depending on the location and its importance to the nation, one RBO can cover multiple River Basin Territories, which can be interprovincial. The existing RBOs can be put into two categories: the public and the corporate RBO. One RBO of each of the two categories is present in the Brantas River basin and fulfills different roles, as elaborated down below.

4.2.1. The Roles of the Public River Basin Organization

The larger National Level River Basin Organizations or (B)BWS ((*Balai) Besar Wilayah Sungai*) are in charge of the management of interprovincial, international, or strategic RBT. These public-utility RBOs are under the supervision of PUPR's Directorate General of Water Resources and are distinguished between Large River Basin Organizations (BBWS – *Balai Besar Wilayah Sungai*) and River Basin Organizations (BWS – *Balai Wilayah Sungai*). These organizations manage the water resources in the larger river basin area and are authorized by the Minister of Public Works and Housing to approve the diversion of river flow (PUPR regulation No. 21 / 2020, Article 3). For the diversion of the river flow, special attention needs to be paid to the following aspects: protection of the river function, maintenance and protection of the existing river infrastructure, maintenance of the sustainability of the water flow, the interest of existing water users, the function of the river, and the entire river morphology aspects (PUPR regulation No. 21 / 2020, Article 4). Based on these aspects is the (B)BWS able to create a water resources management plan, which needs approval from the PUPR.
When an RBT is exclusively within the administrative boundaries of the province or regency and not deemed as a strategic river basin, then the province or regency government is responsible for the management of the river basin delegated to their respective governments (Al'Afghani, 2022).

The irrigation areas are divided into different authorities and so are the tertiary water infrastructure operators. Within their jurisdiction, the (B)BWS, provincial Dinas, and regency Dinas can establish technical implementation units responsible for operating the water infrastructure within their irrigation areas (UPT – *Unit Pelaksana Teknis*) (Al'Afghani, 2022). These units are responsible for the operation and management of the water infrastructure inside the irrigation areas (secondary and tertiary water infrastructure) (PUPR Regulation No. 14/PRT/M/2015, 2015). Larger UPTs cover between two and five regencies (Kabupaten) (Indarto et al., 2017).

4.2.2. The Roles of the Corporate River Basin Organization

In addition to the public-utility RBOs, the Indonesian government established two state-owned enterprises functioning in the water sector. These organizations are tasked with utilizing water resources for commercial purposes to manage the water (Al'Afghani, 2022) and turn profits. As these organizations are state-owned, they must operate within the regulations and legislations written by the Ministry of State-Owned Enterprises. Currently, there are two of these organizations active: Perum Jasa Tirta I (hence called PJT1) and Perum Jasa Tirta II (hence called PJT2). Their distinction can be found in their operation areas: PJT1 covers on Java the Brantas river area, Jratunseluna river area, and Bengawan Solo river from upstream to downstream (located in the Central and East Java province) (PJT1, 2024; Regulation No.46 / 2010, 2010), and PJT2 covers part of Cindanau, Ciliman, Ciluman, Cilujung, Ciliwung, Casadane, and Citarum river (located on West and Central Java) (Regulation No.7 / 2010). The PJT organizations are tasked with operating and maintaining the primary and some of the secondary water infrastructure under their jurisdiction, measuring numerous data points of the river, and providing technical recommendations to water resources managers (Al'Afghani, 2022; Regulation No.46 / 2010, Article 4).

As mentioned in Section 4.2.1., the UPT is also responsible for the operation and management of water infrastructure. So, what is the difference? The PJTs operate the primary infrastructure, linking river and irrigation areas. Depending on the irrigation area, there can be a UPT present that operates the (secondary and tertiary) water infrastructure, linking the main river to towns and towns to farmers. In some irrigation areas under the national government, PJTs also operate some of the secondary infrastructure, leaving the tertiary water infrastructure operations to the WUA.

PJTs and UPT therefore often operate in different zones, but as the PJT manages the larger river's flow and the UPT operates the irrigation area infrastructure, the UPT is dependent on the operations of the PJTs.

4.3. Defining the Structure of Water Users Farmer Associations / (I/G)Hippa in East Java's Irrigation System

Java Island accounts for approximately 46% of the irrigated land in Indonesia (FAO, 2012). Given its significant contribution to the nation's irrigation, coupled with the fact that most farmers manage less than one hectare of land (interview 11), there is a substantial number of water users who require representation in the water management process. To address this need, water users form organizations to represent their interests, resolve issues collectively, and communicate with external organizations. Traditionally, these groups are known as Water Users Farmer Associations (WUFAs), or as referred to in laws and regulations Water Users Associations (P3a - *Perkumpulan Petani Pemakai Air*). The observed structure in East Java consists of multiple levels of WUFAs, referred to as Hippas, Ghippas, and Ihippas (from smallest to largest).
Each irrigation area in Java comprises of plenty small-scale farmers. The smallest form of the WUFA can often be seen within one village, where farmers organize themselves as one so-called Hippa. Within the irrigation area, there are numerous villages containing farmers. Multiple villages are then represented by one Ghippa. As one Ghippa represents still only part of the irrigation area, a collection of Ghippas is generally represented by an Indohippa (Ihippa) Collectively, the structure of these organizations (Hippas, Ghippas, and Ihippas) is referred to in the rest of this research as (I/G)Hippas.

The structure and size of these organizations can vary significantly per region. Typically, a single Hippa contains more than a hundred farmers, each managing less than a hectare of land. One Ghippa may encompass around four or five Hippas and one Ihippa can include around four or five Ghippas. However, each irrigation area can be significantly different. Sometimes this results in a single Ghippa encompassing all farmers within the irrigation area, multiple Ihippas being present within one irrigation area or one Ghippa comprised of just two Hippas,

Within this organizational framework, members of (I/G)Hippas meet regularly to discuss and resolve internal issues, address conflicts, and represent their members' interests. Decision-making within these groups is guided by PUPR Regulation No. 14/PRT/M/2015, which mandates that these organizations are self-assembled and operate based on democratic principles.

These irrigation areas use the WUA (P3A) to discuss various topics related to farming, including internal water allocation, groundwater access, fertilizer compensation, and tertiary irrigation system maintenance. All of the interviews with the in-field practitioners (interviews 11, 12, 13, & 14) indicate that these meetings can become intense, but they all conclude amicably.

4.4. The Surface Water Allocation Framework in East Java's River Basins

In addition to the formal roles of numerous organizations, this section explores the different documents created that drive surface water allocation, demand, intergovernmental coordination, and river basin development.

4.4.1. Introducing the River Basin Territories' Long-Term Development Plans

Development plans have been introduced in Indonesia since 2005 and can be revised every 5 years. This means that the first development plan almost comes to an end. This is also true in the water sector. Often the RBOs are supported by the TKPSDA (Coordination Team for Water Resources Management - *Tim Koordinasi Pengelolaan Sumber Daya Air*). This team is responsible for the creation of the strategic plan (*Pola)* and the master plan *(Rencana) (World Bank, 2021)*. These documents form the basis for the long-term development goals of the river basin (Hatmoko, 2010). Not every RBT has its own Pola or Rencana, but these documents of one river basin can also be applied to multiple RBTs. These documents are created regarding the entire river basin, possibly encompassing multiple RBTs.

4.4.2. Outlining the Annual and Short-Term Water Allocation Plan (RAAT & RAAR) for River Basin Territories

Apart from the development plans posed by the TKPSDA, there is also the general annual water allocation plan (RAAT – *Rencana Alokasi Air Tahunan*) of the river basin created by the respective (B)BWS of the RBT. This plan divides the predicted amount of water amongst the irrigation areas and districts and uses the rainfall predictions of the Meteorology, Climatology, and Geophysical Agency (BKMG – *Badan Meteorologi, Klimatologi, dan Geofisik*) to estimate the surface water availability. *In addition* to the weather predictions the RAAT also takes other data into account: annual water allocation scenarios, water budget plans, cropping plans, implementation plans, and monitoring plans (Al'Afghani, 2022). Afterward, this data is used to create the RAAT, which is in accordance with the *Pola* and *Rencana* of the TKPSDA. If the RAAT is approved by the PUPR (Which is the parent organization of the (B)BWS), then the RAAT divides the expected water in the river amongst irrigation areas, districts, and other water users. Irrigation areas can apply for water via the irrigation committee, which calculates the water needs of the region with the created annual cropping plan (RTTG – *Rencana Tata Tanam Global*). The different processes of the creation of the RTTG are described in Section 4.4.4.

Reallocation of this already approved RAAT is possible through the 10-15 day water allocation plan (RAAR) (Annual Water Allocation Plan Module (PUPR 2017) Module 06). The respective (B)BWS has the authority to reduce, increase, or rotate the water supply under

the condition that the previously proposed water plan cannot be implemented due to: (1) lack of water availability due to natural causes, (2) unforeseen damage to water source or water infrastructure and (3) other factors based on the Minister or regional heads (Al'Afghani, 2022).

4.4.3. Impact of the Irrigation Water Demand by and Creation of the Annual Cropping Plan

As 80% of the surface water is used for irrigation (World Bank, 2021), choosing which crops to plant can have a huge impact on the water demand. Some crops are more water-intensive than others, making the cropping plan impactful in periods of water scarcity.

Different levels of authorities, as described in Table 2 (in Section 4.1.4.), have different systems to create the cropping plan. If an irrigation area falls under the jurisdiction of the regency government, the regency has its own Irrigation Commission (IC - *komisi irigasi*). Similarly, if the irrigation area is managed by the provincial government, it falls under the provincial IC. The East Java province has one IC responsible for the creation of the RTTG of each irrigation area. This process involves considering the previous year's river discharge data and coordinating with local farmers. If an irrigation area falls under the jurisdiction of the national government, the process of creating the RTTG is slightly different. They do not use a distinct organization tasked with the creation of the RTTG and other tasks related to farming practices, such as the IC. Instead, the (B)BWS (River Basin Organization) is responsible for making these decisions and coordinating them with other various organizations involved.

In the Brantas River basin, the provincial IC and all of the regency ICs, BBWS Brantas and Dinas PU SDA (provincial Dinas responsible for the management of the water resources within the province of East Java) come together in a meeting organized by the TKPSDA. In this meeting, they coordinate their proposed RTTGs and discuss the water availability and its suitability to the TKPSDA's master plans (*Pola* and *Rencana*). After this, the IC coordinates with the MoA on which water levels correspond to which crops, creating the RTTG as posed to the farmers.

All the organizations responsible for the RTTGs of irrigation areas (regency ICs, the provincial IC, and BBWS Brantas) come together in the TKPSDA to coordinate their proposed RTTG to shape the water demand of the irrigation sector. Afterward, the IC coordinates with the Ministry of Agriculture (MoA) to match water levels and predictions with appropriate crops, finalizing the RTTG before presenting it to the farmers.

4.4.4. Examining the Role of the Intergovernmental Coordinating Body in Water Resource Management

The name TKPSDA (Water Resources Coordination Team – *Tim Koordinasi Pengelolaan Sumber Daya Air*) has been appearing in this chapter often enough. Let's specify their role within the allocation system. In addition to its tasks regarding the creation of the strategic plan (*Pola)* and the master plan *(Rencana),* the TKPSDA also functions as an intergovernmental coordination team that involves stakeholders in the water resources management sector (Asian Development Bank, 2016; Houser et al., 2022; World Bank, 2021). They were established in December 2010 and legalized by PUPR Ministrial Decree No. 594/2010. They coordinate the creation of multiple documents such as the RAAT and the coordination of the RTTG, as mentioned in Sections 4.4.2. and 4.4.4. respectively. Additionally, they also provide a platform for organizations such as the (B)BWS, PJT1 or PJT2, provincial and district Dinases, and the provincial and district IC to coordinate their plans.

4.5. Describing Individual actors involved in Irrigation Surface Water Management and Allocation in the Brantas River Basin

Before sketching a formal chart containing all relevant actors and their links, it is useful to define the responsibilities of these organizations and on which regulation/legislation this is based.

As this research focuses on the Brantas River Basin, located in the East Java province, only the actors relevant to the case study are mentioned. In East Java, the only RBOs active within this area are the: (1) BBWS Brantas, and (2) PJT1. In the province of East Java, the Dinas PU (*Pekerjaan Umum* – Public Work) and Dinas SDA (*Sumber Daya Air* – Water Resources) are combined into one organization named: Dinas PU SDA. This organization takes over the responsibilities of the provincial government regarding water allocation, water infrastructure, and irrigation areas between 1000 and 3000 hectares.

Additionally, the ministries of Energy and Mineral Resources (ESDM) and the Ministry of Forestry and Environment are not included in Table 3 and the formal chart in Figure 4, as their responsibilities regarding water, are outside of the focus of the allocation of irrigation surface water. Here, ESDM manages the groundwater (Permen PUPR No.6 2021, 2021) and the Ministry of Forestry and Environment is responsible for the water quality, which are both outside of the scope of the research. Table 3 below portrays the relevant actors and is categorized by the three different levels of governance: (1) national, (2) provincial, and (3) local.

Table 3. Specification of involved organizations regarding the irrigation surface water allocation sector in the Brantas River basin.

Organization	Responsibilities related to irrigation water allocation
Organizations operating on National Level	
Ministry of Public Works and Housing (*PUPR*)	- Responsible for the 37 RBOs, who are tasked with allocating the water within their jurisdiction - Regulates the distribution infrastructure, connecting water provider and end user - Approves the RAATs created by the RBOs - Planning and programming of the water resources management development (UNESCO-IHE, 2008) - Provides technical guidance, supports policy reforms and monitors project implementation (UNESCO-IHE, 2008) - Carries responsibility for the BBWS Brantas (UNESCO-IHE, 2008)
Ministry of National Development Planning (*BAPPENAS*)	- Oversees the performance and development plans of all ministries (PUPR, ESDM, etc.) (UNESCO-IHE, 2008) - Coordinates organizations involved in the water sector involved organizations and synchronizes water resources related programs (UNESCO-IHE, 2008) - Formulates water resources management policy and development planning (UNESCO-IHE, 2008) - Oversees and guides the regional agencies of BAPPENAS (BAPPEDA)
Ministry of Agriculture	- Creates National level Agricultural Policy (World Bank, 2021) - Focusses on food production, farmer welfare, sustainable agriculture, and economic development through agriculture (World Bank, 2021)
Ministry of Home Affairs	- Oversees and guides the Governors
Ministry of State-Owned Enterprises	- Oversees all state-owned enterprises (PJT1 & PJT2) and creates legislation in which these organizations must operate
Organizations operating on provincial or cross-provincial level	
BBWS Brantas	- manages the water resources in the river area (PUPR regulation No. 21 / 2020) - Creates the RAAT and RAAR for the Brantas River basin (PUPR regulation No. 21 / 2020) - Has authority and responsibility to carry out development and management of primary and secondary water infrastructure of the irrigation areas inside their jurisdiction (irrigation areas >3000 ha + specified exemptions in table 1) (PUPR Regulation No. 14/PRT/M/2015)

PJT1	- Responsible for providing water to users in utilizing surface water, operation and maintenance of water resources infrastructure that brings benefit to the people, and providing technical recommendations and advice to water resources managers (Al'Afghani, 2022). - Partially manages the water resources duties, and including amongst other operations of the water resources infrastructure, preventative and regular maintenance of water sources, river preservation and monitoring and evaluation of water quantity and quality. Their working area covers the Brantas river area and the Bengawan Solo River, from upstream to downstream (Regulation No.46 / 2010, Article 3) - Operates and maintains the primary and secondary water networks (PUPR Regulation No. 14/PRT/M/2015)
TKPSDA	- creates the strategic plan (*Pola)* and the master plan *(*Rencana) - Functions as an intergovernmental coordination team that involves stakeholders in the water resources management sector (Asian Development Bank, 2016; Houser et al., 2022; World Bank, 2021) - Coordinates organizations related to water resources management (Asian Development Bank, 2016; Houser et al., 2022)
Governor	- Acts as the representatives of the central government (Ainuddin & Sarkawi, 2023; UNESCO-IHE, 2008) - Coordinates provincial government agencies (UNESCO-IHE, 2008; World Bank, 2021)
Dinas PU SDA	- Manages the tasks attributed to the agency through decentralization - Manages and maintains the water infrastructure and develops the irrigation systems under their jurisdiction (irrigation areas between 3000 ha and 1000 ha + specified exemptions in table 1) (PUPR Regulation No. 14/PRT/M/2015)
Provincial Development Planning Agency (*BAPPEDA*)	- Responsible for development planning, spatial planning and intergovernmental agency coordination on provincial level (UNESCO-IHE, 2008) - Formulates technical policy in the water resources sector for regional development planning (Djoeachir, 2008) - Prepares planning, monitors and evaluates regional development planning (Djoeachir, 200s8) - Oversees and guides the district and municipal agencies of BAPPEDA

Provincial Dinas PKP	- Formulates technical policies in agriculture and food (Dinas Pertanian dan Ketahanan Pangan Provinsi Jawa Timur, 2024) - Implements policies, evaluations and reporting in the field of agriculture and food (Dinas Pertanian dan Ketahanan Pangan Provinsi Jawa Timur, 2024) - Provides support to the provincial IC
Organizations operating on a regency or cross-regency level	
District Chief (*Bupati / Walikota*)	- coordinates district or municipal government agencies
Dinas responsible for management of water resources within a district	- manages and maintains the water infrastructure and develops the irrigation systems under their jurisdiction (irrigation areas smaller than 1000 ha) (PUPR Regulation No. 14/PRT/M/2015)
District BAPEDA (planning board)	- Responsible for development planning, spatial planning and intergovernmental agency coordination at district level (UNESCO-IHE, 2008) - formulates technical policy in district development with respect to water resources (Djoeachir, 2008) - prepares planning and programming, monitors and evaluates district development planning for water resources (Djoeachir, 2008)
District Dinas PKP	- Formulates technical policies in agriculture and food (Dinas Pertanian dan Ketahanan Pangan Provinsi Jawa Timur, 2024) - Implements policies, evaluations and reports in the field of agriculture and food (Dinas Pertanian dan Ketahanan Pangan Provinsi Jawa Timur, 2024) - Provide support to the district IC
UPT	- Can be created by the responsible authority of the irrigation area (BBWS Brantas, Dinas PU SDA and the district Dinas responsible for water allocation management) (Indarto et al., 2017) - Can encompass between 2 and 5 different regencies (Indarto et al., 2017) - Responsible for the operation and management of the tertiary irrigation system / infrastructure (PUPR Regulation No. 14/PRT/M/2015)
Water Users Farmers Associations (WUFA)	- self-assembled organizations of the water users (usually within one irrigation area), and the organization is based on democratic principles (PUPR Regulation No. 14/PRT/M/2015, Article 1)

	- responsible for self-distributing water within their irrigation areas (PUPR Regulation No. 14/PRT/M/2015) - operates and maintains the tertiary water infrastructure, linking river to farmer (PUPR Regulation No. 14/PRT/M/2015)
Irrigation Committee (Komisi Irigasi)	- Has to coordinate and communicate with the Water Users Association associates (PUPR Regulation No. 14/PRT/M/2015) - District/city IC is a coordination and communication institution between representatives of the regency/city government, representatives of the association of farmers using irrigation area, and representatives of irrigation network users in the district/city (PUPR Regulation No. 14/PRT/M/2015)

4.6. The Formal Chart of the Actors and Connections in the Irrigation Water Allocation in the Brantas River Basin

From the previous sections of this chapter, a formal chart is created, which is adapted from the formal charts created by UNESCO-IHE (2008) and Wieriks (2011) and modified for the irrigation water sector. This chart links the relevant organizations, as described in Table 3, that shape the irrigation water allocation in the Brantas river basin. All the different ministries and the organizations under their supervision are portrayed in the same color. Additionally, to create a clearer visualization, the UPT and the Irrigation Commission received multiple organizations in one. The UPT can be created by the organization responsible for the irrigation areas: BBWS Brantas, the provincial Dinas PU SDA, and the District Dinas. All of the UPT organizations are put in the same block. For the ICs, this is similar; the province has just one IC, which is responsible for all the irrigation areas under their jurisdiction, and all the irrigation areas under the jurisdiction of the district governments also all have one Irrigation Commission responsible.

The links between the different actors in Figure 4 are defined by the abbreviations stated in Table 4.

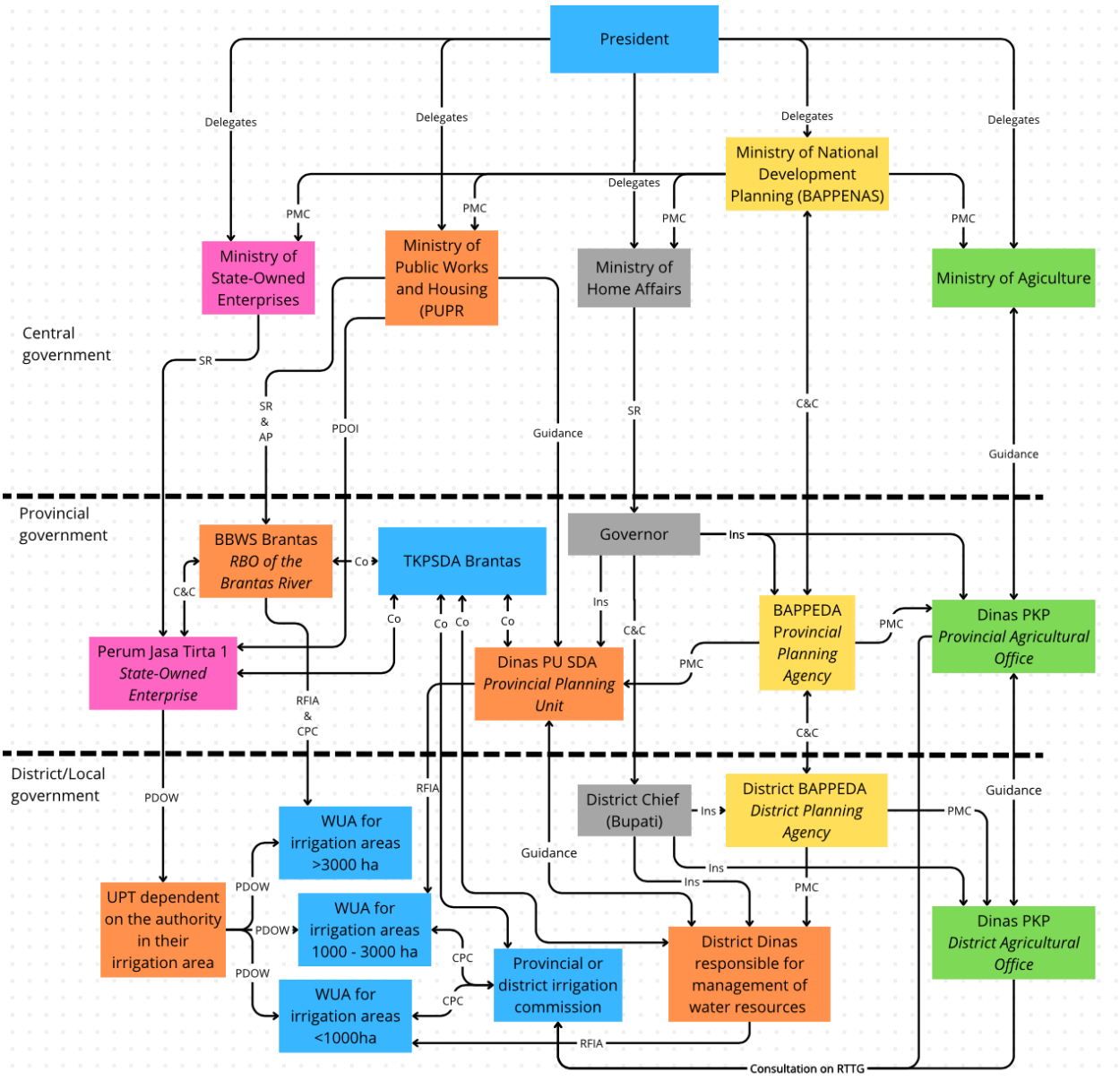

Figure 4. The formal chart of the irrigation surface water allocation system specified to the East Java province. This image is adapted from UNESCO-IHE (2008) and Wieriks (2011). (As seen in this visualization, the colors portray the overarching organizational structure, with the corresponding ministries at the top; only blue has no overarching ministerial connection.)

Table 4. Abbreviations explaining the type of connections between different actors in Figure 4.

Abbreviation	Definition	Explanation
AP	Approves Plans / Approves Proposals	Approves plans of the dependent organization for further execution
C&C	Consult and coordination	Consult and coordination between actors to discuss and coordinate their actions
Co	Coordination	Coordinate plans of all connected stakeholders regarding water management
CPC	Crop Plan Coordination	Carries responsibility regarding the creation of the annual crop rotation plan (RTTG) for the irrigation area
-	Delegates	Delegates tasks to other actors
-	Guidance	Provides guidance in direction and operation of tasks
Ins	Instructs	Instructs organizations due to their responsibility on the appropriate governance level
PMC	Plans, Monitors, and Coordinates	Plans, monitors and coordinates other (governmental) organizations (on the same governance level)
PDOI	Physically Dependent on Infrastructure	The actor to which the arrow points to is dependent on the specific infrastructure provided by the other organization for use
PDOW	Physically Dependent on Water	The actor which the arrow points to is dependent on the other organization to manage the water correctly
RFIA	Responsible for Irrigation Area	Responsibilities: manages and maintains the water infrastructure and develop the irrigation systems under their jurisdiction
SR	Sets Regulations	Sets regulation for the other organization to which they have to adhere to

5. Analyzing Local Irrigation Water Allocation Practices with the Help of Action Arenas

With the help of the interviews (with organizations related to the water sector and with the focus group discussions in the irrigation areas), some action arenas regarding water allocation on the field level are constructed. These action arenas are constructed in the view created during the interviews and aided by other research papers. The action arenas analyzed in this chapter are selected as described in Section 3.4.4.

5.1. Action Arena 1: Farmers Deciding Which Crops to Cultivate

Situation sketch: Every year, farmers experience three farming cycles (Regency of Sukoharjo, 2017). Farmers have to choose which crops to cultivate as a new farming cycle approaches. Each crop is different and has specific wants and needs. Seasons provide changes in the climate, making some crops more suitable than others. Especially during dry season, farmers need to choose their crops carefully. Planting water-intensive crops in the presence of a water shortage has disastrous consequences for the crop and farmer.

As discussed in Section 4.4.3, the organization responsible for advising farmers on their crop rotation choices (the proposed RTTG) depends on the authority overseeing the irrigation area. This advisory RTTG is developed by the respective provincial or district Irrigation Committee (IC) or the BBWS and should be formulated in consultation with representatives from the (I/G)Hippas (Supadmo Arif et al., 2017). The primary data used for constructing the proposed RTTG comes is the previous year's discharge data of the relevant river.

Once the RTTG specific to the irrigation area is developed, it is submitted to BBWS Brantas, the organization responsible for water allocation within the Brantas River basin. BBWS Brantas consolidates all water requests from the irrigation areas and constructs the RAAT based on the rainfall data predictions of the BMKG and in coordination with other organizations, such as in the TKPSDA meetings, as detailed in Section 4.4.2. After approval by the Ministry of Public Works and Housing (PUPR), the RAAT is distributed to the executive organizations for implementation and the irrigation areas.

After the RAAT and RTTGs have been distributed, it is up to the irrigation areas to allocate the water internally. Indonesia has a tropical climate. Water is abundant during the rainy season and scarce during the dry season, making it only necessary to discuss an internal water allocation plan for the dry season. This behavior is observed in all four interviewed irrigation areas (interviews 11, 12, 13 & 14). As the dry season approaches, the representatives of their (I/G)Hippas meet to discuss an internal water allocation plan. Different irrigation areas have the autonomy to create their own water allocation plan, but just slight variations were found. The main differences were observed in the invitees of the meeting and the structure of command. Some irrigation areas (interviews 12 & 13) function

in a hierarchical structure where the members of the Ihippa (who are also the heads of the Ghippas) allocate the water per Ghippa, who in turn allocate the water to the Hippas, down to the farmers. Other irrigation areas (interviews 11 & 14) invite all representatives of the Ghippas and Hippas to discuss the situation and allocate the water together. Conversely, all irrigation areas invite employees from various organizations (for example, operational units such as UPT, the responsible authority of the irrigation area, the BBWS if not already included, MoA, Ministry of Environment, heads of villages, and potential industries in the area) to generate valuable information to support their decisions. The exact organizations invited depend on the irrigation areas and the circumstances.

In all the meetings, the representatives of the (I/G)Hippas have a chance to address reoccurring issues inside their operational territory (often associated with unfair water distribution between Ghippas or Hippas). Mentioning these issues provides opportunities for all invitees to discuss and find communal solutions (such as compensation with more water allocated to these disadvantaged regions). These meetings often can get heated and emotions are high. Screaming at and blaming one another is common practice (interviews 11, 13 & 14). All invitees obtain one vote in the communal decision-making, and the plan with the most votes wins (interviews 11, 12, 13 & 14). After these meetings are over, the representatives mention reconciling their differences and are even observed during these interviews to be making jokes with one another.
The outcomes of these meetings are the water allocation plans of the irrigation areas during that year's dry season, comprised of a plan to allocate the water within certain periods to one section of the irrigation system, taking around a week before the same irrigation area receives water again.

After these internal irrigation area meetings, the farmers can estimate the amount of water they will receive and the farmers can choose their cropping plan. The farmers view the posed RTTG by the IC as a guideline (interview 11 & 13). Previous research has shown that farmers deviate from this plan around 15% of the time (Subandiyah, 2011). That farmers occasionally deviate from the RTTG is also confirmed in this case study by interviews 11, 12 & 13 in East Java. Often, the deviation results in planting more water-intensive crops, as these crops provide a higher financial yield on the market. These deviations from the plan are seen as 'the responsibility of the farmer' (interviews 11, 12, 13 & 14). The farmers deviating from the posed RTTG are not punished, nor do farmers upholding the RTTG receive special treatment during water-scarce periods (interviews 11, 12). Farmers deviating from the posed RTTG take a risk, potentially losing (part of) their crops in exchange for higher financial returns. However, if all farmers were to cultivate more water-intensive crops during the dry season, there would likely be insufficient water for all the crops to survive.

One of the critiques on the RTTG mentioned in interview 11 is that the proposed RTTG generates underwhelming amounts of revenue for the farmers to fulfill their livelihoods. The same interviewee mentions "farmers are economic maximizers", which is the reason why

farmers deviate from the proposed plan. A visualization of the action arena with the involved actors can be seen in Figure 5.

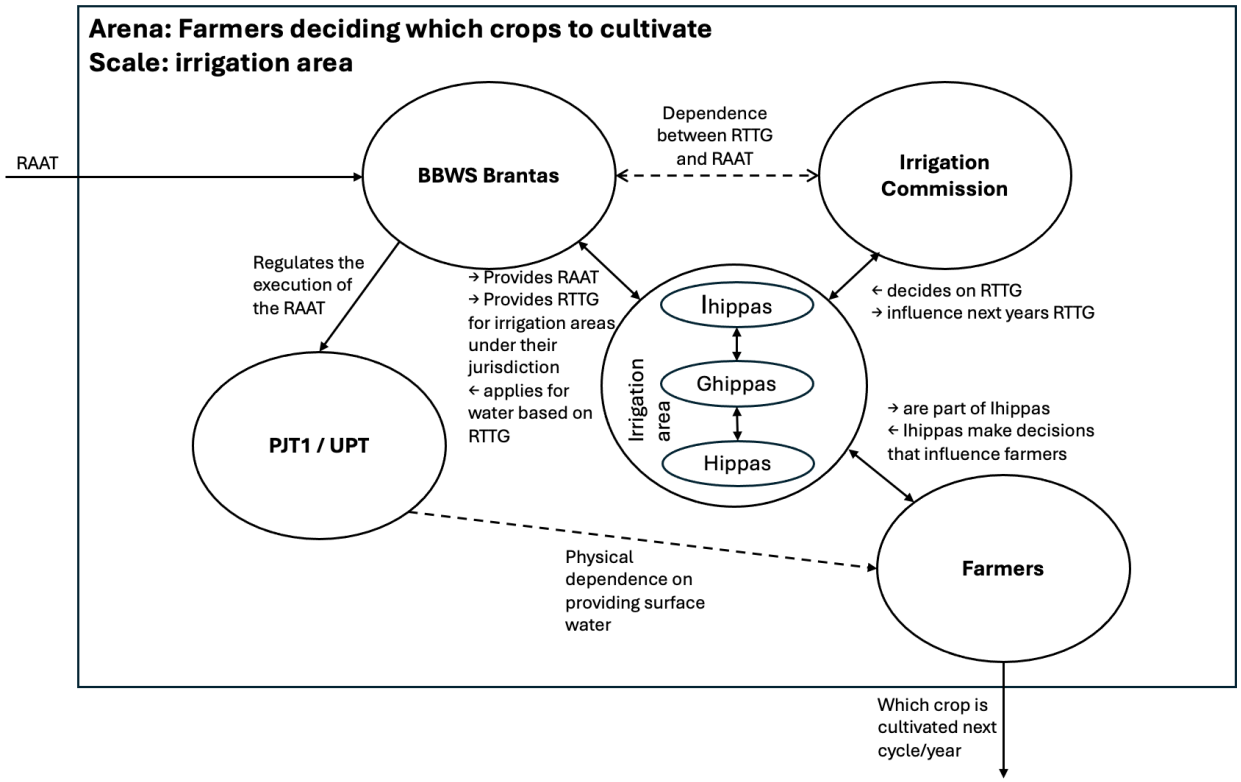

Figure 5. Farmers Choosing Their Crops. This figure shows the involved actors influencing the system in how farmers eventually choose which crops to cultivate. The dotted lines indicate the presence of a dependency.

5.1.1. Arena Description and Actor Identification

Analyzing the situation sketch, five different actors are identified: (1) BBWS Brantas, (2) IC / MoA, (3) the (I/G)Hippas, (4) the farmers themselves, and (5) PJT1/UPT. BBWS Brantas is the organization that proposes the RAAT, influencing the risks for and amounts of water towards each irrigation area. This document is influenced by the RTTG, which is decided on by the irrigation committee/Ministry of Agriculture with influence from the (I/G)Hippas from the irrigation area, who in turn are invited to partake in the new RTTG proposal. After the RTTG is approved, the document finds its way to the farmers via the (I/G)Hippas. Each farmer decides for themselves if they implement the proposed RTTG or if they alter it to their own needs and objectives. Even though PJT1 and UPT are not included in the decision-making itself, they fulfill an important role, delivering the water to the farmers. Due to their similarity in role (operating infrastructure) and that the BBWS Brantas influences their actions by creating their regulatory framework, their organizations are represented as one group.

The two other actors mentioned in the situation sketch and not seen as actors are the PUPR and the BKMG. These actors are involved in another action arena involving the RAAT decision-making and approval process. The RAAT action arena significantly influences this action arena but is considered different. The RAAT action arena is not analyzed in this research, but its outcome is portrayed by the actor BBWS Brantas and its links.

5.1.2. Actor Values, Resources, and Perceptions

Table 5. Actors, partaking in the action arena related to farmers deciding which crops to cultivate, their values, resources, and perceptions. Everything italic inside this table is based on educated guesses and has no literature backup and/or is not mentioned in one of the interviews.

Actor	Values	Resources	Perceptions
BBWS Brantas	*Allocates available surface water fairly across water users inside their jurisdiction*	Creates the RAAT (interview BBWS), Regulates the execution of the RAAT by the PJT1 (interview BBWS)	Some areas are disappointed with the RAAT results wishing for more (interview BBWS), *Surface water is a limited resource, meaning that assigning more water to one there is less for the rest,* RAAT has a strong correlation on weather data provided by BMKG (Al'Afghani, 2022)
Irrigation Commission (IC)	*Reaches the crop production targets, and improve on the current climate condition without reducing crop production*	provides the eventual RTTG, which should be implemented by the farmers (Supadmo Arif et al., 2017).	There are differences between posed and implemented RTTG (interview 1, 11, 12 & 13). *Collaboration of the farmers in the RTTG helps increase compliance of the farmers. Farmers are the ones creating Indonesia's crop production, therefore an essential link to obtaining the crop production targets*, RTTG is based on discharge data from respective river from last year (Supadmo Arif et al., 2017).
(I/G)Hippas	Helps farmers to prosper (interview 11), *represent farmers' interest as best as possible*	Influences next year's RTTG (Supadmo Arif et al., 2017)	*Is aware of the farmer's problems such as poverty and lack of water*
Farmers	Secures livelihood with farming activities and maximize profits (interview 11)	Has own volition to choose their crops (interview 1, 11, 12 & 13), additionally they are involved in next year's RTTG proposal	RTTG is a guideline (interview). In farmer's experience is initial RAAT an overestimation of the water that they will receive (interview 12 &13). Farmers are poor. Cannot secure livelihood with proposed RTTG, 'forcing'

		(Supadmo Arif et al., 2017)	them to take risks with planting more water intensive crops (interview 11).
PJT1/UPT	Executive organization of the RAAT (interview PJT1), *strive towards providing all water users within their responsibility with the predetermined correct amounts of water*	Operates the water infrastructure, regulating the flow of the water (interview PJT1). UPT operates the tertiary water infrastructure inside the irrigation areas (interview 13)	Received funds for maintenance is too little to suffice all needs and often have to ask the central government for more (interview PJT1). They also notice that the farmers do not uphold the RTTG, which is one of the reasons the irrigation sector uses more water than expected (interview PJT1). The condition of the tertiary infrastructure is in bad condition. This condition reduces the water availability due to leakages and more (interview PJT1).

5.1.3. Arena Inputs and Outputs

The input of this action arena is the RAAT, dividing the available surface water across the interested water users.

One of the outputs of this action arena is the farmer's crop cultivation, influencing the water demanded, used, and risks the farmer takes considering failed crops.

5.1.4. Arena Observations

Interesting is the difference in data usage for the creation of the RTTG and the RAAT. The RAAT is created with the weather predictions of the BMKG, whilst the RTTG uses previous years' river discharge data. As already mentioned in the situation sketch, the previous and next year's weather can be significantly different. This difference in data usage can create an inequitable allocation of water amongst irrigation areas and a difference in expected water usage and water availability.

Additionally, there is a gap between the creation of the posed RTTG by the ICs and the farmers. This gap possibly originates from different perspectives, (1) the ICs take the available water into account in the creation of the RTTG, whilst (2) the farmers, even though they influence the RTTG, also mention the decreased financial benefits from the proposed RTTG of which they cannot survive of. Pushing the farmers to take risks regarding the crops they plant.

Regarding the enforcement of the RTTG, there is no difference in the treatment of farmers adhering to and deviating from the proposed RTTG. The decision to deviate from the plan is seen as a risk taken by the farmer.

5.2. Action Arena 2: The Response of One Irrigation Area to Sudden Water Scarcity

Situation sketch: The Brantas River basin is one of the most significant crop-producing river basins and covers around 25% of East Java (Roestamy & Fulazzaky, 2022). To allocate the water amongst the numerous irrigation areas across this river basin, an annual water allocation plan (RAAT) is created by the BBWS Brantas. This document allocates the surface water caught inside the Brantas water catchment amongst all eligible areas. To divide the water amongst users, the forecast uses various factors, i.e. weather predictions of the Indonesian Agency of Meteorology, Climatology, and Geophysics (BMKG), cropping plans of the irrigation areas, and the irrigation size of each irrigation area.

As expected, strong deviations from the forecast of the BMKG occur regularly, as the weather is unpredictable. These wrongful forecasts often lead to a decrease in water availability, leaving irrigation areas with water levels below prediction. Reallocation is possible through the ten to fifteen-day water allocation plan (RAAR). The authority to alter the already approved RAAT under unexpected circumstances is with the BBWS Brantas (Al'Afghani, 2022).

Two out of the four local interviews mention that the RAAT is sometimes / regularly wrong (interview 11 & 13). Leaving the irrigation areas with less water than initially assigned by the RAAT. As the short-term (10-15 day) allocation plan of the river basin (RAAR) is based on the yearly allocation plan (RAAT)

PJT1 is responsible for the water infrastructure operations and monitoring of the water level inside the primary and secondary system (linking river and irrigation areas), making them also the executor of the RAAR. Each irrigation area receives the water they are allocated, but for the distribution within the irrigation area, another organization is involved. The UPT is responsible for the operations of the water infrastructure of the tertiary channels, linking irrigation areas and farmers (interviews 11, 13 & 14). One UPT covers between two to five regencies (Kabupaten) (Indarto et al., 2017).

If the RAAT is revised, the organizations responsible for the irrigation area, BBWS/Dinas PUSDA, or the district government, inform the irrigation areas one week in advance of these changes. In turn, the irrigation areas organize internal meetings to influence their outcomes. The outcomes of these meetings are different per area. This research has observed two different responses to these warnings. Their responses are separately mentioned down below.

1) **Access to groundwater:** three out of the four irrigation areas, with mixed irrigation area jurisdictions, rely on access to groundwater. Water wells are constructed in often less than a day and seem to be accessible from almost everywhere. In response to the modifications to their surface water access, they turn to groundwater to fulfill their needs.
2) **Sacrifice few for the greater benefit of the rest:** The other irrigation area, which is under the jurisdiction of the provincial government, has another response to the modifications of the RAAT is found in one of the irrigation areas. They mention that the chiefs of the IHIPPAs, GHIPPAs, and HIPPAs come together to discuss the situation (interview 12). This particular irrigation area contains multiple Ihippas, so it is unlikely that a meeting is organized with so many invitees (each Ihippas contains around 8 Ghippas, and each Ghippa contains around 8 Hippas; accumulates to 64 invitees per Ihippa).
   In recent years, a regular response to these meetings was the decision that areas of farmers should leave their farming practices for a certain period (often a month) before they can start growing crops again. In turn for their compliance, the disadvantaged farmers are offered compensation. They are eligible for 2 different subsidies (1 from the MoA and one from the Dinas PU SDA). Additionally, members inside the irrigation area organize alternative jobs for them in one of the cities nearby (Surabaya or Malang). The exclusion of certain water users is then shared with the UPT, who in turn has to approve the new proposal before execution.
   The disadvantaged farmers are often the same as in previous years. The reason is practical: these farmers grow their crops in elevated areas, making it hard for the surface water to reach their farms in periods of drought.
   Which farmers are chosen, the length of the duration of the water cut, and who is going to arrange the alternative jobs in the city for the disadvantaged farmers are all unknown.
   Another factor influencing the water allocation in the area is the lack of an alternate water resource. Groundwater in this area is quite inaccessible. It is stored deep in the ground, making it costly for potential users to gain access to the groundwater. Other areas in similar positions who have access to groundwater, fulfill their water needs with this access. As a response to the water shortages, some of the farmers have turned to water infrastructure vandalism and intimidation of UPT operators in hopes of obtaining more water.

The first scenario sketched in this action arena only changes the water source partially from surface water to a mix with groundwater and does not lead to internal changes in the irrigation area. The second scenario is used for this action situation and is the way one of the irrigation areas operates, and its visualization can be seen in Figure 6.

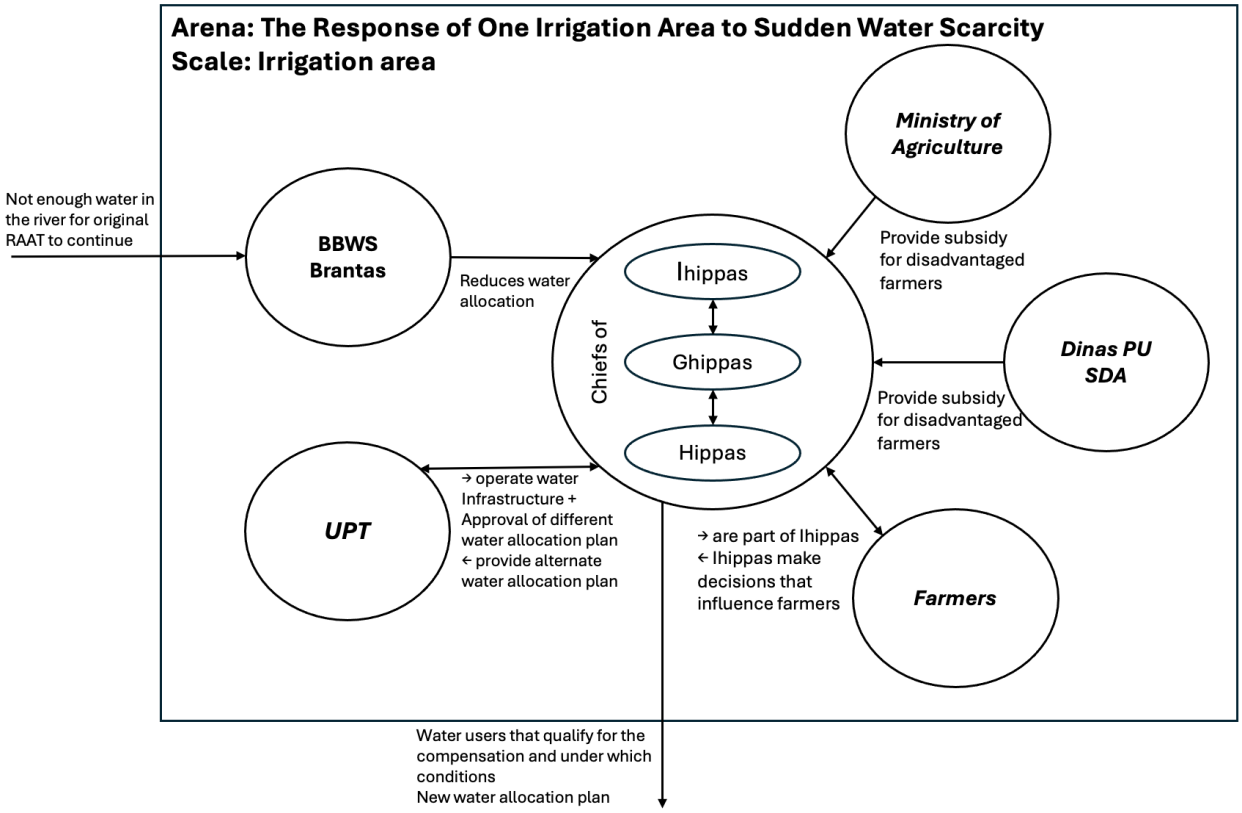

Figure 6. Action arena 2: Sudden water scarcity in one of the irrigation areas. This action arena occurs in the face of unexpected water scarcity (often in the peak of the dry season). The scale in which this action arena is played is within one irrigation area.

5.2.1. Arena Description and Actor Identification

In this arena, the following actors are identified: (1) BBWS Brantas, (2) the chiefs of the (I/G)Hippas, (3) UPT, (4) Ministry of Agriculture, (5) Dinas PU SDA, and (6) the farmers. Here the BBWS is an actor that reduces the predicted water availability, even though this is based on there not being enough water caught in the river (infrastructure). The actors deciding the action taken within the irrigation area are the invitees of the meeting. The invitees of this meeting are mentioned to be all the chiefs of the (I/G)Hippas, even though the large number of invitees raises questions about the validity of this information. After the internal meeting, an alternative allocation of the water is proposed, cutting out certain sections of the irrigation area to ensure the survival of others. UPT approves this new internal water allocation plan. Even though PJT1 is responsible for the operation of the primary and secondary water infrastructure, the scale of the allocation is inside the irrigation area itself (tertiary infrastructure). Therefore it is chosen to exclude PJT1 from this action arena. The two actors that provide subsidies are the Ministry of Agriculture and the Dinas PU SDA. Both these organizations provide the requirements of eligibility for and the amount of the subsidy. It is assumed that the requirements and the compensation offered by the subsidy are considered in creating the final decision of the meeting inside the irrigation area. At last, the farmers of the irrigation area are comprised of two groups, the farmers who can and cannot continue farming. If a farmer wants to continue farming, they

are allowed to, but chances are that they will not have access to water in the predetermined period.

5.2.2. Actor Values, Resources, and Perceptions

Table 6. Actors, partaking in the action arena related to sudden water scarcity within this one irrigation area, their values, resources, and perceptions. Everything italic is based on educated guesses and has no literature to back it up or mentioned in an interview.

Actors	Values	Resources	Perceptions
BBWS Brantas	*Allocates the water fairly across all water users in the Brantas River basin*	Can revise the RAAT to reduce or increase water amount received by irrigation areas (interview BBWS Brantas)	As there is less surface water available, the previous version of the RAAT doesn't allocate the water fairly across water users
Chiefs of (I/G)Hippas	Wants the best for the water users within their organization	Creates new proposal water allocation plan within the irrigation area (interview 12)	*If all water users continue with their practices, all have reduced profit and no farmers are eligible for the subsidies.*
UPT	*Performs tasks of operation of water infrastructure, willing to aid (I/G)Hippas / farmers where possible, as long as it's aid is relatively fair to other users*	Operates the water infrastructure creating a physical dependence of the irrigation area, approves of the new water allocation proposal for inside the irrigation area (interview 13)	*New water allocation proposal for inside the irrigation area is always fair, well discussed and arrangements are made between (I/G)Hippas.*
Ministry of Agriculture	Reaches the crop production targets (interview MoA), *reduce risk to and total amount of failed crops*	Financial resources, expertise in agriculture (interview MoA)	*Decides on the conditions to be eligible to obtain the subsidy*
Dinas PU SDA of East Java	Maintains water resources in East Java province (interview Dinas PU SDA), *support irrigation areas under their*	Financial resources (interview Dinas PU SDA)	*Decides on the conditions to be eligible to obtain the subsidy*

	jurisdiction as best as possible		
Farmers	Secures livelihood with farming activities and maximize profits (interview 11)	Has influence within the (I/G)Hippa in which they partake, as they are a member. Can refuse the outcomes of the meetings of the chiefs but take risks (interview 12)	The compensation needs to be enough to compensate them to leave the farm and pursue a temporary job in the city (interview 12)

5.2.3. Arena Inputs and Outputs

The main input of this arena is the current state of the water availability in the river, which is reduced. This input is dependent on the total duration and severity of the drought, influencing the reduced water that the irrigation area will receive.

The arena output is the revised water allocation plan within the irrigation area, who the disadvantaged farmers are, and the compensation for these disadvantaged farmers.

5.2.4. Arena Observations

This irrigation area seems to be leaning on the subsidies of the Ministry of Agriculture and Dinas PU SDA for a peaceful outcome. If these subsidies would fall away, the disadvantaged farmers would need some other form of compensation arranged within the irrigation area. This could lead to conflict and vandalization, as this region has had troubles with that in the past. Possibly, reality is not as smooth as described in the interviews. The disadvantaged farmers were not present in the interviews, therefore possibly coloring the information.

Another observation is that the disadvantaged farmers appear to largely belong to the same group. These farmers cultivate their crops in more elevated areas, which makes it difficult for water to reach their fields. As a result, they are constrained by the physical limitations of the irrigation system.

5.3. Action Arena 3: Maintenance and Construction of the Tertiary Water Infrastructure

Situation sketch: As stated by Law No.17/2019 on Water Resources, the Ministry of Public Works (PUPR) is responsible for the entire water infrastructure line: “connecting provider to end user”. The water infrastructure line is divided into 3 different sections: the primary, secondary, and tertiary infrastructure. The latter connects farmers to the river. The PUPR has created daughter organizations to accommodate the needs of all governance levels

regarding water infrastructure. In the Brantas river basin, this includes the river basin organization BBWS Brantas and the PUPR's provincial organization; Dinas PU SDA.

The responsibilities regarding different irrigation areas are put onto multiple levels of government, these levels of government delegate these tasks to governance-level appropriate organizations (as described in Section 4.1.4.). In addition to their responsibilities, these organizations also represent their irrigation areas in the TKPSDA and RAAT meetings (interview 9). The organization responsible for operating and managing the primary and some secondary infrastructure is the state-owned enterprise PJT1 (interviews 1, 3, 4). The other organization responsible for the operation of the tertiary infrastructure is the UPT (interviews 11, 12, 13 & 14). One UPT covers around two to five regencies (Kabupaten) (Indarto et al., 2017).

These organizations receive funds to accommodate their responsibilities for the irrigation areas under their jurisdiction. These organizations, in turn, provide funds to their irrigation areas to maintain and construct water infrastructure (World Bank, 2014). Unfortunately, these funds are not sufficient enough or inadequately spent to improve the current condition of the infrastructure, leading to neglect (World Bank, 2014; interview 6, 12 & 13). This neglect can be seen in the condition of the tertiary infrastructure, as more than half of it is in poor condition (World Bank, 2021). The poor state of the tertiary water infrastructure leads to large water losses at the end of the distribution line, causing local conflict (World Bank, 2014, interview 1).

To maintain the status quo, the MoA takes responsibility for the condition of the tertiary water infrastructure, even though this is not officially their responsibility (interviews 6 & 7). They provide aid to the WUFAs in the construction or maintenance of tertiary water infrastructure (interview 6) and groundwater wells (interviews 6, 11 & 13). They seem to step into the void left by the lack of funding (interview 6). As these poorly funded and conditioned tertiary irrigation systems obstruct their goal of reaching the national food targets, they step into the role. A visualization of this action arena can be seen in Figure 7 below.

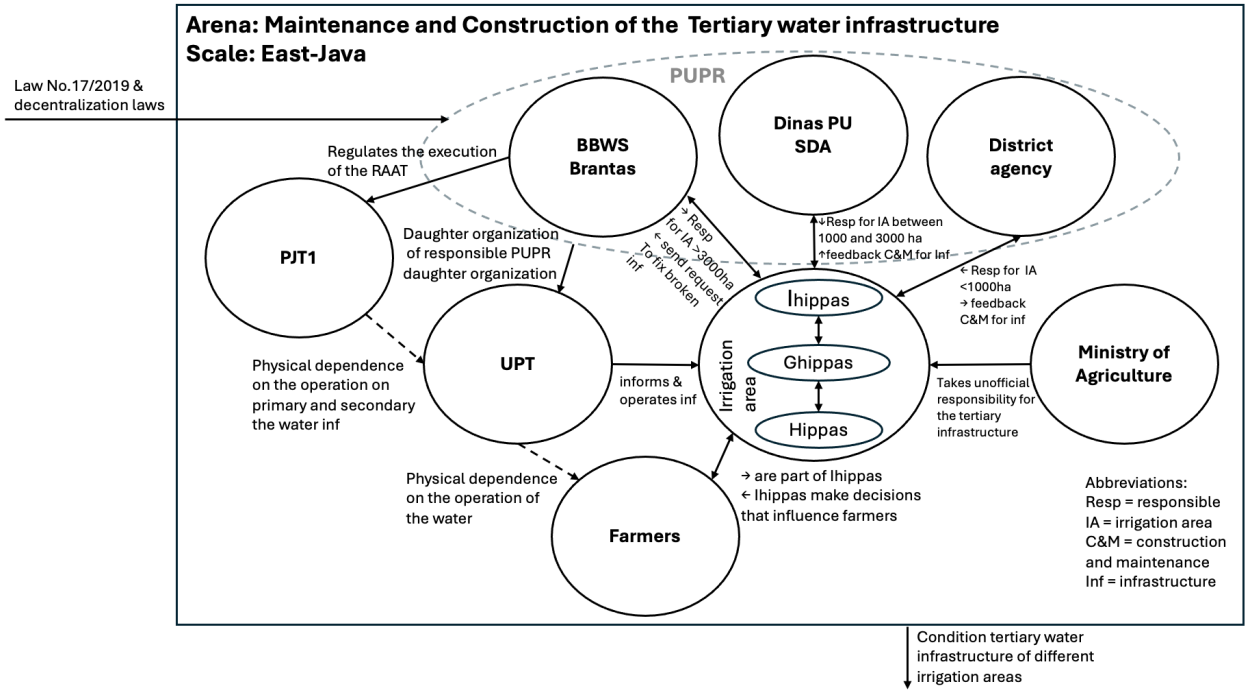

Figure 7. Action arena portraying the actors involved in the condition of the tertiary water infrastructure of different irrigation areas.

5.3.1. Arena Description and Actor Identification

Inside this action arena, eight different actors are identified Instead of using the situation sketch: (1) BBWS Brantas, (2) Dinas PU SDA, (3) District agency, (4) PJT1, (5) UPT, (6) (I/G)Hippas, (7) farmers, and (8) Ministry of Agriculture.

Different levels of government (central, provincial, or district) carry responsibility for different irrigation areas depending on their size. The governmental organizations executing these tasks in the name of the level of government are all part of the PUPR, being daughter organizations or provincial or district PUPR representatives, and have to comply with certain legislation of the PUPR. Even regarding that the PUPR is the over coupling organization, they are left out of this action arena as an actor. Their influence is portrayed by their presence in their respective organizations. All of these organizations have responsibilities regarding different sizes of irrigation areas, specified in the situation sketch above. These irrigation areas all operate according to the structure of the (I/G)Hippas.

BBWS Brantas takes on the responsibility of the central government regarding irrigation areas, as described in Section 4.1.4. In this system, PJT1 is responsible for the operation of the primary and some of the secondary water infrastructure. In turn, the UPT is responsible for operating the irrigation area-specific water infrastructure, linking the larger river to the farmers. Here the UPT has a physical dependence on the operation and maintenance of PJT1 and, in turn, the farmers on the UPT regarding the irrigation area-specific water infrastructure. As the farmers are represented by the (I/G)Hippas inside the irrigation area, the farmers are influenced by the actions of the (I/G)Hippas. As farmers are part of the (I/G)Hippas, they have internal influence towards these actions.

The last actor involved in this action arena is the Ministry of Agriculture, they have no legislative power, but take responsibility for the maintenance and rehabilitation of the tertiary water infrastructure.

5.3.2. Actor Values, Resources, and Perceptions

For each actor, their values, resources, and perceptions are shown in Table 3.

Table 7. Actors, partaking in the action arena regarding tertiary water infrastructure, their values, resources, and perceptions. Everything italic is based on educated guesses and has no literature to back it up or is mentioned in an interview.

Actor	Values	Resources	Perceptions
BBWS Brantas	Carrying out their responsibilities for the management of water resources within their area of jurisdiction (interview BBWS)	Funds for construction and maintenance of tertiary infrastructure (interview BBWS & 9), creates RAAT (interview BBWS)	Not enough funding to overlook all areas under their jurisdiction, this leads to prioritization (interview BBWS).
Dinas PU SDA of East Java	Maintaining water resources in East Java province (interview Dinas PU SDA), *support irrigation areas under their jurisdiction as best as possible*	Funds for construction and maintenance of tertiary infrastructure (interview Dinas PU SDA), build water wells if needed (interview Dinas PU SDA)	Do not have enough funds necessary to fulfill all their desires regarding the water infrastructure (interview Dinas PU SDA)
District agency	*support irrigation areas under their jurisdiction as best as possible*	Funds for construction and maintenance of tertiary infrastructure (interview 9),	*Do not have enough funds necessary to fulfill all their desires regarding the water infrastructure*
UPT	*Operate according to the plan, help Ihippas/farmers out where possible*	Responsible for the operation of the irrigation area specific water infrastructure (interview 11, 12, 13 & 14)	*Feel for the position of farmers, experience some poor quality infrastructure*
(I/G)Hippas	Help farmers to prosper (interview 11)	Receive funds for maintaining tertiary infrastructure (World Bank, 2014; interview 6), can make suggestions to responsible	Poor quality of some of the existing infrastructure (partially due to corruption), Even though they make suggestions about the

		governmental body for improvement of certain infrastructure (interview 12)	infrastructure that should be improved, this takes 3 to 4 years before it is implemented (interview 12)
Ministry of Agriculture	Reach production targets (interview MoA)	Funds for construction and maintenance of infrastructure, expertise in groundwater wells, expertise in constructing and rehabilitating of tertiary channels (interview MoA)	To reach the production targets, the MoA relies on the (daughter organizations of) PUPR to allocate the water fairly, (the daughter organizations of) PUPR do not address all problems in tertiary channels which obstruct production targets (interview MoA), Do not have jurisdiction in the tertiary channels (interview MoA), *more than half of the tertiary water infrastructure is in poor condition (World Bank, 2021)*
Farmers	Secure livelihood with farming activities and maximize profits (interview 11)	Have influence by being part of (I/G)Hippa (interviews 11, 12, 13, 14)	Receive too little water to water their crops (World Bank Group, 2022; interview 11, 13 & 14)

5.3.3. Arena Inputs and Outputs

The only arena input of this arena is Law No.17/2019. This law distinguishes the difference between the three irrigation area sizes which are of major influence on the structure of the arena.

The outcome of the arena is the condition of the tertiary infrastructure. For each irrigation area, this can be different depending on the irrigation area's current condition, land size, funds, functioning of the Ihippa, and the responsibilities of the farmers regarding mutual agreements between them. The actors influencing the current condition of the tertiary water infrastructure are therefore all actors in the action arena. Some organizations have a legal obligation (BBWS Brantas, Dinas PU SDA, District Agency) and some organizations help to obtain other goals (MoA) or themselves (Ihippas & farmers).

5.3.4. Arena Observations

An interesting observation is the inclusion of the MoA in this action arena. The Ministry of Agriculture does not have any legal obligation or mandate to aid in the rehabilitation or construction of the tertiary infrastructure, as all the water infrastructure is under the jurisdiction of the PUPR. Still, they are involved, in fear of reduced harvests as more than half of the tertiary infrastructure is in *poor condition* (World Bank, 2021). This could result in tensions between the Ministry of Agriculture and the (daughter organizations of the) PUPR.

5.4. Action Arena 4: Analyzing the Working Culture in Governmental Organizations Related to Water Allocation

Disclaimer: This action arena is more based on speculation, building on observations by the researcher regarding some of the interviews. Additionally, this action arena does not apply to all governmental organizations interviewed.

The structure of this action arena is different due to its speculative nature. Similarly as in other action arenas, a situation sketch is provided, but it differs in the absence of an actor identification section.

Situation sketch: regarding some of the interviews, there was some constant tension out of a combination of fear and a desire to ensure the well-perceived status of the organization (interviews 1 & 4).

Some of the organizations involved in the water allocation sector in Indonesia are organizations that obtain tasks from a parent organization, often PUPR. They are obliged to execute these tasks in specific areas, whilst other organizations with similar tasks carry responsibility in other areas, regencies, or provinces. Their performance is measured according to Key Performance Indicators (KPIs). KPIs are generally used to measure key points of performance, indicating whether or not the organization is increasing its performance. The presence of other similar organizations performing the same role means that the KPIs of these organizations can be compared. This can create an informal sense of competition between the employees of these organizations, wanting to be the best-performing organization.
Now, these organization's performances can be ranked and compared with one another. The person carrying responsibility for the organization can feel the need to maximize them as they could be praised or condemned by them. This shifts their focus (partially) from their designated tasks towards improving these KPIs. This causes organizations to use resources to maximize the KPIs instead of putting them toward the task and increasing compatibility with their designated tasks. An alternative way to maximize KPIs is to reject certain responsibilities for fear of penalization for not improving/reducing the KPI values whilst spending extra resources.

This shift of focus has its effect on the employees too, taking over this behavior and experiencing pressure from higher up the company. Creating a sense of fear to be condemned themselves. As many students in the hallways of the water resources engineering department of the University of Brawijaya, express their desire to work in the public sector due to its favorable working hours, good pay, and benefits. Creating an extra initiative for employees to conform to this culture.

Even though measuring an organization has its upsides, such as possible transparency and increased productivity. KPIs without actions restricting their optimization often led to its optimization. This reduces the KPI's effectiveness in contributing to other non-measured goals of the organization (De Bruijn, 2002).
One can see that in the infrastructure that is operated by PJT1. They do not have jurisdiction over all river-based water infrastructure that is not profitable enough for operation. Another example is the lack of data points in certain areas of the river. Almost all of the governmental organizations mention data as a large obstacle for their organization (interviews 1, 3, 6, 9). Increasing the quantity of data points in certain regions would mean that their KPIs could go down, therefore reducing the incentive to construct these data points.

Even though multiple reasons leading to the speculated work culture in organizations regarding water allocation are mentioned (i.e. way of measuring performance, interplay between organizations, perception of punishment, sense of competition, high employee benefits), it does not mean that all of these reasons are of the same influence.

5.5. Conclusion: Drawing Key Insights from Local Irrigation Water Allocation Practices

Zooming out from each action arena and analyzing the basis of the observations, there are a few common themes, namely: (1) a mismatch between water demand and supply expectations (action arenas 1 and 2) and (2) organizations filling in the practical vacuum left by the formal network (action arenas 2 and 3).

A mismatch between water demand and supply expectations:
The observations regarding the first action arena (Section 5.2.) portray two gaps between water demand and supply expectations. The data used to calculate water supply (next year's weather expectations) is in a different timeframe than the data used to generate next year's water demand (last year's river discharge data). As the climate is difficult to predict and next year's weather can be significantly different from the previous, it can leave significant gaps in actual water supply and demand.

In addition to using different data timeframes, there is a gap between the proposed RTTG and its actual implementation in the field. As previously mentioned, farmers have the autonomy to plant crops of their choice. However, they have raised concerns about the

economic feasibility of the proposed RTTGs, leading them to occasionally deviate from the recommendations, which further strains water resources.

Organizations filling in the practical vacuum left:
Action arenas two and three, both have different implications for the practical vacuum left by the formal network.
Whilst analyzing action arena 3 (Section 5.4.), the MoA takes part in the tertiary infrastructure, although they have no legal authority or role in this domain. They fulfill a role that is in line with their own goals, which has not been properly addressed yet, as half the tertiary infrastructure is in poor condition (World Bank, 2021).

This phenomenon is also evident in Action Arena Two. In this arena, the Ministry of Agriculture (MoA) and the Dinas PU SDA offer subsidies to disadvantaged farmers to help mitigate the impact of sudden water shortages in irrigation areas. While no organization is responsible for the reduction in rainfall, the subsidy is intended to fill the gap left by the lack of rainfall. The absence of these subsidies may inadvertently increase local conflicts and raise the risk of failed crops.

The numerous roles of the BBWS Brantas
In the four analyzed action arenas, the BBWS portrays multiple roles: they (1) represent the largest irrigation areas, (2) are responsible for the creation of the RAAT, (3) create legislation for the execution of the RAAT that relates to the role of the PJT1, and (4) are the parent organization which manages the UPTs under their jurisdictions whom in turn are responsible for the operation of the tertiary infrastructure. The roles that BBWS Brantas fulfills are plenty and possibly conflicting.

Observed approaches within the action arenas:
Some different overarching approaches from involved actors are observed within the analyzed action arenas. The first of these approaches can be described as the conservative approach, in which the actor relies solely on the tasks assigned by the formal framework. These organizations are fully occupied and engaged with these tasks and have not been observed undertaking additional tasks to alter certain outcomes. Organizations like the BBWS Brantas and the Dinas PU SDA implement this strategy.

Another strategy observed is the proactive approach. Organizations using this approach also focus on their formally assigned tasks but take on additional tasks that aid in achieving their goals. The MoA is an example of this proactive approach, taking on additional tasks not mandated by their original tasks, such as rehabilitation of tertiary water infrastructure (action arena 3) and aiding disadvantaged farmers in stressful periods (action arena 2).

The last strategy observed is the ‘coordination’ approach. Actors implementing this approach coordinate, discuss, and inform each other to shape the water allocation. Examples of this approach can be seen in action areas 2 and 3 and involve actors UPT and the (I/G)Hippas. These organizations seem to work together internally or externally beyond

their original tasks. So inform, discuss, and solve the (I/G)Hippas internal problems together passed on democratic principles as ensured by PUPR Regulation No. 14/PRT/M/2015. Within this process, the UPT seems to have an important role also. They are well involved in these internal processes and support the local decision-making seemingly beyond their formal tasks to operate the irrigation areas' internal infrastructure.

None of these approaches are better than the other. The underlying reasons for the chosen strategy are outside of the scope of this research. Actors implementing the 'conservative' approach can have various valid reasons, such as too little capacity (expertise, size of the organization's workforce, or financial) within their organization to support additional tasks to influence outcomes or the perception that optimizing their assigned tasks contributes the most to the system in which they operate, or fear of repercussions of lacking in assigned tasks. Actors implementing the proactive approach can have valid reasons, they can lack authority or judicial power to be differently involved, leading to filling in the practical void left by others or by laws or regulations without overstepping. Regarding the 'cooperative' approach, actors can choose this approach for a multitude of reasons, including lack of alternatives, monitoring, accountability, and responsibility to implement solutions outside of their assigned tasks. As this research has not investigated the actors' motives behind the implemented strategies, no value can be assigned to the implementation of these different strategies. To conclude the underlying motives, more organization-specific research needs to be done.

6. Synthesis and Discussion

This chapter is comprised of two different subsections. First of all, a joint analysis of Chapters 4 and 5 will be conducted to find similarities and differences between the formal framework posed in these chapters and secondly, this research will be put into context regarding the already existing literature.

6.1. Analyzing the Intersection of the Formal Framework and Local Irrigation Water Allocation Practices

In this section, a joint analysis of Chapters 4 and 5 is made. This section focuses on the overlap and differences of the formal framework posed in Chapter 4 and the differences observed in the action arenas of Chapter 5.

6.1.1. Analyzing Discrepancies Between Formal Roles and Field Observations in the Ministry of Agriculture

Concluding from the formal framework created in Chapter 4, the irrigation surface water system is quite well-defined but complex. The division of the three different irrigation sizes seems reasonable from the perspective of national importance and adaptability to area-specific governance. Unfortunately, the combination with the different levels of authority creates a rather complex field of organizations and their relations with others, confusing responsibility and corresponding organization. Additionally, this complexity is also reflected in the numerous and seemingly conflicting tasks of the BBWS Brantas, which is responsible for the creation of the water allocation plans (RAAT & RAAR), creation of the cropping plan (RTTG) for irrigation areas under their jurisdiction, operation and maintenance of water infrastructure inside irrigation areas. These three tasks could potentially create a conflict of interest, possibly using the authority of one task to enhance performance in another.

Differences between the formal chart and the real-world implementation can be seen in the roles of the MoA and their provincial and district counterparts. Beyond their official duties within the agricultural sector, the MoA takes on additional roles outside their formal jurisdiction. They play a formal role in connecting water availability to the corresponding RTTGs. Moreover, the MoA also significantly influences water demand by supporting local authorities by providing funds to retain harmony in drought-struck irrigation areas (action arena 2) and funds for irrigation area infrastructure rehabilitation (action arena 3). This highlights the MoA's informal role, despite its limited influence in the formal chart.

Additionally, the UPT appears to be underemphasized in the formal organizational chart despite its significant role in local irrigation water allocation. Officially, the UPT is primarily responsible for operating the irrigation infrastructure (Al'Afghani, 2022; UNESCO-IHE, 2008; Wieriks, 2011). However, group interviews with field practitioners (interviews 11, 12,

13 & 14) reveal that the UPT works closely with the irrigation areas. Interviews 11 and 13 highlight that they regularly consult the UPT to revise water allocation plans, particularly during shortages or infrastructure failures. They also receive updates on the current condition of the infrastructure and assistance from the UPT in identifying suitable locations for groundwater wells. Interviews 12 and 14 further emphasize the UPT's readiness to aid beyond its formal duties, even when such actions might conflict with its designated tasks. As Lipsky (1980) described, street-level bureaucrats are "public employees who interact directly with citizens and exercise considerable discretion in their work," a definition that applies well to the role of the UPT.

To critically analyze the information obtained during the field practitioner interviews, where in all of the interviews (11, 12, 13 & 14), at least one of the interviewees was a worker from the UPT. To possibly uphold the relationship between the irrigation areas and the UPT, the information provided by all the interviewees could be colored in favor of the UPT.

6.1.2. Analyzing Coordination and Decision-Making through Collective Choice Mechanisms on Multiple Governance Levels

As mentioned in action arenas 1, 2, and 3, the members and sometimes representatives of the (I/G)Hippas participate in public local problem-solving. These (I/G)Hippas are self-arranged and based on democratic principles, protected by PUPR Regulation No. 14/PRT/M/2015 Article 1. These public local problem-solving and democratic principles follow the collective choice arrangements and minimal recognition of rights design principles posed by Ostrom (1993). One aspect regarding collective choice this research did not highlight is the condition to enter or leave these collective choice arrangements as a participant. Some question marks pop up regarding these arrangements, as the only field practitioners interviewed were men, leaving questions about the role of the women unanswered.

At the river basin level, the TKPSDA is the coordinating organization bringing stakeholders in the irrigation water sector together to solve problems, such as controlling water demand by coordinating RTTGs. Even though the collective choice arrangements are formally arranged within the TKPSDA meetings, the influence on the outcomes of these meetings is still unknown. Question marks can be again placed on the conflicting roles of the BBWS Brantas, having the authority to create the water allocation plans and representing the irrigation areas under their jurisdiction. On paper, this is well arranged, bringing various stakeholders together to discuss and solve their issues. As the impact of these TKPSDA meetings is not analyzed nor is the TKPSDA interviewed, can this research not say anything about the functionality of the TKPSDA.

Regarding water demand coordination, differences are observed between the proposed and implemented RTTGs. This indicates a degree of misalignment between the representing organizations and the needs of the ones they represent. The gap between the proposed and implemented RTTGs seems to be a result of the farmers' adverse conditions.

6.1.3. Integrating Nested Enterprises of the Irrigation Water Sector

As expected, the action arenas described in Chapter 5 focus solely on local irrigation water allocation practices, thereby highlighting only the organizations that play an active role in local governance. The governance levels, as divided by the decentralization laws of Indonesia, provide a solid base of structure and organizations to create more regional-specific solutions to the problems faced. On a local level, the basis of the layering of governance is embodied by the (I/G)Hippa structure, providing a solid base for collective choice arrangements and conflict resolution platforms.

In contrast, several governmental organizations have counterparts operating at various levels of governance, with some active across multiple levels simultaneously. An example can be found in the division of irrigation areas amongst the different governance levels, especially the tasks assigned to the BBWS Brantas and the Dinas PU SDA. These organizations have responsibilities on multiple levels; on the provincial level, they fulfill their tasks as assigned, and on a local level, they have to care for certain irrigation areas. The local tasks might be considered 'minor' compared to their provincial tasks, and due to their limited budget, the responsible organizations may have different priorities than the development of irrigation areas under their jurisdiction, leaving question marks around the functionality of this task delegation.

6.2. Discussion of Results

This research discussion discusses the analysis of the two result chapters separately, Chapters 4 and 5.

6.2.1. Discussing the Formal Chart for Irrigation Water Allocation in the Brantas River Basin

To develop an updated version of the formal chart specific to the Brantas River and focused on irrigation water, the works of UNESCO-IHE (2008) and Wieriks (2011) were analyzed in light of more recent institutional analyses by Al'Afghani (2022) and the World Bank (2021). Several differences emerge between the models described by UNESCO-IHE (2008) and Wieriks (2011) and the model described in this research. These differences stem from changes in laws and regulations in the water allocation sector and the specific scope of this analysis.

One change in the water allocation system was the implementation of the TKPSDA in December 2010, as mandated by the PUPR Ministerial Decree No. 594/2010. This change rendered previous formal charts outdated. In this new structure, the TKPSDA replaced the role of the organization previously known as PTPA, which was also responsible for inter-organizational and stakeholder coordination (UNESCO-IHE, 2008; Wieriks, 2011). Additionally, the TKPSDA took on new responsibilities, such as creating the river basin's strategic and master plans, known as the *Pola* and *Rencana*, respectively.

Furthermore, the earlier studies did not capture the roles of the (B)BWS and the provincial and district Dinas responsible for water allocation regarding the operation and maintenance of irrigation water infrastructure in their formal charts. The operation and maintenance of the water infrastructure within irrigation areas is crucial, due to the combination of the overwhelming water demand of agriculture and the poor conditions of these systems leading to significant water losses.

While UNESCO-IHE (2008) and Wieriks (2011) aimed to cover the entire water allocation sector in Indonesia, there is a case to be made for the exclusion of the PJT organizations, as they are only active within certain regions of the country. However, given the significant role that PJTs play in the operation and maintenance of water infrastructure within specific areas, their inclusion is essential in the context of the Brantas River Basin.

On the contrary, this research also excluded some of the organizations mentioned by UNESCO-IHE (2008) and Wieriks (2011), e.g. BAPPEDALDA, Balai PSDA, and PPTPA. These (daughter) organizations might have had an impact in the water allocation sector back then, but have not seen recognition within the formal frameworks posed by Al'Afghani (2022) and the World Bank (2021). Therefore, these organizations have been excluded from the created formal chart.

6.2.2. Discussing the Application of Action Arena Literature in this Research

Even though the larger formal context sketched in Chapter 4 still plays an important part in understanding the local irrigation water allocation practices, do the action arenas sketch irrigation water allocation practices that operate within local and sometimes provincial governance levels, reducing the scope. Thus excluding numerous other inter- and intra-organizational action arenas on larger governance levels, such as the TKPSDA meetings in which the RAATs and RTTGs are coordinated, coordination between the RBOs, and more. Regarding the action arenas of local water allocation institutions, this research has not found similar applications of theory in Indonesia. Instead of comparing results, the application of the theory is discussed.

As mentioned in Section 2.2.2., institutions consist of formal and informal institutions. Here, formal institutions are explicitly spoken arrangements, but informal institutions can also be unconsciously designed and implemented. Using interviews as a data collection method then struggles with unraveling these informal institutions. This means that this research's action arenas analyzed have the potential to be missing important information. To solve this issue, engaging with the community for longer periods, such as partaking in inter- and intra-organizational meetings and speaking with all stakeholders in the community (including women), could enhance understanding of the system and unravel these unspoken and unconscious institutions.

Section 2.4.6. mentions the categorization of individuals under one overarching or umbrella term. Hermans & Cunningham (2018) refers to this phenomenon as a ‘composite actor’. Composite actors create a trade-off between complexity and comprehensibility and the analysis’ resilience to change. The umbrella term consistently used in this research is the organization employing these individuals. An incorrect use of such an umbrella term can influence the system.
An example of this phenomenon is the BBWS Brantas. As mentioned in section 5.3.4. (action arena observations of action arena 3), the BBWS Brantas has multiple roles, which could potentially create a conflict of interest. As the BBWS Brantas consists of different groups operating under the same name, it does not mean that all of these subgroups have the same objectives. This means that there still is a possibility that these tasks are not causing a conflict of interest.

7. Conclusions, Recommendations, and Reflections

This chapter provides an overview of the research reflections, conclusions, and policy and science recommendations. First, this section answers the main research question by answering the sub-questions separately. The structure of these conclusions can be found in the order of the sub-questions stated in Section 3.1. The conclusion starts with the analysis of the institutions and actors, followed by an analysis of the interactions of different actors to shape irrigation water allocation practices and outcomes. At last, the links between the institutional factors that influence these irrigation water allocation practices are analyzed. In Sections 7.2. and 7.3. suitable policy and science recommendations are found for the irrigation water allocation system in the Brantas River basin. At last, this research reflects on the research objectives, data collection (methods), processing, and adds a personal reflection.

7.1. Answering the Sub- and Main Research Questions

1. *What are the formal institutions that scope the irrigation water allocation playing field in the Brantas river basin?*

This research found that the primary laws shaping irrigation water allocation in the Brantas River basin are the statement in the Constitution of the Republic of Indonesia that states that the central government is responsible for the utilization of the water for the benefit of its citizens, Law No.17/2019 on Water Resources, and decentralization laws. The combination of these laws creates the levels of governance (national, provincial, and local) in which the irrigation water sector of Indonesia operates and allocates the water management responsibilities. The definition of water utilization for the 'greater benefit of the people' is stipulated in the 6 basic principles of water resources management established by Court decision. These principles create the basis for the six different water utility priorities, which can be seen in Section 4.1.2.

Another important institution is PUPR Regulation No. 14/PRT/M/2015 (Articles 9, 10, and 11). This regulation divides the irrigation areas (often by size) and assigns to each a responsible governance level. How these governance levels structure the implementation of these responsibilities and their application is partially up to them, but it forms the basis of the involved organizations taking over the respective government's responsibilities on water demand management and operation and maintenance of irrigation infrastructure.

On a local level, the water demand management is shaped by the presence of irrigation area-specific crop rotation plans (RTTG) formed by the responsible organizations (provincial and district Irrigation Commissions (ICs), and BBWS Brantas) and coordinated with help from the TKPSDA. The TKPSDA provides a platform for the coordination of the area-specific RTTGs by involving several stakeholders to shape water demand. In turn, these meetings shape the water allocation within the Brantas River basin. The BBWS Brantas uses the weather data provided by BKMG to estimate the water supply, creating the

annual water allocation plan (RAAT) of the river whilst considering the proposed RTTGs. Afterward, the plan is further developed and any deviations are implemented in the short-term water allocation plan (RAAR).

In addition to the coordination challenges surrounding the area-specific RTTGs, there is an institutional misalignment of the data timeframes used to calculate these plans. The Irrigation Commissions (ICs) rely on the previous year's river discharge data to shape expectations for the next year's RTTGs. In contrast, BBWS Brantas uses weather forecasts for the upcoming year to develop the RAAT based on the projected water supply. The discrepancy between using historical data and future weather predictions can result in significant differences, leading to inaccurate expectations and a rigid allocation system.

At last, PUPR Regulation No. 14/PRT/M/2015 ensures the existence of WUAs (P3a) / WUFAs and the autonomous and democratic principles on which they are built. These WUFAs additionally receive the authority to operate the tertiary infrastructure network in the absence of a technical operations unit (UPT), which the responsible governmental organization can establish.

2. *How do different actors interact to shape irrigation water allocation practices and outcomes?*

Some different instances of actors shaping irrigation water allocation practices and outcomes are described in Chapter 5 using action arenas. These action arenas' focus is on the local implementation of these irrigation water allocation practices, which is also reflected in the answer to this sub-question.

The first action arena describes the interactions that shape the water demand of the irrigation areas. The farmers have the autonomy to cultivate the crop they like. As interview 11 mentions, the farmers are poor and act as economic maximizers, wanting to always cultivate the most profitable crop (rice), which also happens to be the most water-intensive crop. Acting upon this desire enhances the water shortages. To prevent all farmers from planting rice, two separate coordination mechanisms have been implemented: (1) the coordination and communication of the RAAT and corresponding RTTG and (2) the internal coordination within the irrigation area. The coordination of the RTTGs happens within the TKPSDA meetings at the provincial level of governance. In this meeting, the provincial and district ICs are present, together with the BBWS, to coordinate the proposed RTTGs, which have to correspond with the created RAAT. After the creation of the RAAT, the irrigation areas know the amount and timing of the allocated water. After the first signs of dry season are present, the irrigation areas coordinate an internal meeting, allocating the water amongst their users. In the situation sketch of action arena 1, Section 5.1.1., two different processes are described. One is more hierarchical than the other, but all base their solutions on democratic principles to create an irrigation area water allocation plan for the dry season. This irrigation area created a water allocation plan, together with the posed

RTTGs by the respective ICs, the experience of the farmers in previous years, and the willingness to take risks all led to the farmers' own cropping plan.

The first action arena outlines the interactions that shape water demand in the irrigation areas. Farmers have the autonomy to choose which crops to cultivate. As noted in interview 11, many farmers are economically disadvantaged and tend to act as economic maximizers, favoring the most profitable crop (rice), which also happens to be the most water intensive. Acting upon this desire enhances water shortages. To prevent all farmers from planting rice, two separate coordination mechanisms have been put in place: (1) coordination and communication between the RAAT and the corresponding RTTG and (2) internal coordination within each irrigation area.

The coordination of RTTGs occurs during TKPSDA meetings at the provincial governance level, where provincial and district ICs, along with the BBWS, are present to align the proposed RTTGs with the RAAT. Once the RAAT is established, the irrigation areas are informed of the amount and timing of their water allocations. When signs of the dry season begin to appear, the irrigation areas hold internal meetings to allocate water among their users.

In the scenario described in action arena 1 (Section 5.1.1), two distinct processes are outlined. While one process is more hierarchical than the other, both rely on democratic principles to create a water allocation plan for the dry season. This irrigation area developed a water allocation plan that, along with the assigned RTTGs from the ICs, farmers' past experiences, and their willingness to take risks, shaped the farmers' cropping plans.

The second action arena describes the response and solution to the sudden decrease in the expected RAAT of one of the irrigation areas. This irrigation area does not have access to an alternate water resource. The other irrigation areas use this resource in similar periods to fulfill their water demands and are therefore not taken into consideration in this action arena. Due to the lack of an alternate water resource, there is a sudden need for the farmers to evaluate the new situation and possibly alter their previous allocation plan. As previous years have suggested, some farmers will be excluded from the water source to preserve enough water for the rest. These farmers are compensated by the MoA, Dinas PU SDA, and by the (I/G)Hippas themselves. Such compensation is expected from the (I/G)Hippas, but the presence of the compensation of MoA and Dinas PU SDA suggests inter-organizational information exchange and coordination between the irrigation areas and irrigation areas in similar situations.

In the third action arena is the tertiary water infrastructure construction and maintenance system analyzed. This system portrays the formal system as described in Chapter 4, with an addition of the MoA. The formal system of irrigation area responsibility regarding tertiary water infrastructure construction and maintenance is not functioning well or fast enough. This could indicate a misalignment in prioritization of the MoA and the respective

responsible irrigation area organization or could indicate a systematically underfunded tertiary water infrastructure. Both these possibilities create an operational gap between the formal system and implementation. To support the organizations responsible and to obtain its own agriculture-related goals, the MoA fills this operational gap (partially) by providing additional funds to certain irrigation areas to help increase the speed of the rehabilitation of such infrastructure. These funds of the MoA and the respective responsible organization are allocated to the (I/G)Hippas, which can use the funds to improve its current condition. Here

3. *How are these irrigation water allocation practices influenced by formal and informal institutional factors?*

This section answers the sub-question with two differently observed institutional influences, namely (1) the formal influence of regulatory institutions on the structure and operation of (I/G)Hippas and (2) lacking institutions leading to implementation gaps.

The formal influence of regulatory institutions on the structure and operation of (I/G)Hippas

The structure of the (I/G)Hippas follows PUPR's Regulation No. 14/PRT/M/2015, which states that these organizations must be self-assembled and the decision-making based on democratic principles. The organizational structure (Ihippa → Ghippa → Hippa) is specific to East Java and tailors towards decision-making on the socio-relevant scale. Even though per region slight variations were observed regarding decision-making principles, do the field-practitioner interviewees mention that they all are based on democratic principles, as all invitees have an equal distribution of votes and the solution with the highest amounts of votes is implemented. This follows the set regulation and is a direct result of the national formal and local informal institutions to influence outcomes.

Lacking institutions leads to implementation gaps

Other irrigation water allocation practices observed find their roots in the lack of support from formal institutions. Such irrigation water allocation practices are the presence of compensation for disadvantaged farmers within irrigation areas lacking alternate water resources to fulfill demand in periods of sudden reduced water availability, and providing additional funds to speed up tertiary water infrastructure rehabilitation.

The water allocation practice relating to the previously mentioned rehabilitation is created by lacking funds, leading to implementation gaps left by the responsible organizations. These organizations have to prioritize their capacity due to the lack of institutional support (such as funding) for the full implementation of their desires regarding infrastructure construction and maintenance.

Another example of insufficient institutional support is the compensation available for disadvantaged farmers within irrigation areas lacking alternate water sources to fulfill their demand in suddenly reduced water availability. These practices are necessary due to the

wrongful weather predictions and lack of support from the institutional system, minimizing their effects. This results in the aid of external and responsible organizations to soften the otherwise devastating results such as the increased risk of massive irrigation area crop losses.

7.2. Policy Recommendations

Based on the observations of this research, the following recommendations are proposed for the Indonesian government. Each recommendation is presented with a clear statement, followed by a rationale that links back to this research's findings. The first two of these recommendations are based on the conclusions regarding the observations in Section 6.1. and regarding the answers provided to the sub-questions in Section 7.1. An additional policy recommendation is made based on an observation regarding Action Arena 2: The Response of One Irrigation Area to Sudden Water Scarcity.

Policy recommendation 1
Delegate the responsibilities regarding the irrigation area of the national government to a different organization than the BBWS Brantas.

The current delegation of tasks to the BBWS Brantas poses the organization with many and seemingly conflicting roles. They are responsible for the creation of the RAAT & RAAR plans, they regulate and monitor the execution of the RAARs, they carry responsibility for the operation and maintenance of the water infrastructure within nationally strategic or interprovincial irrigation areas, and they have to coordinate the RTTGs of the irrigation areas under their jurisdiction. These roles can potentially create a conflict of interest within the organization, and the local tasks might be considered as 'minor' within the organization. The BBWS Brantas has a crucial role in the allocation of water within the river basin, and this should be their primary role. Assigning the other roles related to irrigation areas to another organization could relieve pressure on the respective organization. Reducing the seemingly conflicting roles, increasing focus, and enhancing engagement in the irrigation areas to address specific needs.

Policy recommendation 2

Find solutions to enhance the living standards of the farmers, and increase farmer participation to enhance engagement and willingness of the farmers to contribute towards surface water management.

Multiple factors can contribute to the misalignment of the posed and implemented RTTGs which are influencing a significant portion of the water demand. One of these factors contributing to this misalignment is the poor living standards associated with the farmers, forcing them to take risks to ensure some financial boosts and altering the farmers' attitude towards being economic maximizers. A solution would then consist of the enhancement of the living standards. Additionally, to increase the farmers' engagement, it is important to

enhance farmer participation within the management of the CPR. Ostrom (1993) and Asprilla-Echeverri (2024) also stress the importance of CPR's monitoring and system feedback to enhance stakeholders' engagement.

Policy recommendation 3

Align adjustments to the RAAT in response to decreased water supply with the availability of alternative water resources.

While weather will inevitably remain unpredictable, what can be changed is the system's robustness against sudden water availability changes. This research has observed varying responses from different irrigation areas to abrupt depletions of water availability. Irrigation areas with access to alternative water resources appear less affected by these fluctuations due to the alternate access to fulfill demand, whereas those without suffer more severe consequences. Therefore, it is recommended that the Indonesian government prioritize water allocation during periods of sudden decreases in water availability, considering the absence of alternative water sources in certain areas. Implementing this recommendation would enhance the robustness of water availability in irrigation areas lacking alternative sources while still ensuring sufficient water supply for those areas with access to alternative resources.

7.3. Science Recommendations

Similarly to the policy recommendations, are these recommendations also presented with a clear statement, followed by the rationale that links back to the research.

Science recommendation 1
Increase coupling between institutional analysis and the quantitative models.

To create a more effective a comprehensive approach, the institutional analysis should be coupled with the many already existing quantitative models. Institutional analysis provides a deep understanding of the formal and informal rules, norms, and behaviors that shape human interactions. However, on its own, institutional analysis cannot often quantify the impacts of these governance structures.

By integrating institutional analysis with quantitative models, which are adept at simulating and forecasting environmental, economic, and social dynamics, policymakers and researchers can bridge the gap between qualitative insights and measurable outcomes. This coupling allows for a more nuanced understanding of the interactions between institutional arrangements and physical processes, such as river flows or rainfall patterns.

Science recommendation 2
Enhance measurement tools and techniques for identifying informal institutions within the 'interview' data collection method.

This research found it challenging to uncover informal institutions through interviews, as they are often unconsciously embedded in social practices. Informal institutions have a critical role in shaping decision-making and behavior within a community. Enhancing the measurement tools and techniques used to identify informal institutions through interviews can significantly improve the depth and accuracy of institutional analysis.

7.4. Research Reflection

This section contains this research's reflections. It starts with the use of the research methodology, which is followed by a reflection of the data collection methods and use.

7.4.1. Reflecting on the Research Objectives

The research objective of this thesis is to analyze how formal and informal institutions influence irrigation water allocation practices in the Brantas River Basin in Indonesia. To provide an answer to this research objective, this research analyzed the formal institutions that shape the irrigation water allocation within multiple layers of governance and used interviews with key organizations and field practitioners to formulate and analyze irrigation water allocation practices.

The main focus of this research was the creation of a formal chart, in combination with the application of the IAD framework following the structure posed by Hermans & Cunningham (2018). While this research did not fully succeed in mapping additional action arenas or uncovering all the connections across multiple governance levels, it identified several action arenas. These arenas, though somewhat connected, remain distinct and provide valuable insights, even if they do not capture the entire complexity of the system. The absence of connections between multiple levels of governance is not due to the usefulness of the framework but due to the focus of this research. The focus was on the local irrigation water allocation practices, already focusing less on the possible action arenas in other levels of governance.

The stepwise approach used in this research for analyzing the Institutional Analysis and Development (IAD) framework reflects a difference from the recommended approaches as described by Hermans & Cunningham (2018) and McGinnis (2012). In this research's approach, several elements of the 'recommended' approaches switched positions or were intertwined, resulting in a somewhat unstructured process. This lack of consistency led to certain elements of the action arenas not being fully addressed during interviews, causing gaps in the collected knowledge. These gaps are evident in the tables presented in Chapter 5, where missing information is highlighted in *italics*. This research therefore lost opportunities for collecting the corresponding data, leaving gaps that are currently filled with educated guesses, affecting the overall robustness and completeness of the analysis.

7.4.2. Reflecting on Data Collection and Processing

This research has conducted a total of fourteen interviews. Ten of these interviews were conducted with expert interviews active in national or provincial (governmental) organizations. The interviewees present during these interviews represent one or water allocation sector in this research.

Semi-structured interviews
One of the processes limiting the quality of the action arena is the data-gathering method. An interview only portrays a version of reality and is guided by the questions of the researcher and the awareness and willingness of the interviewee to answer the questions. Additionally is the interview also limited by the time in which the interview has to be completed, not enabling the interviewer to understand the full complexity of the system of interest.

Group interviews
Group interviews pose their disadvantages. These occurred in the field interviews and unexpectedly in some of the expert interviews. To reduce the risk of actors not speaking up, the other participants were asked to provide different insights if present. However, this approach never fully eliminates the problem.

In addition to the previously mentioned points regarding the field-practitioner interviews, there are disadvantages to group interviews, especially group interviews containing members from different organizations. Group interviews can negatively influence the information obtained from the interviews. Examples of these disadvantages are, decreased willingness and truthfulness of the participants due to social pressures, dominance of strong personalities, and limited depth of responses as responses may lack depth and details.

Language barrier
Additionally, English was not the first language of the researcher and interviewees. Some interviewees did not have the English skills to communicate with one another, creating the necessity for a translator, who again suffered from the same problem. To mitigate the effect this has on the analysis, interview reports were sent back to the interviewees in English, who were able to revise and alter information where they saw fit. Unfortunately, none of the field practitioners spoke any English, making them unable to revise the information. To still reduce the chances of wrongful interpretation are the interview reports shown to the present translator, who again had the opportunity to revise the information.

Cultural reflection on interviews
On several occasions, individual interviews turned into last-minute group interviews at the last minute. While this situation could potentially enhance the width of knowledge about the system, it also poses a risk to the honesty of the interviewees, as they may alter their responses to avoid conflict or disagreement in the presence of others.

Another factor influencing the data quality was the hierarchical and/or bureaucratic culture in Indonesia. Arranging interviews with the organizations was not difficult but time-consuming. Often, to arrange interviews, multiple steps were necessary before an interview was planned. First of all, an official letter from the university addressed to someone higher up in the organization was drafted and sent to someone in the organization. Then, a team related to the topic was assigned to participate in the interview. This process seemed necessary for most organizations but could influence the willingness of the participants to participate in the interview as they were assigned. This process could have resulted in an unwillingness to share information due to a fear of repercussions of oversharing or putting the organization in a bad light or a lack of interest in participating due to different personal priorities.

Field practitioner group interviews
Regarding the four field-practitioner group interviews, the interviewees present had often different occupations and positions within the irrigation area, as can be seen in Table 1. The answers provided in these interviews were considered group answers. Additionally, the participants were provided with a small financial compensation for their efforts. This could have affected the willingness of participants to provide extra insights or new information due to a different focus than actively participating in the interview.

Width and depth of the data
Not all relevant actors in the irrigation surface water allocation sector are interviewed, limiting the width of the analysis. Examples of organizations and interviewees missed in the analysis are TKPSDA, provincial and district Dinas PKP, district Dinas PU SDA, provincial and district ICs, and disadvantaged farmers (mentioned in action arena 2).

Additionally, regarding the expert interviews, one interview formed a representation of the organization employing the interviewees. This has significant drawbacks due to the

The second limitation concerns the expert interviews. Individual interviews were treated as a representative of the entire organization, employing the interviewee(s). As a result, there is a possibility that the interviewee lacked certain information or expressed a personal opinion that may not (fully) reflect the perspectives of the organization.

Regarding the interviewed organizations, one is specifically overrepresented in the analysis. This organization is the Ministry of National Development Planning (Bappenas). An effect of this overrepresentation is that this research's vision and perception of the water allocation system are probably more influenced by the vision of Bappenas.

Data processing
Section 3.4.4. describes just one of the qualitative data encoding techniques. Using a different technique could have led to different results. Additionally, the data is encoded by a human, possibly overlooking some important data.

7.4.3. Personal reflection

Personal thesis process:
The thesis process has been interesting, to say the least. During my thesis, I have learned a lot about what it means to be in charge of such projects. During the education on the TU Delft, the focus is often on executing a process that is designed by someone else. During this project, a switch has been made: you need to design your own research methodology and execute it. These approaches seem to be psychologically different, as the first approach provides safety in structure and support, whilst the second approach provides freedom however, it also lacks structure and reference. This shift has also been experienced during this research, leaving some stones unturned at the beginning of the project, which later could not be caught up due to time constraints. As someone with a different background than policy analysis, some concepts and processes were unfamiliar. This created the need for a crash course in a lot of concepts in a short amount of time, such as institutions, conducting interviews, and qualitative data coding. These newly introduced concepts, even though new, sparked an interest in these topics as their usefulness reaches beyond research, i.e., daily communication practices and personal reflection.

Personal experiences in a research project abroad:
Between governments, the systems can have similarities and differences. Indonesia and the Netherlands are no different. These countries also share similarities (such as the structure and functions of the ministries) and differences (such as the level of decentralization and the influence of multiple governance levels on each other). It took some time to understand these similarities and differences, creating a steep learning curve and a broadening of perspective and understanding of governance systems.

Apart from the structural differences, there were also cultural differences, which took some time to get used to. The working culture in Indonesia is different. It came across as more hierarchical than in the Netherlands. This had its influence on communication and expectations, as described in Section 7.4.2. under the headline of ‘interviews’. These changes needed some getting used to, but the more interviews conducted, the more normal it became.

Apart from cultural differences affecting the interviews, language was also a common barrier. Apart from the national offices in Jakarta, where everyone expressed themselves well in English, language was a larger barrier during the interviews with regional and local interviews. This created the necessity for someone to translate from Indonesian (Bahasa) to English. Since this issue was anticipated from the moment I arrived in Indonesia, I made an effort to learn the basics of the general language, Bahasa. This sometimes helped with communication and understanding, and I also believe it put me in a more favorable light with the interviewees, which contributed to the success of the research.

As someone with a different background, the transition towards qualitative research was large. I struggled with new concepts such as institutions, action arenas, qualitative

research methods, and more. Especially regarding the interviews, I experienced fast growth in my ability to gather the correct information. Often, the day after the interview, I analyzed and summarized the data gathered. In the first interviews, I often found myself thinking, 'I should have continued to ask that question'. The more interviews conducted and analyzed, the less it occurred.

Additionally, having some knowledge about the country's history helped to put things into context faster. The Netherlands and Indonesia share a history, the Netherlands as the colonizer and Indonesia as the colonized. Having some basic knowledge of the history and being open to learning, I think, helped to put some interactions into context. The interactions that I am referring to are not talking about any of the interviews, but about some interactions with people on the street. Generally, was my experience with the Indonesians very pleasant. I would describe them as the most friendly, inviting, and open people I have met. Occasionally, the translator pointed my attention toward something that I would barely notice and which was outside of the scope of the interviews. This was not of any importance or did not create any dangerous situations, but it allowed me to put the interactions into context better.

Regarding my experiences in Indonesia, I can only be positive. I feel immense gratitude for all the culture, adventures, friendliness, and hospitality that I experienced during my stay in Indonesia. It has been a heartwarming and enriching experience, which I will always cherish and carry with me.

Appendix A: Structure of the Interview Questions of Organizations in English

1. What is your name, and what is your position within your organization?
2. What role and responsibility does your organization take regarding water allocation?
    a. Which laws, regulations, and/or policies regulate the role of your organization?
3. With what other organizations does your organization collaborate regarding water allocation?
    a. With what kind of projects do you collaborate with one another?
    b. Why do you collaborate with one another?
    c. What are their responsibilities?
    d. What does your collaboration entail? / What do you collaborate about?
4. Which other organizations are dependent on your organization regarding water allocation?
    a. On which grounds/laws/policy/legislation is this authority based?
5. Is the organization that you work for dependent on other organizations regarding water allocation?
    a. Why is it dependent?
    b. What are you dependent on?
    c. On which grounds/laws/policy/legislation is this authority based?
6. What do you think of the existing water allocation system in Indonesia (/ East Java)?
7. What are some advantages and disadvantages of the water allocation system in Indonesia(/ East Java)?
8. What problems does your organization run into regarding implementation in water allocation? (e.g., funds, staff, expertise, information, legal mandate)
9. Do you think that there is a water scarcity problem in Java? If yes:
    a. How would you define the problem? /What do you think that the problem is?
    b. What is/are the causes of this problem?
    c. What could your organization do to reduce the problem?
10. What would be your recommendations to improve the water allocation system as it is?
    a. What do you need to implement these recommendations?

Appendix B: Structure of the Field Practitioner Group Interview Questions in English

1. What are your names? What do you do? What are your responsibilities in this irrigation area?

Farming background:

2. How many hectares of land are in the irrigation area? What is the name of the irrigation area?
3. What kind of crops are grown in the irrigation area?
    a. Why these crops?
4. Do you engage in other income-generating activities besides farming? If so, which?

Farm-level experiences with water shortages:

5. What type of water do you use for farming? Rained, or also irrigation? What kind of water sources do you use?
6. How is water divided (amongst farmers)? Both on a yearly basis and during different seasons
7. As a farmer, do you sometimes experience water shortages?
    a. When? What periods of the year, how long and how frequent?
    b. How do you deal with shortages? (e.g. grow less crop, grow different crop, sell water)
    c. Has the situation related to water shortages changed in the past few years? If so, how?

Local water allocation platforms and mechanisms:

8. Do you have structures, platforms, or associations in which you discuss how you deal with water shortages?
    a. What kind of platform is used or organization is responsible?
    b. How do meetings on this platform normally go?
        i. Who is involved in the discussions?
        ii. How often do they occur?
        iii. Are you satisfied with these meetings? And with the outcomes of these meetings?
            1. If not, what would you like to see changed?
    c. Are decisions made by this group/platform? What kind of decisions?
        i. Who are making the decisions?
        ii. Why are they involved? And who is NOT involved, and maybe should be more involved?
        iii. Why is this the way decisions are made?

Formal water allocation mechanisms:

9. How are the TPKSDA and the RAAT communicated with you?
10. Do you know how TPKSDA and the RAAT make their decisions, and do you understand why the TKPSDA and the RAAT make the decisions as they do? Do you think this is a good way of making water allocation decisions? If not, what would you propose to change?

Optional question:

11. Which attributes in water management do you value most?/could you rank them?
    a. Examples: water quality, amount, security, risk aversion, consistency, trust in the system, trust in the community (are there more?)
    b. (are the answers more towards formal or informal systems?)

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