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Integrated Assessment—How Does It Help Unpack Water Access by Marginalized Farmers?

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Abstract: Water is critical to the lives and livelihoods of rural communities in developing countries; however, access to water can be inequitable within communities. This paper uses a generalized integrated assessment approach to explore the determinants of water access by marginalized farmers in two villages in coastal Bangladesh, before and after the setup of local water institutions. The study was part of a broader project aimed at promoting socially inclusive agricultural intensification. An integrative framework was developed in this study to capture and link the diverse range of factors that influence the distribution of water, including the often-overlooked role of social dynamics and governance arrangements. While interventions around improving water resource infrastructure can be critical for freshwater availability, the case studies show that a breakdown of asymmetric power structures may also be needed for water access to all individuals, especially marginalized groups. Establishing a community-based water institution on its own does not necessarily address power issues in a community. It is imperative that the agency and capacities of the marginalized members are developed and that the institutional arrangements foster an enabling environment for marginalized members to influence decision making. Integrated assessment allowed the case studies to be explored from multiple perspectives so as to gain a greater understanding of the barriers and levers to obtaining equitable outcomes from water interventions.

Keywords: inclusive water management; marginalization; Bangladesh; water governance; South Asia; integrated assessment

1. Introduction

1.1. Background

Water availability is often one of the key constraints to increasing productivity in agriculture [1,2]. Even tropical regions like southern Bangladesh, where annual rainfall typically exceeds 2000 mm, can suffer water shortages for several months a year [3,4]. In such regions, limited or unreliable rainfall [5] can prevent cropping [6] or greatly reduce germination, establishment and yields outside of the monsoon period [7–9]. Water resource development, including infrastructure for water storage or flow diversions, has successfully led to all-year-round freshwater availability in many communities across the globe. However, it is common for internal conflicts to exist over water use, with some groups left without access to water resources that are meant to be shared by the community.

Many developed and developing regions face problems of inequitable distribution of water within communities. Marginalized groups, such as small-holder, landless and women farmers, and indigenous peoples or tribal minorities, typically fare worse in terms of access to water compared to more affluent or politically influential groups [10,11]. In developing regions, inequitable access to water can potentially have more severe consequences for the livelihoods and health of marginalized households who are often more reliant upon water resources [12]. Beyond water for food production, access to water is fundamental for physical health and sanitation and, at least indirectly, underpins other aspects of well-being [13]. For example, without access to water on their premise, household members, typically women or children, may need to spend several hours each day fetching water, thereby sacrificing time that could otherwise be spent on livelihood activities, schooling, caring for the household or recreation [14]. The challenge with water resource management is ensuring that marginalized groups are neither excluded nor disadvantaged from the benefits of interventions or allocation decisions.

1.2. Equity Issues in Water Interventions

While the criticality of water to lives and livelihoods is well established, many households across the world still struggle to secure water for their basic needs, e.g., Ref. [15]. Despite the poor and marginalized being the target beneficiaries of many water development projects, often the more affluent groups are better positioned to capture the benefits of such interventions [16]. Hussain and Hanjra [17] highlighted the direct and indirect positive linkages between irrigation and poverty alleviation in their review of the irrigation development and management in relation to poverty. However, they stressed the need to create enabling conditions to achieve functional inclusion of the poor and enhance their outcomes from irrigation development.

Prior to the 1990s, water management across the globe primarily involved command and control approaches, whereby water supply is secured and controlled through dams, levees, canals and other engineering solutions. Over the last few decades there has been a shift towards a more holistic approach to water resources management that strives for the equitable, efficient and environmentally sustainable development, distribution and use of water resources [18]. While this holistic approach is often aligned with the basin-scale unit of management, it has been argued that water management at such a scale becomes too focused on allocation between major sectors and poorly addresses the needs of the poor and marginalized [19]. Merrey et al. [20] also contend that a policy of basin-scale demand management and the reallocation of water to higher-value use may not be appropriate in underdeveloped basins, where water resources development is considered to be necessary for encouraging economic development and thus reducing poverty.

The community management of water resources has been one approach widely advocated in developing regions [21]. Often referred to as 'bottom-up' or 'grassroots' management, it is seen as a way to accommodate the broader interest of the community, including that of the more marginalized households [22]. It has been recognized that community participation in water management is critical for achieving the following: legitimacy of and trust in the governance process; better community awareness on water-related issues; increased ownership of, commitment to and confidence in management outcomes; more effective management and improved accountability; and improved sustainability of service provision [23]. However, unless an enabling environment for participation is provided and people are given a meaningful role in the decision-making process, there is a risk that participation processes or the local institution itself are captured by the local elite rather than serving the whole community [23–25]. It has also been shown that social structures and norms influence the behavior of different groups in relation to the sharing of water resources [26]. Thus, a better understanding is needed of how social and governance arrangements, including the workings of the local institutions, affect the decision making around water. This understanding can help the design of more appropriate and effective forms of local water governance and partnerships. We refer to institutions as sets of rules, norms and constraints that regulate the activities and behaviors of both formal (e.g., organizations) and informal structures (e.g., interactions between actors) [27,28].

As attested in the aforementioned literature, the important role of social dynamics and governance arrangements is well established. However, the continued, widespread inequities in water access across the globe despite investments in water resources developments, e.g., [29–31], suggest that these learnings have not consistently translated into improved water management. To address these persistent equity issues, Keeler et al. [32] recently called for new approaches to collaboration and knowledge production in water management and policy that address some of the research blind spots, particularly around the justice dimensions. This paper demonstrates an integrated approach that facilitates the co-production of transdisciplinary understanding around marginal farmers' access to water in two case studies by a diverse team of researchers and on-ground practitioners. We posit that this type of collaborative study is in the realm of approaches needed to advance water management towards more equitable and sustainable outcomes.

1.3. Study Aims and Scope

This study aims to understand the main factors that determine access to and use of water by marginal farmers in two case studies in Bangladesh, including the role of social and governance arrangements. Given the multi-faceted nature of water for agricultural development, which includes social, environmental, economic and institutional dimensions, the study adopts integrated assessment as its underlying approach. We developed an integrative framework that maps out the key elements of water governance and distribution, and the causal pathways from interventions and drivers to outcomes. We introduce the case studies in Section 2, describe the methodology we adopted in developing and applying the framework in Section 3, and present the results in Section 4. Insights gained from developing the framework and applying it to the case studies are discussed along with the possible implications of the research on water governance in the region and beyond (Section 5). The paper intends to demonstrate how integrated assessment can be used to facilitate transdisciplinary and collaborative research to enhance the understanding of complex water issues.

The study is part of a larger project aimed at promoting socially inclusive and sustainable agricultural intensification in West Bengal in India and Bangladesh, herein referred to as the SIAGI project (www.siagi.org; [33]). The project has explored the various social, market, environmental and institutional issues and processes involved with agricultural intensification in six rural communities in the region. The focus of the SIAGI project has been on understanding how to address the issues faced by marginalized groups who are at risk of social exclusion and increasing inequity. With this perspective in mind, this paper investigates the role of local water institutions and other factors on access by marginalized farmers to water resources that are intended to be shared by the community.

2. Background to Case Studies

This paper considers two case study villages—Sekendarkhali and Khatail—both located along the coastal delta of south-western Bangladesh (Figure 1). The villages are situated on land bordering tidal rivers and protected by polder embankments. Sekendarkhali is in Amtali Upazila in the Barguna District, and Khatail is part of Dacope Upazila in the Khulna District. Household surveys were carried out in 2016 by the SIAGI project team to obtain basic socio-demographic data for the villages. Sekendarkhali has a population of about 1450 people (292 households), with the majority of households (58%) dependent on agriculture. Khatail has a population of about 1620 people (345 households), with most households (72%) dependent on agriculture.

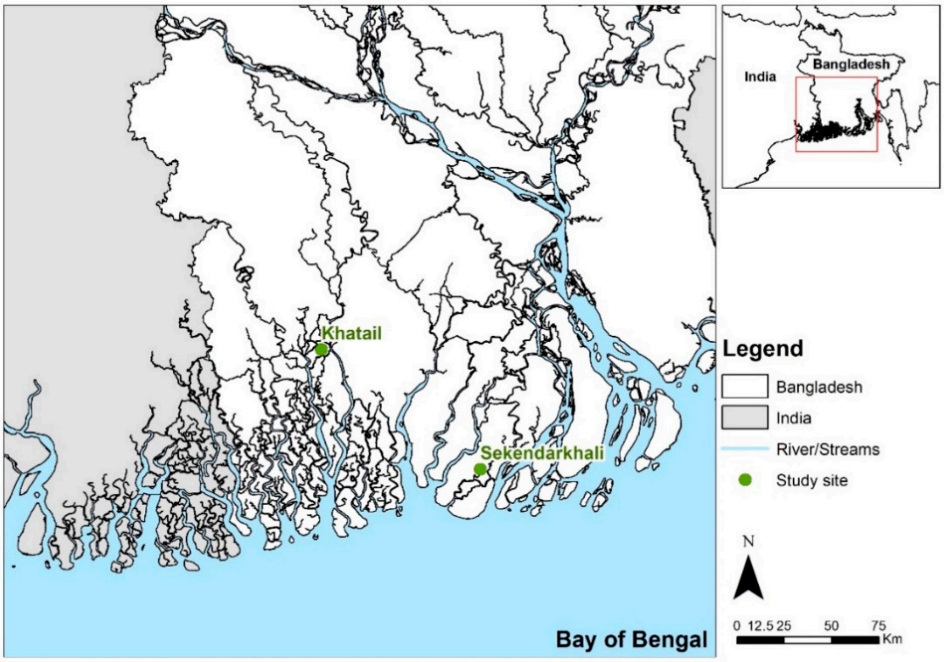

Figure 1. Location of the two case study villages, Sekendarkhali and Khatail, in southern Bangladesh.

At the time of the surveys, 48% of farmers in both villages were landless, and 44% of farmers in Sekendarkhali and 41% in Khatail were small-holder (owning 0.202 to 1.008 ha of land) or marginal farmers (owning less than 0.202 ha of land). Women represented 14% and 20% of farmers in Sekendarkhali and Khatail, respectively. In both villages, the average income for landless, women, marginal and small-holder farmers was USD 0.50–0.70 per day, well below the national poverty line (USD 1.90/day). Food security was particularly concerning for landless, marginal and women-headed farmer households in Sekendarkhali, who on average could only ensure approximately four months of food in a year from their agricultural livelihood activities. In Khatail, landless, marginal and women farmer households could secure food for about seven to nine months a year.

The region has a tropical climate with wet, hot and humid conditions in the monsoon season (*Kharif-II*, July to October) and cooler conditions during the dry 'winter' season (*Rabi*, November to February), followed by a hot and generally dry 'spring' season (*Kharif-I*, March to June) in the lead up to the next monsoon [34]. Rainfall tends to be higher in Khatail, where the annual rainfall typically exceeds 2500 mm, than in Sekendarkhali where the annual rainfall ranges from 1500 to 2000 mm (Bangladesh Meteorological Department, [5]). However, rainfall is highly variable within and between months, seasons and years [5]. During the dry Rabi season, median rainfall is low (≤100 mm) in both villages.

The south-western region of Bangladesh sits on a highly dynamic, tidal floodplain, with a river network that carries and deposits large amounts of silt [35]. From the 1960s through to the 1980s, the national Coastal Embankment Project (CEP) led to the construction of around 125 polders, in addition to canals and sluice gates, across the coastal zone of Bangladesh [26]. The CEP aimed to increase agricultural productivity in the region, and in the first 10 to 15 years was seen as successful in achieving this. However, over time there was a gradual reduction in floodplain storage, accompanied by rising high tide river levels and decreasing low tide river levels. Since the 1980s, in the absence of adequate maintenance of the embankments, the polders have become the source of a range of environmental problems, including the siltation of channel beds, waterlogging and increasing water and soil salinity. This has led to damage to the agriculture, forestry and fisheries sectors, as well as to polder and canal infrastructure [26,35].

From the 1990s until the late 2000s, shrimp cultivation expanded across the region, typically led by absentee land-owners and businessmen [26]. This expansion in shrimp farming, which relies on brackish water conditions, adversely impacted on agriculture, livestock and fisheries through the increase in the salinity of land and water. The increases in salinity in the region are also attributed to reduced river inflows, and occurrences of storm surges from cyclones [36]. Notably, cyclones Sidr (November 2007) and Aila (May 2009) led to the overtopping of the poorly maintained embankments and the subsequent inundation of seawater on land, severely impacting the livelihoods of local communities [37].

The SIAGI project has been working with the Sekendarkhali and Khatail communities since 2016 to identify opportunities for socially inclusive and environmentally sustainable agricultural intensification. Access to freshwater was identified as the key constraint to agricultural intensification in the villages. Although both communities have canals that run through or surround the villages, there were serious issues around water quality and water access. Accordingly, in each of the villages, our NGO (non-government organization) partner facilitated the formation of a Water and Silt Management Committee (WSMC) with support from researchers. The study presented in this paper examines how access to water has changed since the formation of the WSMCs and the role of these local water institutions in the process.

3. Methods

3.1. IA as a Tool for Supporting Water Resources Management

Integrated assessment (IA) is considered a meta-discipline that combines and interprets knowledge from various disciplines and communicates this integrated knowledge in learning and decision-making processes [38]. As a methodology, IA considers multiple and diverse system components (e.g., social, environmental, institutional and market) and their linkages, and it crosses disciplinary, organizational and conceptual boundaries [39,40]. As a process, IA is interdisciplinary (and transdisciplinary), reflective and iterative, and aims to link science to action [41].

IA has become increasingly used for addressing complex socio-environmental problems, including those associated with water resources [42,43], environmental impacts on human health [44], climate and energy security [45] and other cross-cutting areas. Many cases across sectors have shown that assessments that fail to recognize and understand the interlinkages between systems of people and nature can lead to partial solutions, which are ineffective in the long term, or worse, lead to unintended and adverse outcomes [46]. By providing a holistic treatment of issues, IA provides a means to identify connections between issues, explore sustainability trade-offs between policy options, and broaden and deepen understanding of complex problems [47].

Equity in water and natural resource management is a value-laden concept around the fairness of access to a resource and the distribution of benefits and costs. Phansalkar [48] states that equity effects "*are inexorably interlinked with patterns of relationship between resources, action of people, inputs and outputs*", and are inherently emergent and contested. Given the complex nature of equity in agricultural development, IA offers a promising approach to examine its sources and repercussions, and explore ways to manage them.

3.2. IA Framework Development Process

The local water management framework presented in this paper is one of a series of three linked IA frameworks developed in the SIAGI project. The other two frameworks examined (i) inclusive value chains, linking factors determining the producibility and marketability of a crop with the desired outcomes of farmers, and (ii) empowerment as a process of change through the pathways of motivation, self-efficacy, agency and access to resources. The local water management framework facilitates the exploration of factors and issues involved with improving water availability, water quality and ensuring the equitable distribution of water within the community. This scope was first determined in a workshop process with the project team, and subsequently refined through iterative cycles of deliberation.

The IA framework developed in this study is a form of system conceptualization. It identifies and connects the main elements of the problem, thereby capturing the structure and functioning of the system. The process of developing the IA frameworks in the SIAGI project is described in Hamilton et al. [49] and summarized in Figure 2. The frameworks attempt to map out assumptions about the entire process of change in relation to the problem. This includes all factors from the interventions or drivers through to the targeted outcomes, including the intermediate outcomes and the set of conditions that enable the change. This articulation of the connection between activities and outcomes is akin to Theory of Change [50].

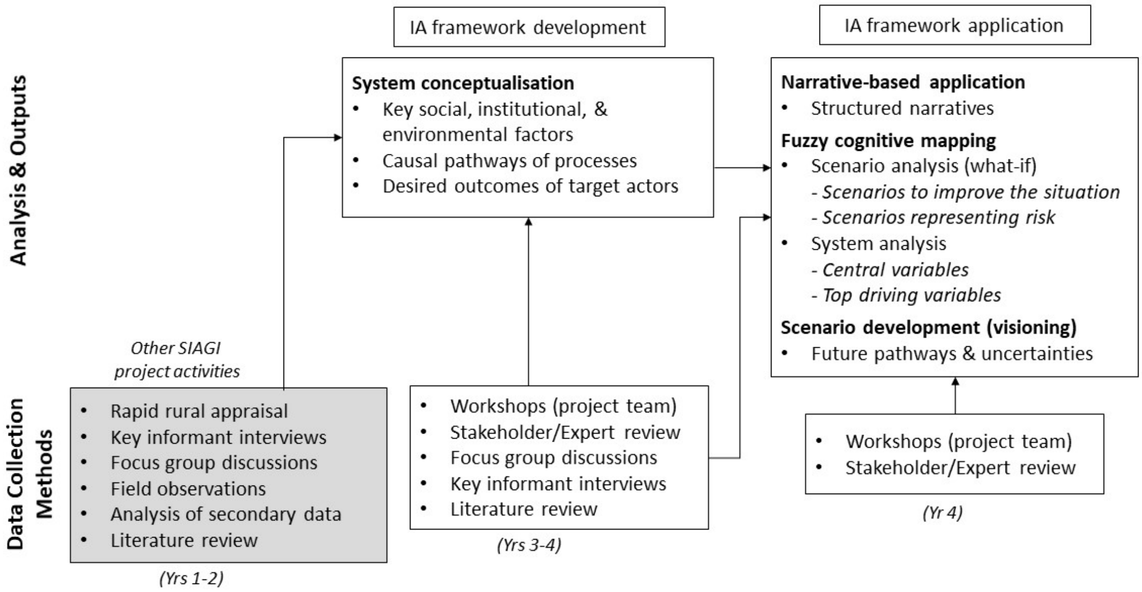

Figure 2. Overview of the integrated assessment (IA) framework development and application methodology, including the data collection methods used and their input to the various analyses and outputs, and the approximate timeline of activities within the 4-year project.

The framework takes the perspective of an actor, who could be an individual farmer or farmer group, and recognizes that each actor may have their own desired outcomes (e.g., reduced workload, good health for their children, increased income). The intermediate and targeted outcomes are dependent on a number of conditions and are bounded by the contextual factors of the actor, including their environmental and cultural setting, and their socio-political and economic position. We refer to any characteristic, factor or variable in the system as concepts. The state of each concept and the strength of the relationships between them can vary between contexts as well as between actors.

The first draft of the framework was developed in a workshop with the project team, including practitioners from the NGO working directly with the communities, and local and international researchers. The identification and delineation of key factors and processes was also based on outputs from other SIAGI project activities, including information from focus group discussions, interviews and field observations. The framework was subject to numerous rounds of review and revision, with additional input from the international literature to ensure the framework was theoretically grounded. The robustness of the framework was tested by applying it across study villages and contexts (including study cases outside of Bangladesh). Where concepts or relationships were poorly understood, additional focus group discussions and interviews were held with community members to obtain and clarify information.

Although the framework was originally conceived for the two Bangladesh case studies, considering water access and use from the community-owned canals, it was modified to be non-specific to Bangladesh, and applicable to SIAGI's West Bengal case studies, and potentially communities in the greater South Asian region.

3.3. Application

The resulting IA framework formed the basis for further analyses. Three forms of application of the IA frameworks were used in the SIAGI project: (1) narrative-based application, (2) semi-quantitative analysis using fuzzy cognitive mapping (FCM), and (3) future scenario development (Figure 2). The local water management study in this paper focuses on a narrative-based application in which the framework was used to structure narratives as a form of qualitative analysis. The narratives document changes in community, including why or how they occurred. A structured approach to developing narratives helps ensure information is collected systematically, and that important details are not missed. This can also enable a better comparison between cases.

4. Results

4.1. The Local Water Management Framework

The framework captures the key factors and issues involved with improving water availability and facilitating more equitable distribution of water within a community, as observed in the case study region. The key concepts we identified can be grouped according to those related to: (i) the physical aspects of the freshwater resource including the water availability and quality, (ii) the governance of the local water institution, (iii) the community dynamics in relation to water, and (iv) the individual actor's access to water (Figure 3). The concepts within and between these four groups are interlinked. In terms of the outputs of the framework, the actors of interest in this study are the often-marginalized farmers, namely landless, marginal, small-holder and women farmers. Other actors are captured in community dynamics and the relevant institutions.

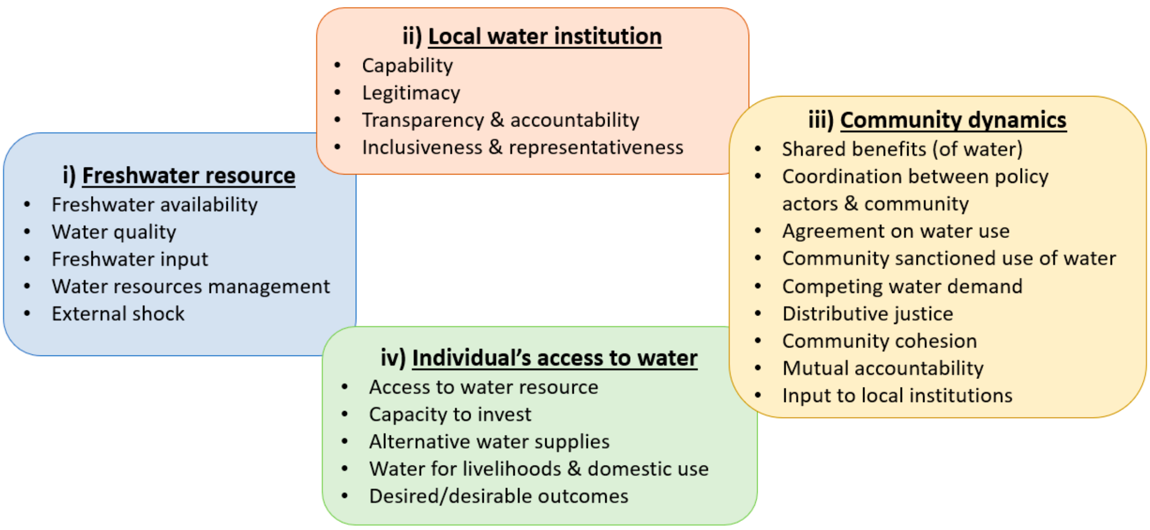

Figure 3. The concepts identified for the local water management framework, grouped according to those related to (i) the physical aspects of the freshwater resource, (ii) the governance of the local water institution, (iii) the community dynamics, and (iv) the individual actor's access to water.

The framework is applied to a water resource shared by a community (e.g., canals, groundwater, etc.). At a high level, the framework describes how access to water by actors can serve their individual livelihood and domestic needs, and is affected by not only the availability and quality of water, but also whether the water has been distributed justly within the community (Figure 4). The full framework presented in Figure 4 identifies all the concepts and their main linkages (refer to Table A1 in the Appendix A for a description of each concept). The concepts and links, which can be positive or negative, are described in the text below, with concept names italicized and numbers cross-referencing their location in Figure 4.

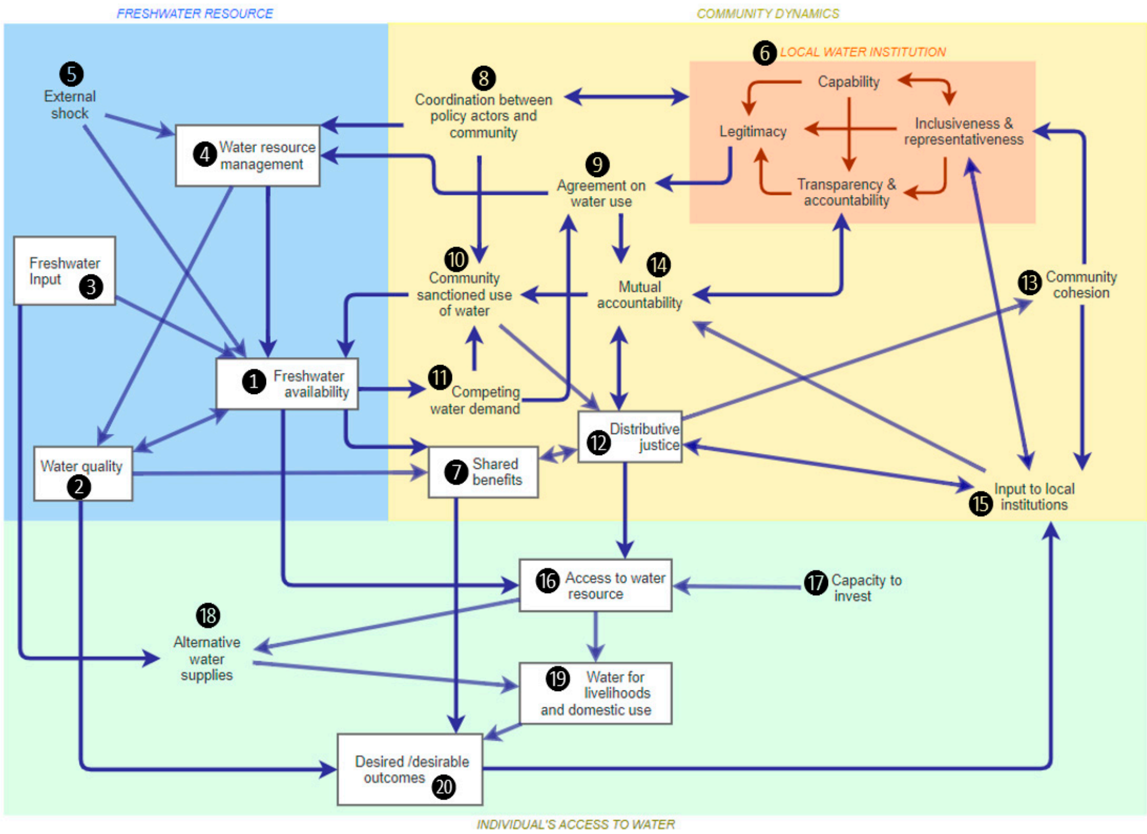

Figure 4. The local water management framework showing the core structure of the framework (concepts in the white boxes) and the concepts that describe the pathways to the core concepts (black text not in a box). For all concepts, definitions or relative importance may differ between people, groups or locations. The concepts are related to the freshwater resource (blue), community dynamics (yellow), the local water institution (orange), and the individual actor's access to water (green).

(i) Freshwater resource

Freshwater availability ❶ is the volume of freshwater available in the water resource and is affected by *Freshwater input* ❸ (e.g., rainfall, streamflow), the *Water quality* ❷ (in that poor quality can render the water unusable), the community's commitment to developing and maintaining the water resource (*Water resource management* ❹), *External shocks* ❺ and the control of *Community sanctioned use of water* ❿. *Water resource management* ❹ includes the development and maintenance of infrastructure as well as appropriate land management for the purposes of maintaining the reliability of supply (*Freshwater availability* ❶) and good *Water quality* ❷. The level of coordination between policy makers, implementing agencies and the community ❽, and agreement (or not) around how water is to be used ❾, are both critical to achieving commitment to water resource management ❹ [16]. Some water resource infrastructure may be exposed to damage from 'outside' the community (*External shock* ❺), for example from extreme weather events or deliberate damage, which can negatively affect *Freshwater availability* (❺→❶).

(ii) Local water institution

The local water institution ❻ is considered in terms of the four pillars of governance adapted from the natural resource management (NRM) governance principles by Lockwood et al. [51]:

- *Capability*—the leadership and skills, competency, knowledge, and experiences of the members of the institution to effectively deliver on their responsibilities, and their ability to adapt to changing conditions;
- *Legitimacy*—the social acceptability of the institution's right to govern;
- *Transparency and accountability*—the visibility of the decision-making process, and whether the institution meets its obligations and is answerable for their actions;
- *Inclusiveness and representativeness*—whether the institution provides the opportunity for all to participate in and influence decision making, and gives unbiased and respectful attention to community members' views in their decision making.

These four governance concepts are interconnected. The capability of the institution and its committee affects its *Legitimacy*, *Inclusiveness and representativeness*, and *Transparency and accountability*. The institution is perceived as more legitimate if it is inclusive, representative, transparent and accountable, and if it has support from the relevant government authorities (i.e., link to *Coordination between policy actors and community* ❽). In addition, the *Inclusiveness and representativeness* of the institution is affected by the level of *Community cohesion* ⓭, which supports the participation of often-marginalized groups in community planning. Being inclusive potentially increases the capabilities of the organization by widening its collective knowledge base and skillset and increases its transparency.

(iii) Community dynamics

Assuming that the level of water allocation decided on by the local water institution is within sustainable limits, the unsanctioned extraction and use of water by groups or individuals can threaten the availability of the resource for the rest of the community (❿→❶). *Community sanctioned use of water* ❿ is determined by *Mutual accountability* ⓮ and the level of *Competing water demand* ⓫ in the community. *Mutual accountability* (defined in Table A1) is expected to reduce the unsanctioned use of water (⓮→❿). If there is a high level of competing demands for water, then the non-sanctioned use of water is considered more likely to occur (⓫→❿), particularly if *Mutual accountability* is low and there is a lack of *Coordination between policy actors and community* ❽.

Mutual accountability ⓮ develops from the *Transparency and accountability* of local water institutions (❻), the *Agreement on water use* ❾, *Distributive justice* ⓬, and *Input to local institutions* ⓯ by community members. *Agreement on water use* ❾ is a general agreement within the community on how much water is needed, how it is to be used, and by whom; this agreement should be strengthened if the local water institution is considered legitimate (❾→❻). *Agreement on water use* may be challenged if there are competing demands for water quantity or quality (⓫→❾), particularly if freshwater availability is low (❶→⓫).

Whether the community believes the distribution of water and costs are fair (i.e., *Distributive justice* ⓬) can depend on not only individual access to and use of water (⓴) but also on potential *Shared benefits* ❼ that arise at a community level and the level of input community members have to local water institutions (⓯). For example, a water-dependent industry may provide off-farm employment opportunities for marginalized actors, or a healthy environment can benefit the whole community. *Shared benefits* ❼ are expected to generally increase with enhanced *Distributive justice*, *Freshwater availability*, and *Water quality*.

The link from *Distributive justice* to *Mutual accountability* is a reinforcing feedback. If the community believes the distribution of water and costs are fair then the commitment to abide by decisions should be further strengthened, and if the community is mutually accountable, distributive justice is more likely to occur (⓬⇆⓮). If (marginalized) actors or the wider community feel they can contribute their opinions and influence decisions, *Mutual accountability* will increase (⓯→⓮). *Input to local institutions* ⓯ will be enhanced with *Community cohesion* ⓭ and inclusive and representative local water institutions ❻, and will be reinforced if a community sense of *Distributive justice* ⓬ develops.

(iv) Individual's access to water

Access to water resource ⓰ describes the ability of an actor (e.g., a person, household or group) to access the community water resource as they require. This access is expected to increase with greater *Freshwater availability* ❶, *Distributive justice* ⓬, and the actor's *Capacity to invest* in irrigation ⓱. The *Capacity to invest* in irrigation captures not only access to finance for irrigation infrastructure such as pumps, but also considerations such as proximity to the water resource (e.g., distance between the canal and farmland, or depth to groundwater) and the security of land tenure, which can affect the willingness or ability to invest in infrastructure [52].

Water for livelihoods and domestic use ⓳ is connected to the actors' access to the community water resource as well as access to *Alternative water supplies* ⓲ such as household ponds, community ponds or tube wells. Water uses can include crop irrigation, fish cultivation, livestock and other livelihood uses, as well as domestic uses such as drinking, cooking, and washing. In many rural communities in South Asia, multi-use household ponds are common as a supplementary or alternative source of water, albeit of limited supply [53]. Such ponds are directly filled through freshwater inputs (e.g., rainfall) (❸→⓲) or by owners filling them from the community-owned water resource (⓰→⓲).

Water use for livelihoods and domestic use ⓳, as well as *Water quality* ❷ and *Shared benefits* ❼, lead to the final output of the framework *Desired outcomes* ⓴. As mentioned in Section 3.2, the framework intentionally avoids imposing what the endpoint is for individual actors, and instead recognizes that each actor has their own set of desired outcomes, including both needs and wants. Water use, through direct use ⓳ or through *Shared benefits* ❼, can enable farmers to achieve their *Desired outcomes*, which might include improved income, improved WASH (water, sanitation and hygiene) outcomes, reduced workload or greater food security. The *Shared benefits* may include off-farm employment opportunities derived from a water-dependent industry, or health and well-being outcomes for individuals derived from improvements to the environmental health of the waterbody. *Water quality* ❷ can affect the desired outcomes through two possible ways. Firstly, if quality of water is too poor (e.g., saline or high in heavy metals such as arsenic) then the freshwater resource may not be used by the community or individual (❷→❶). Secondly, there are cases where, despite poor *Water quality*, the water is still used (knowingly or not) without the necessary treatment to make it safe, and this can have negative outcomes for the health of humans, crops or livestock (❷→⓴).

Small or marginal households comprise the majority of the communities in our study. We hypothesize that as marginalized actors start to achieve positive, *Desirable outcomes*, this should strengthen their agency to give input to, and influence, local institutions (⓴→⓯).

4.2. Case Study Narratives

The framework was used to structure narratives around water access in the two case study villages, both before and after SIAGI project interventions. Each of the concepts from the framework were considered in developing the narratives, however some concepts were not included if deemed unimportant (e.g., 'external shock' was not considered a key driver in water access in Sekendarkhali in the baseline situation).

4.2.1. Sekendarkhali Case Study

Sekendarkhali before the SIAGI Project (Pre-Intervention)

Prior to 2016, agriculture in Sekendarkhali was primarily constrained to the production of rice crops in the rainy (Kharif) season. Most of the land was fallow for the remaining seasons of the year, with some open rearing of cattle. During the dry Rabi season, the village was faced with water availability issues. Only a limited amount of freshwater was available in the deeper aquifer, at depths of 700 to 1000 feet below ground. Three hand tube wells had been installed by the government or through cost-sharing arrangements with the community for domestic water supply. There are two canals that flow through the village: Hafamari and Muchibari. However, during the dry season, both canals would dry out and the Muchibari canal in particular would become saline (➊, ➋ and ➌ low in Rabi season). The canals were also poorly managed, and left heavily silted with the sluice gates not fully functional (poor ➍).

Saline water was introduced into the canals through the sluice gates to support brackish water fishing and shrimp farming. Even though the canals were regarded as common resources, they were controlled by a few influential members of the community, including fisherman and shrimp farmers, and could not be accessed by all those in the community (➐, ➓ and ⓬ lacking). There was no local water institution (➏), and no coordination between the local government and community with regards to water management (➑). Consequently, there was no community cohesion in relation to water, no agreement on water use, no mutual accountability, and marginalized groups had no agency to influence the behavior of, and use of water resources by, others (i.e., ⓭, ➒, ⓮ and ⓯ were absent). Household members (mostly women) had to carry drinking water sourced from one of the three shared hand tube wells, typically 300 to 500 m away from their houses. Freshwater availability was a critical issue in this village that needed to be addressed for both livelihood and domestic needs (limited ⓰, ⓳ and ⓴).

Sekendarkhali Post-Interventions

From the start of the SIAGI project, engagement with the Sekendarkhali village revealed a high level of motivation within the community to improve their water-dependent agricultural and WASH outcomes. A Water and Silt Management Committee (WSMC), covering the Hafamari and Munchibar canals, was formed in the village with the help of project partners (➏ established). The project partners (i.e., the NGO) supported the community in developing a constitution that outlines rules and regulations around the membership and operation of the WSMC. The WSMC aims to include all members of the community, and build accountability and transparency in discussions and decisions on the maintenance, development and use of community water resources. This included rules about minimum representation of women, landless and marginal farmers in the elected executive committee. Through village-wide campaigning, over 80 households (out of a total of 292) became members of the WSMC.

One of the first decisions made by the WSMC was to re-excavate the Hafamari canal, with all members contributing to the excavation work through either cash or labor (➍). The community contributed to 48% of the costs of the excavation, with the remaining covered by the local government (8%) and funds from SIAGI and its sister project (44%). The WSMC also made the decision to limit saline ingress and keep the canal water fresh (increase in ➒, and subsequently ➋). The re-excavation of the Hafamari canal substantially increased its storage capacity and enabled it to form a good connection to the Pujakhola Canal, which connects to the Payra River, thereby providing freshwater to the Hafamari canal (➍→➊).

Another key change that has occurred in the community was greater coordination between policy actors and community (increase in ➑). Before, most in the community were reluctant to talk to the politically connected or government officials, but the project partners encouraged the more active group members to step up and talk with these stakeholders. Gradually the community has gained the support of the government officials, who now participate in some community meetings. WSMC negotiated with the local government to construct culverts to enable regular water flow and improve freshwater availability in the canal through flows from the Pujakhola canal and Payra river (➑→➍→➊). Having the government support has been important in helping to resolve conflicts, and has given more legitimacy to the WSMC (➑→➏). Community members are increasingly raising their voices regarding water-related issues (increase in ⓯). There is a greater sense of community ownership of the local water management, which has led to increased mutual accountability and subsequently reduced the unsanctioned use of water (⓯→⓮→❿).

There is no longer brackish water fishing and shrimp farming in the village, with many of those fishermen and shrimp farmers shifting to freshwater fish culture. Some conflicts over water use remain, but overall the shared benefits from water in the community have increased across the board (❼). There have been times when individuals have not complied with the wishes of the majority (❿ and ⓫). An example of this is the brick manufacturing field owner who listened to community concerns over the extraction of water from the canal for the business, yet continued to take water from the canal. In this case the community raised the issue with the local government, but no intervention or penalties applied. In another example, there was an agreement with the WSMC and community to limit dry-season Boro rice, however a couple of the executive members started planting Boro. When the general members questioned this, those executive members declared that the ban had been lifted due to sufficient water, although this was never formally discussed with the WSMC. These examples suggest that although there have been demonstrated improvements in the community with regards to water management (e.g., in all concepts from ❼ to ⓮), this is still a work in progress, and there is much room for further improvement, especially around the transparency of decisions, and building mutual accountability.

Members of the community have reported that social capital and community cohesion in general have improved considerably since the formation of the WSMC (increase in ⓭). However, some have noted that tensions do remain due to external influences or political reasons, and as a result of some members driven to gain more wealth over others. Such conflicts of interests have created problems for others, particularly the poor.

The improved freshwater availability and access to water resources has enabled villagers (including marginal, landless and women farmers) to increase their use of freshwater for livelihood and domestic uses (increase in ⓰ and ⓳). There has been a notable increase in vegetable cultivation (along the canal dykes and in the field) in the village in the dry season. Although this increase in production is also a result of other project activities aimed at farmers' technical knowledge in agriculture, it would not have been possible without improved access to water. Some households have been able to replenish their household ponds several times from the Hafamari canal during the Rabi season to use for domestic purposes (increase in ⓲). The capacity to invest (⓱) remains a key constraint for many marginalized farmers, especially with their limited access to finance. There remains an equity issue for women and other poor farmers whose land is distant from the canal, as it affects their access to water, and the cost to irrigate.

A number of outcomes (⓴) from improved access to water have been reported by households, ranging from increased vegetable consumption, increased income, and a reduced need to migrate for work (i.e., increased earnings from Rabi production means that there is less pressure for men to seasonally migrate), to increased expenditure on children's education. Another important outcome from the formation of the WSMC has been an increase in the collective agency of the community and agency of individuals. The inclusiveness of the WSMC has helped increase the voice of marginalized members of the community, empowering many to speak out about issues including those unrelated to water. The WSMC has served as a venue for the community to manage other conflicts; for example, in 2019 the WSMC acted as a mediator to resolve a conflict between two groups over livestock damage to crops. The WSMC also helped three poor female members to lease land for cultivation free of charge by negotiating with the landowners on their behalf.

4.2.2. Khatail Case Study

Khatail before the SIAGI Project (Pre-Intervention)

Similar to Sekendarkhali, agricultural production in Khatail was relatively low prior to 2016, with most cultivation limited to Aman rice in the rainy season. Due to its location, Khatail is subject to higher salinity than Sekendarkhali; Khatail sits within Dacope Upazila, which is considered one of the most cyclone-prone and saline-affected areas in Bangladesh [37]. The rivers and canals that surround the village are fed by freshwater discharges from the Ganges River through the distributaries of the Gorai River. While the waters are fresh during, and in the couple of months after, the monsoon, the offtake to the Gorai River becomes dry thereafter, causing saline water to ingress from the Bay of Bengal during the dry season [54]. River salinity in the dry season has been exacerbated by reduced inflows from the Ganges River and the siltation of the river system over the last few decades [36]. In addition, the sluice gates were controlled by shrimp farmers (comprising 3–5% of households), who would allow saline water to enter the canals. Although few in number, the shrimp farmers had strong political and institutional links with government officials. Prior to the SIAGI project, the seven canals surrounding Khatail were brackish during the dry season and heavily silted due to poor management of the canals and sluice gates (poor ❶, ❷, ❸ and ❹), preventing most farmers from growing dry season crops (no ❼ and ⓬). The use and consumption of brackish water has also been linked to widespread health-related problems (stomach, liver, and skin) in the community, particularly in women and children, as well as livestock and poultry (❷→⓴).

The village was badly affected by the storm surge associated with cyclone Aila in 2009, which inundated its polder, rendering its land too saline for cropping for almost four years (❺). Following cyclone Aila, a High Court ruling stopped sluice gate operators from allowing saline water to enter the canals. While this ruling was abided by in the first few years while the land and environment recovered, subsequently shrimp farmers recommenced manipulating the operation of the sluice gates to allow the ingress of saline water (❾, ❿ and ⓮ lacking). There were high tensions in the community over freshwater availability (⓫). Marginalized farmers, despite being the majority in the community (95–97%), felt unable to speak up about the salinity issue due to the influence of more powerful shrimp farmers and their affiliates (no ⓭ and ⓯). As with Sekendarkhali, Khatail had no local water institution, and lacked coordination between the local government and the community over water management (no ❻ and ❽). The groundwater in the village is saline at depths of up to 1200 feet below the surface, making tube wells unfeasible. Households harvested rainwater for drinking using mud-pots or plastic tanks; however, for most households this was insufficient for the dry season. Women often fetched water for drinking and some other domestic uses from tube wells in neighboring villages 3 to 4 km away from their homes, and sometimes purchased water from a water treatment plant in Chalna market 7 km away (limited ⓰, ⓳ and ⓴).

Khatail Post-Interventions

A Water and Silt Management Committee (WSMC) was formed in Khatail with support from the SIAGI team. The Khatail WSMC constitution is similar to that of Sekendarkhali, with rules and regulations aimed at including all members of the community and with a minimum representation of marginalized groups in the executive committee (❻). Other interventions included community engagement processes by the project partners that sought to encourage and empower the marginalized members of the community (⓯), and help connect the WSMC with the local government (❽). Unlike Sekendarkhali, the WSMC and community in Khatail have had difficulties obtaining support from the local administration (Upazila); this likely stems from the competing interests of those who are associated with shrimp farming. The conflict between shrimp farmers and crop farmers in Khatail has somewhat intensified (increase in ⓫). Marginalized farmers have reported an increase in harassment from shrimp farmers and their associates. There were allegations that some members of the WSMC may have been bribed to spy on the WSMC on behalf of shrimp farmers. However, in parallel, unity amongst the marginalized farmers has improved, and as a group they have developed collective agency that has enabled them to speak up to higher authorities (overall increase in ⓭ and ⓯). The WSMC successfully coordinated a petition to the local administration, with support from the villagers, neighboring communities, and community leaders, to effectively close the sluice gates in the dry season so that all community members can get access to freshwater (❻→❽, ❻→❾). The WSMC was able to store freshwater in four out of seven of the village's canals for the dry season through building dykes (❹→❶, ❹→❷→❶). Members of the community take turns to guard the freshwater canals and dykes (especially from intentional breaching of dykes), and it has been reported that on the whole the community is complying with the water use agreements of the WSMC (⓮→❿).

With access to freshwater from these canals, farmers have been able to grow crops during the dry season, as well as access water for drinking, domestic use and livestock use (increase in ⓰ and ⓳). Women are happier as they no longer need to travel long distances to collect water (⓴). For the first time, in 2020 farmers across the village have had successful dry season crops. Watermelon in particular has been highly successful, bringing returns on investments of 500 to 600%. The watermelon growers also received marketing support from the local administration, which has led to farmers starting to sell watermelons and vegetables to new markets, including those in Khulna and Dhaka. These outcomes have encouraged many farmers to seek to increase land to grow more crops in future years. Farmers have reported that the additional income from dry season crops has provided them with money to buy essential things for their family and home, pay for their children's education, buy livestock and poultry, and invest in future crops (⓳→⓴).

5. Discussion

5.1. Key Case Study Insights

The IA framework integrated a range of social, institutional and environmental factors and processes. Water access is determined by the intersection of four dimensions: (i) the physical availability of freshwater, (ii) the effectiveness of the local water institution, (iii) the community dynamics, including power relationships within the community, and (iv) the individual's access to water. While the availability of the freshwater resource itself is undoubtedly important, the case studies highlighted that when the resource is partially or fully constrained, institutional factors and social dynamics are critical to determining if marginalized actors can benefit from water interventions.

From a justice perspective, the interventions of the WSMC establishment and capacity building have elements of building interactive justice (interactions between participants are seen to be fair and respectful) and procedural justice (intervention is organized to ensure that there is appropriate influence, representation, opportunity for voice, power sharing and leadership) [16,55]. The collective agency of the community that developed through the establishment of the WSMC and capacity-building activities, and their relative success in achieving distributive justice in water, has led to marginalized households having greater agency to speak up about not only water issues but also other non-related issues within the community. This supports the notion that by treating water management as a 'creation of benefits', water becomes a tool for empowerment. This is a discernible improvement in the case study communities.

Procedural justice issues of representativeness and voice have been largely successfully demonstrated in these case studies; but perhaps on this point there needs to be more definition in the spheres of power and impartiality. This is shown by the seeming impunity of the more powerful of the community, feeling entitled to grow crops, as they felt that there was enough water without consultation with the community group and the apparent bias of local government officials to the more wealthy. In Patrick et al. [55], consistency and impartiality are considered as important dimensions of procedural justice, and these do not seem to have been formally achieved at this point. Further, in examining value chains in a case study setting, Thorpe [56] has recognized further considerations are necessary if the new institutions are to successfully operate in the long term. There will be a need for locally agreed conflict resolution mechanisms dealing with complaints, and informal long-term agreements on mutual expectations as to the functioning of water management, including the role of the government [56,57].

It must also be considered that whilst transferring power and responsibility for the management of water resources to the community has been posited to lead to improved efficiency and equity in its distribution, the evidence for this in the literature has been mixed [21,58,59]. This adds weight to the complexity of the processes and relationships represented in the framework, whereby positive outcomes for the community are dependent on a number of conditions. The major barriers to achieving equitable outcomes from community-based or participatory management identified in the international literature seem to be based around the perpetuation of unequal power relations [22], and to a lesser degree, the inadequate capacity within the community to effectively manage the resources [59]. We therefore discuss the role of power dynamics in the management of water resources in greater detail.

Inequalities in Power

Studies elsewhere have shown that inequalities in power can be reinforced with the introduction of local water institutional structures [24,60]. Those less powerful tend to forgo their own interests to avoid challenging social norms and disrupting the social cohesion at an interpersonal or community level [61]. Individuals may seek to maintain the status quo in power dynamics if they are dependent on these social relationships. Funder et al. [22], who examined the strategies of the poorest community members in local water conflict in three case studies across the globe, found that the poor were often dependent on the more affluent for work or for borrowing food or money in times of need, and so they avoided any direct confrontation with these more powerful actors in regards to water. Poor people in such dependency relations did not speak up, and either relied on the 'middle strata' to argue their case, or they completely disengaged and sought alternative (less desirable) water resources [22]. This highlights that addressing inequalities in water access needs an understanding of the constraints that the marginalized face, and a broad approach in tackling the sources of the power asymmetries.

Asymmetric power relations were evident in both case study villages, particularly prior to project interventions. Similar power dynamics with respect to water have also been reported elsewhere in southern Bangladesh [62], with communities in the region described as highly patriarchal, hierarchical and unequal [26]. In our two case studies, there was evidence that the SIAGI project interventions led to shifts in power relations within the communities. Although the marginalized households represent a majority in terms of numbers, their voices were previously limited with respect to community-level issues or decisions. There are indications that the local water institutions formed have provided an inclusive space where marginalized farmers are empowered to speak out. This outcome is likely due to a number of factors, not only the establishment of the local water institution.

Firstly, the local water institutions in both villages were specifically designed to be inclusive, through rules about the minimum representation of women, landless and marginal farmers in the executive committees and the explicit aim to include all members of the community in the project's engagement with the WSMC. Our NGO partner's engagement in a range of community engagement activities over the years helped to sensitize the community, motivate and empower the marginalized members, and build capacities within the community to manage resources and improve their irrigated agriculture. They facilitated some of the initial discussions and encouraged marginalized members to participate and speak out in WSMC meetings, as well as to sit together at the same level as landlords and community leaders during these meetings. The NGO also encouraged the more active members to talk to stakeholders and government officials. As a result, in Sekendarkhali in particular, community members have taken a more active role in voicing concerns directly to government officials, without involvement of the NGO. Therefore, the project's interventions through the NGO's activities directly contributed to the development of several broad-reaching factors related to water management and community dynamics in general, as well as empowering farmers to access finance and other government and non-governmental services (❹–❽, ⓭, ⓯ and ⓱ in Figure 4).

While the case studies showed that power over decisions about water has shifted to the community on a whole, there are indications that individual players can potentially undermine outcomes in achieving equity in water access. In the first instance, the executive members of the WSMC in Sekendarkhali made decisions about water management without consulting with the WSMC or community. Only when they were seen planting dry-season Boro rice and were challenged by the other members did they declare that the ban was lifted due to sufficient water. The lack of consultation and transparency seemed to be quickly dismissed by the community as most farmers were set to benefit from Boro rice production, although it is positive that these executive members were somewhat held accountable. Such misuse of power may not have been overlooked so easily in other circumstances, particularly if such unilateral decisions led to uneven outcomes in the community.

Redressing the power imbalance over water in Khatail has been more challenging. The local water institution relies on support from local- and district-level governments to uphold decisions that they make and to build cooperation between the community and government. However, the perceived vested interests of some government officials in protecting their relationships with shrimp farmers may have stymied efforts by the community to ensure freshwater availability in Khatail.

5.2. Advantages and Limitations of the IA Approach

The process of developing and implementing this water management framework has highlighted the complexity of water governance and community dynamics. Although each of the individual concepts in the framework are relatively simple, their interactions are complex. Notably, the framework contains many reinforcing feedback loops between the four main components of the framework (i.e., the freshwater resource, local water institution, community dynamics and individual's access to water), and particularly between concepts within the community dynamics component. For example, limited freshwater availability can increase competition for water (❶→⓫), which can lead to unsanctioned use of water (⓫→❿), which subsequently reinforces the limited availability of freshwater (❿→❶). The high interconnectivity of the system means that many variables may change simultaneously, making it difficult to isolate the effect of a single variable and confounding understanding of the system's behavior [63]. The framework also shows that there are a number of intermediate outcomes between potential interventions or drivers and the target outcomes ('Water for livelihoods and domestic use' and 'Desired outcomes'), as well as several potential impact pathways. These may lead to the impact of an intervention being dampened by other drivers.

In the two case studies, there were interventions involved at all four components illustrated in the framework, including the set-up of the local water institution (❻), the community engagement activities (⓭, ⓯), improvements to the water infrastructure (❹) and other support (❽, ⓱). It is likely that the relative success observed in the villages thus far is a result of having this broad suite of interventions that address different constraints across the system. The IA approach as used in this study cannot test which intervention(s) contributed most to the outcomes observed. Rather, the approach provides a means to think through, articulate and discuss the multidimensional problem. It explicitly avoids a purely management or technical discourse around interventions and their outcomes, an approach which Venot and Clement [16] note can fail to meet local demands and even reinforce injustices.

The framework was also applied to the other four SIAGI project villages in West Bengal, India, to test the validity of the concepts and relationships (unpublished). The context there was irrigated groundwater development in two villages, and the community use of ponds and WASH outcomes in the other two villages. Despite the different contexts, the same high-level concepts and relationships seemed to hold true. Local water institutions had yet been established in the West Bengal case studies, which limited their applicability in this study, although the framework could help guide the design of equivalent interventions in these case studies. We consider the framework appropriate to similar agro-ecological settings (i.e., Eastern Gangetic Plains) and perhaps more broadly to international development and water research in other countries; however, this needs to be tested.

The process of developing the framework involved synthesizing and structuring the team's understanding and assumptions about the problem [64]. This allowed the team to co-develop a broader and deeper understanding of the role of local water institutions and community dynamics in the equitable distribution of water within communities. Transdisciplinary learning also occurred amongst the disciplinary and culturally diverse members of the team. The generality of IA means that concepts from across disciplines could be brought together in one framework. This process enabled the team to capture and link a diverse range of important concepts in the framework, including those that are often overlooked in water management, such as justice and governance concepts [32]. Potential users of the framework (e.g., donors, researchers or other stakeholders) can use it as a tool to think through pathways from actions through to intended outcomes, including possible risks to and from those outcomes, and supporting the mechanisms needed to achieve the outcomes. This could potentially be helpful to all stages of a project or intervention, from the design to completion, and its monitoring and evaluation.

There is potential to apply the framework in a semi-quantitative analysis using an integrated modeling approach, such as fuzzy cognitive mapping (see [65]). Such quantitative modeling was applied to one of the other IA frameworks developed in the SIAGI project on inclusive value chains [66], but due to resource and time limitations, was not carried out for the water framework presented here. A common challenge with modeling socio-environmental systems, such as the one presented in this study, is the difficulty in measuring many of the variables. In the case of the value chain framework, fuzzy cognitive mapping was found to be amendable to this challenge, by allowing relationships to be quantified by weights between 0 (no relationship) and 1 (very strong relationship); such weights can be readily elicited from stakeholders or experts. As such, there is capacity for the framework to be applied in further analyses. Despite being limited to a narrative-based analysis in this study, the IA approach was found to provide a rich reflection of the system and its relationships, and a depth of analysis that would not have been achieved through purely quantitative methods.

Another potential area for the future application of the framework (or approach in general) is as a tool for monitoring, evaluation and learning (MEL). IA can provide a means to structure the MEL process, such that the framework, which essentially represents the team's working hypotheses of how the system functions, guides the selection of indicators to measure and monitor. The indicators targeted may be important factors as well as knowledge gaps. This process will enable the hypotheses around the various impact pathways to be tested once enough data have been collected.

6. Conclusions

Addressing equity in the access and distribution of water in impoverished communities is a complex challenge that requires a whole-of-system approach in order to understand the various factors involved and how they are connected. We demonstrated how such a holistic and transdisciplinary view can be developed using an IA approach. This approach facilitated an improved understanding of the intricacies of the social processes involved in attaining sufficient agreement within the community about how the water resources are managed, and ensuring that benefits and costs are distributed equitably amongst the community. Insights from the IA process suggested that for equitable outcomes in water to be achieved, a community requires not only an effective water management institution but also community dynamics that encourage and maintain mutual accountability. The crux of the issue around equity in water access, as found in our study and others, appeared to be the unequal power dynamics within communities. For equitable access to be realized in a community, existing power structures need to be challenged and reconfigured. This implies that efforts need to go beyond interventions focused on physical infrastructure, to interventions that build agency and capacities particularly within marginalized groups to ensure they (at least collectively) have the confidence to influence decision making at the community and local government levels. Part of this also includes having institutional arrangements that provide an enabling environment for marginalized groups to meaningfully contribute to discussions and decision making. The IA approach, as adopted in this study, is not intended to replace more sociological approaches but to provide a means for researchers and practitioners to think about the broader aspects of water-related problems and the implications for design, monitoring and evaluation of interventions. Such an approach can facilitate the collaboration of diverse teams and the co-production of knowledge that is required for water science to help address issues of sustainability and inequalities in water access.

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Appendix A

Table A1. A description of all the concepts mapped out in the local water management framework.

Concept	Description
	Freshwater resource
❶ Freshwater availability	Volume of freshwater available in the water resource
❷ Water quality	Quality of the water resource (e.g., salinity, nutrients, heavy metals, and pesticides)
❸ Freshwater input	The volume of water input to the resource through recharge, river flow, or direct rainfall
❹ Water resource management	The community's commitment to (and action in) managing the water resource to maintain reliability of supply and quality of water. This includes infrastructure (e.g., sluices gate, solar pumps) and appropriate land management (e.g., stock exclusion; use of pesticides, etc)
❺ External shock	Damage to the community water resource that is the result of a 'shock' that is external to the community
	❻ *Local water institution*
Capability	The leadership and skills, competency, knowledge, and experiences of the members of the institution to effectively deliver on their responsibilities, and their ability to adapt to changing conditions
Legitimacy	The social and political acceptability of the local institution's right to govern
Transparency & accountability	The visibility of the decision-making process, and whether the institution meets its obligations and is answerable for their actions
Inclusiveness & representativeness	Whether the institution provides opportunity for all to participate in and influence decision making, and gives unbiased and respectful attention to community members' views in their decision making
	Community dynamics
❼ Shared benefits	Benefits of freshwater resource that are shared by the community (e.g., community aquaculture, employment opportunities, ecosystem services)
❽ Coordination between policy actors & community	Coordination between policy actors and the community, as evidenced by (e.g.,) mutual trust and empathy, keeping agreements, regular communication and co-development of plans for water infrastructure and management
❾ Agreement on water use(s)	General agreement on how the water resource is to be used, and by whom
❿ Community sanctioned use of water	Use of the water resource by individuals complies with the wishes of the majority of the community
⓫ Competing water demand	Presence of water users that have competing needs for water quantity and/or quality
⓬ Distributive justice	Community feel that water allocation, and costs to develop and maintain water infrastructure are fair
⓭ Community cohesion	The culture and unity of the community that supports the participation of often-marginalized groups in community activities.

Table A1. *Cont.*

Concept	Description
⓮ Mutual accountability	The commitment of the community as a whole to take responsibility for the water management and abide by the decisions and rules of the local water institution around the distribution and use of water
⓯ Input to local institutions	Actors can give input and influence the discussions and decisions of the local water institution
Individual's access to water	
⓰ Access to water resource	The ability of the actor (e.g., a person, household or group) to access the water resource as they require
⓱ Capacity to invest in irrigation	Capacity to invest in a water-dependent livelihood activity reflects access to assets (finances, equipment, proximity to resources, etc) needed to invest in irrigation, as well as the actor's autonomy to invest in irrigation (e.g., influence by land tenure, social norms, etc)
⓲ Alternative water supplies	Access to alternative water supplies that may be used to supplement household water needs (consumption and livelihood), for example household ponds, community ponds or tubewells
⓳ Water use for livelihoods and domestic uses	Water use by the actor for (e.g.,) freshwater fish cultivation, livestock production, crop production and/or domestic purposes (e.g., consumption, WASH)
⓴ Desired/desirable outcomes	Outcomes that support the capacity of the actor to meet their underlying goals. These may be anticipated outcomes (desired) or emergent outcomes of benefit to the actor (desirable).

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