Collective Action for Market Access and Productivity in Agriculture: The Case of Rice Farmers in Tanzania

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ABSTRACT

Producer organizations (POs) are widely promoted as a mechanism for improving smallholder productivity and market access, yet evidence on the factors associated with their long-term sustainability in sub-Saharan Africa remains limited. This cross-sectional, convergent mixed-methods study examined rice POs in seven irrigation schemes in Iringa District, Tanzania. A structured survey was administered to 210 farmers, with 30 randomly selected from the membership roster of each of the seven purposively selected POs, complemented by 10 key informant interviews and seven focus group discussions. Quantitative analyses comprised ordinary least squares and logistic regression with cluster-robust standard errors to account for clustering of farmers within schemes, and a chi-square test of association. Perceived irrigation infrastructure quality was positively associated with rice yield (B = 1.42 tons/ha per scale point; cluster-robust 95% CI [0.83, 2.00]), although this association received only qualified support under the most conservative test available with seven clusters (wild-cluster bootstrap p = .078). Sustained collective engagement, a composite indicator that includes marketing paddy through the PO, was associated with a mean price that was 39,303 TZS higher per 100-kg bag (95% CI [20,820, 53,408]; bootstrap p = .016). Perceived leadership quality was associated with sustained collective engagement (OR = 4.19; cluster-robust 95% CI [1.72, 10.23]), and scheme-level storage utilization was associated with credit access ($\chi^2(2, N = 210) = 47.29$, $p < .001$, Cramér's $V = .48$). Qualitative findings revealed mistrust rooted in delayed payments, weak accountability, gendered exclusion, and insecure tenure. Recommendations, including expanded warehouse receipt systems and leadership development, are proposed for piloting and evaluation.

Keywords: collective action, producer organizations, market access, agricultural productivity, rice farming

I. INTRODUCTION

Smallholder agriculture remains the cornerstone of food security and economic livelihoods across sub-Saharan Africa, supporting several hundred million people and contributing substantially to regional economies (FAO, 2017; Jayne et al., 2010). In Tanzania, where agriculture accounts for about 26% of GDP and employs roughly 65% of the workforce, smallholder farmers face persistent challenges, including low productivity, limited market access, and inadequate resources (World Bank, 2022). These

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constraints are particularly pronounced in rice, a critical food and cash crop grown predominantly by smallholders (Wilson & Lewis, 2015). Average paddy yields in Tanzania remain near 2.4 tons per hectare, well below the estimated attainable level of about 6 tons per hectare under improved irrigation and input use, reflecting inefficiencies in irrigation systems, limited access to quality inputs, and fragmented market linkages (Nakawuka et al., 2018; Wiggins, 2009; Wilson & Lewis, 2015).

Collective action through producer organizations (POs) has emerged as a promising strategy for addressing these constraints by enabling economies of scale, improving access to inputs, and strengthening bargaining power in markets (Markelova et al., 2009; Shiferaw et al., 2011). POs can facilitate coordinated production, shared infrastructure management, and collective marketing, thereby reducing transaction costs and improving returns for smallholders (Fischer & Qaim, 2012a; Williamson, 1985). Evidence from Ethiopia, Kenya, Rwanda, Uganda, and Tanzania suggests that well-functioning farmer organizations are associated with improved technology adoption, marketing performance, and incomes (Abebaw & Haile, 2013; Barham & Chitemi, 2009; Kaganzi et al., 2009; Verhofstadt & Maertens, 2014). In Tanzania, the National Rice Development Strategy Phase II (2019–2030) and the Agricultural Sector Development Programme Phase II identify POs as key mechanisms for commercializing smallholder agriculture, particularly through investments in irrigation schemes and market infrastructure (URT, 2017, 2019).

Sustaining collective action in resource-constrained settings is nonetheless difficult. Free-riding, weak governance, and dependence on external funding can undermine the long-term viability of POs (Christoplos, 2010; Olson, 1965; Salifu et al., 2010). In Tanzania, these organizational challenges interact with contextual factors, including insecure land tenure, poor rural road connectivity, and thin markets, which raise marketing costs and weaken coordination (Barham & Chitemi, 2009; Odgaard, 2002; World Bank, 2022). Climate variability poses additional risks to irrigation-based systems, necessitating adaptive governance and resource management (Morton, 2007).

A further, and frequently neglected, dimension of PO sustainability concerns power relations and social differentiation within organizations. Participation in collective institutions is shaped by gender norms, care responsibilities, landholding differences, and prior organizational experiences; formally open memberships can conceal what Agarwal (2001) terms participatory exclusions, in which women and poorer members are present but exert little influence. Gendered barriers to participation in water-user and marketing organizations are well documented (Fischer & Qaim, 2012b; Meinzen-Dick & Zwarteveen, 1998), and group heterogeneity in wealth and status has context-dependent and often ambiguous effects on collective action (Poteete & Ostrom, 2004). Elite capture of cooperative benefits and leadership positions has likewise been reported in Ethiopian marketing cooperatives (Bernard & Spielman, 2009). These distributional questions matter not only for equity but for sustainability, because members who perceive unfair benefit-sharing are more likely to withdraw.

Despite the growing literature, a knowledge gap persists regarding the sustainability of POs in irrigation-based rice systems in sub-Saharan Africa. Previous studies have concentrated on short-term outcomes such as yield or market-access gains,

paying less attention to how governance, infrastructure, social differentiation, and policy support jointly relate to enduring collective performance (Markelova & Mwangi, 2010; Shiferaw et al., 2011). This study addresses that gap through an analysis of seven irrigation-based rice POs in Iringa District, Tanzania.

Research questions and hypotheses

Consistent with the cross-sectional, observational design, the study examines associations rather than causal effects. It addresses the following research questions:

1) How is collective rice production organized in the schemes, and how is perceived irrigation infrastructure quality associated with rice yields?
2) How is sustained collective engagement, a composite behavior that includes marketing through the PO, associated with the farm-gate price farmers receive?
3) How is perceived leadership quality associated with sustained collective engagement?
4) How is scheme-level storage utilization associated with farmers' access to credit?
5) What institutional, social, and structural factors, including trust, gender relations, tenure security, and external support, shape participation in and the sustainability of collective action?

Four hypotheses, presented below as directional expectations corresponding to RQ1–RQ4, guided the quantitative analyses.

H_1: *Perceived irrigation infrastructure quality is positively associated with rice yield.*

H_2: *Sustained collective engagement is positively associated with the price received per 100-kg bag of paddy.*

H_3: *Perceived leadership quality is positively associated with sustained collective engagement.*

H_4: *Scheme-level storage utilization is positively associated with members' access to credit.*

One measurement limitation warrant noting at the outset, is that, the survey captured engagement as a single composite indicator (meeting attendance, contributions to maintenance, and marketing through the PO). Accordingly, H2 and H3 concern the same indicator, serving as the exposure in H2 and outcome in H3, and the data cannot isolate the marketing component from general engagement (Section 3.4). RQ5 was examined qualitatively.

Theoretical Framework

The study employs an integrated framework combining Olson's (1965) theory of collective action, Williamson's (1985) transaction cost theory, Ostrom's (1990) Institutional Analysis and Development (IAD) framework, and social capital theory (Putnam, 1993). Table 1 summarizes how each perspective maps onto the study's constructs, operational variables, and analyses.

Table 1.
Mapping of theoretical perspectives to constructs, variables, and analyses

Theoretical lens	Key construct	Operational variable(s)	Analysis
Olson (1965)	Free-riding; selective incentives	Sustained collective engagement (binary); FGD themes on rule enforcement	Logistic regression (Model 3); thematic analysis
Williamson (1985)	Transaction costs of marketing	Sustained collective engagement (includes PO marketing); price per 100-kg bag	OLS regression (Model 2); thematic analysis
Ostrom (1990) IAD	Rules-in-use; biophysical conditions	Perceived infrastructure quality; yield (tons/ha)	OLS regression (Model 1); thematic analysis
Putnam (1993)	Trust, networks, reciprocity	Storage utilization class; credit access; FGD themes on mistrust	Chi-square test; thematic analysis

Olson's theory of collective action

Olson (1965) posits that collective endeavors are vulnerable to face free-riding, whereby individuals benefit from group efforts without contributing. In smallholder irrigation, farmers may access shared water, storage, or market contracts without contributing to maintenance or governance. Olson argues that selective incentives and sanctions are required to sustain cooperation. In this study, Olson's theory informs the analysis of sustained collective engagement (the outcome in the logistic regression model) and the qualitative interpretation of free-riding, defined here as benefiting from collective irrigation, storage, or marketing services while failing to fulfill agreed obligations such as fee payment, canal-maintenance labor, or meeting attendance.

Transaction cost theory

Transaction cost theory (Williamson, 1985) focuses on the costs of coordinating economic activity, including information search, negotiation, and contract enforcement. POs can lower these costs by aggregating produce and centralizing negotiations, thereby increasing the farm-gate prices for members who market collectively (Fischer & Qaim, 2012a; Markelova & Mwangi, 2010). This perspective provides the theoretical basis for H2 and the price model, while also informing the qualitative analysis of input procurement and buyer negotiation.

The IAD framework

Ostrom's (1990) IAD framework directs attention to the action arena in which farmers and leaders make decisions, the rules-in-use governing water allocation and maintenance, and external biophysical and policy conditions. It underpins H1, linking the physical condition of irrigation infrastructure, itself a product of rules for maintenance financing and enforcement, to productivity. It also provides a framework for examining multi-scalar influences such as national programs (URT, 2017, 2019) on local scheme governance.

Social capital theory

Social capital theory emphasizes networks, trust, and norms of reciprocity as facilitators of collective action (Pretty & Ward, 2001; Putnam, 1993). Trust reduces monitoring costs and mitigates free riding; conversely, mistrust rooted in delayed payments or opaque pricing undermines collective marketing and storage. This perspective also informs H4, because willingness to deposit paddy in collective stores presupposes trust in management, and guides the qualitative analysis of mistrust, reciprocity, and exclusion.

II. MATERIALS AND METHODS

Research design

The study used a cross-sectional, convergent (parallel) mixed-methods design (Creswell & Plano Clark, 2017). Quantitative and qualitative strands were collected during the same period (November 2023 to February 2024, covering the post-harvest season to aid recall of the preceding season), analyzed separately, and then integrated at the interpretation stage through a joint triangulation matrix in which each quantitative result was juxtaposed with the corresponding qualitative theme (convergence, complementarity, or dissonance). Points of integration are reported explicitly in the Results and Discussion. Because the design is observational and cross-sectional, all quantitative findings are interpreted as associations, not causal effects.

Study area

Iringa District, located in Tanzania's Southern Highlands, was selected for its significance in irrigated rice production, diverse agro-ecologies, and established irrigation schemes. The district covers approximately 20,414 km² with a population of approximately 265,000, consisting predominantly of smallholder farmers (URT, 2022). Rice is cultivated in gravity-fed schemes supplied by rivers including the Great Ruaha, under a unimodal rainfall regime (800–1,200 mm annually), where climate variability has increased reliance on irrigation (Mdemu et al., 2017). Seven schemes were studied: Luganga, Tungamalenga, Makifu, Mkombozi, Idodi, Magozi, and Mafuruto. They represent a range of performance levels and have received substantial external support, notably from the Marketing Infrastructure, Value Addition and Rural Finance (MIVARF) programme and FAO-supported projects. The schemes have a combined potential command area of 12,557 ha.

Sampling

The sampling frame was the list of formally registered rice POs held by the District Agricultural Office. Seven POs were purposively selected to capture active irrigation schemes, agro-ecological diversity, and variation in past external support, deliberately including both higher- and lower-performing schemes to enable comparative analysis. Findings therefore describe these seven organizations and cannot be generalized to all POs in Tanzania.

Within each PO, 30 members were selected by simple random sampling from the current membership roster, yielding a target sample of 210. There were no refusals,

exclusions, or replacements. This unusually complete response reflects the fieldwork protocol rather than good fortune: interviews were scheduled around routine PO meetings after advance mobilization by village leaders, and enumerators made up to three revisits to reach absent members. Equal allocation of 30 respondents per scheme was chosen a priori to give each scheme sufficient precision for between-scheme comparison; it was not proportional to PO membership size. Pooled sample statistics therefore weight each scheme equally rather than each member of the study population equally, and are reported as descriptive of the achieved sample. For reference, a sample of 210 would yield a margin of error of about ±6.8% for a proportion of .5 at 95% confidence under simple random sampling; the effective precision here is lower for variables that cluster within schemes, and all statistical inference accounts for that clustering.

For the qualitative strand, 10 key informants were purposively selected (seven PO leaders, one district cooperative officer, and two extension officers). Seven focus group discussions (FGDs), one per scheme with 10 to 15 participants each (total n = 84), were convened. FGD participants were recruited through village announcements and roster-based invitations, with quotas to ensure inclusion of women, youth, and ordinary members without leadership positions, so that discussions were not dominated by office-holders or larger landholders. Facilitators actively invited contributions from quieter participants.

Measures

The survey instrument was translated into Swahili and back-translated into English by two independent bilingual research assistants, with discrepancies reconciled by the research team. It was pre-tested with 20 farmers in a non-study scheme. Cronbach's alpha for the pooled multi-item battery in the pretest was .82; however, item-level pretest records needed to calculate separate alphas for each subscale were unfortunately not retained, a reporting limitation acknowledged in Section 5.3.

Variables used in the analyses were measured as follows. Rice yield was elicited as the number of 100-kg bags harvested from the farmer's rice plot in the reference season together with the plot area, and was converted to tons per hectare and recorded to one decimal place; the resulting values were cross-checked against PO harvest records. Two consequences of this procedure must be stated plainly. First, recall in whole bags and rounding to 0.1 tons/ha resulted in a coarse (29 distinct values in the dataset, within narrow scheme-specific bands). Second, cross-verification against scheme records anchored responses to those records and likely compressed within-scheme variance; measurement effects of this kind are well documented in agricultural household surveys (Carletto et al., 2015). Price is the farm-gate price (TZS) the farmer received per 100-kg bag of paddy in the reference season.

The price variable takes only eight distinct values across the dataset, reflecting institutional arrangements rather than solely a measurement artifact: collective sales occur at a single PO-negotiated price per scheme and season, whereas individual sales cluster around prevailing trader prices, so within-scheme price dispersion is inherently limited. Perceived infrastructure quality is the mean of farmer ratings of irrigation canal

condition items on 5-point scales (1 = poor, 5 = excellent), measured at the individual farmer level. Perceived leadership quality is the mean of farmer ratings of PO leadership effectiveness items on 5-point scales (1 = ineffective, 5 = highly effective), also at the farmer level. Because both are individual perceptions of largely scheme-level conditions, their intraclass correlations are reported, and all inference is cluster-adjusted (Section 3.6). No scheme-level mean scores were entered into farmer-level models, thereby avoiding pseudoreplication. Sustained collective engagement is a binary indicator defined ex ante as having, in the previous 12 months, attended at least three-quarters of scheduled PO meetings, contributed labor or fees to scheme maintenance, and marketed paddy through the PO (1 = yes, 0 = otherwise).

This single composite serves as the exposure in Model 2 and the outcome in Model 3. Because the survey did not capture its three components separately, the marketing element cannot be isolated from general engagement. Accordingly, the price model therefore estimates the price difference associated with the bundle of engaged behaviors, not with the marketing channel alone, and this constraint is reflected throughout the interpretation of both models. Credit access is a binary indicator of having obtained credit from any formal or semi-formal source in the previous 12 months. Storage utilization is a scheme-level classification from PO storage ledgers for the 2023/24 season (high > 1,000 MT stored annually; medium 500-1,000 MT; low < 500 MT); because it is measured at the scheme level, farmer-level tests involving it are interpreted with corresponding caution. Demographic covariates are age (years) and PO membership duration (years).

Years of schooling were collected but are excluded from all analyses and descriptive tables. A data audit conducted during this revision established that the education field had been overwritten during data cleaning by a spreadsheet fill operation (every stored value equal membership duration plus exactly two years), and the original responses could not be recovered from the tablet exports. All other analysis variables were re-verified against the original tablet exports and PO records and were unaffected. Gender was recorded for FGD composition but is not available in the analytic survey dataset, a limitation discussed in the Limitations section.

Data Collection

Structured surveys were administered face-to-face in Swahili by trained enumerators using tablets. Responses were cross verified against PO records and District Agricultural Office market price reports. Semi-structured key-informant interviews covered PO formation, governance, policy support, and sustainability challenges. FGDs explored perceived benefits and barriers of collective production, storage, and marketing, as well as trust, rule enforcement, and inclusion. Interviews and FGDs were audio-recorded, transcribed verbatim in Swahili, and translated into English by the bilingual assistants, with back-checks on a 20% sample of transcripts; field notes captured non-verbal and contextual details. All quotations reproduced in the Results are verbatim excerpts from the translated transcripts, identified by speaker role, scheme, and FGD code.

Data Analysis

Quantitative analyses used the farmer-level dataset (N = 210). Descriptive statistics were computed for all analysis variables (Tables 2 to 4). Because farmers are nested within seven schemes, and infrastructure quality, leadership quality, and yields cluster strongly within schemes (intraclass correlations: yield = .99, infrastructure = .96, leadership = .97, price = .15), conventional standard errors would overstate precision (Cameron & Miller, 2015). These very high ICCs partly reflect genuinely shared conditions, a common water source, uniform PO-negotiated prices, and collectively procured inputs, but they also reflect the coarseness of the outcome measures documented in Section 3.4. Together, these factors compress within-scheme variance and can inflate R^2 in farmer-level models (Carletto et al., 2015). Model fit statistics should be read with this in mind and should not be taken as evidence of near-deterministic production or pricing relationships. All regression models therefore report, alongside conventional estimates, cluster-robust standard errors with the scheme as the clustering unit, using *t*-statistics referred to $G - 1 = 6$ degrees of freedom. Because cluster-robust inference can itself be liberal when the number of clusters is small, the key coefficients were additionally tested using the wild-cluster bootstrap under the null, enumerating all 128 Rademacher sign patterns for the seven clusters (Cameron et al., 2008). With only seven schemes, scheme-level models were judged infeasible; accordingly, the design supports farmer-level models with cluster adjustment, and this constraint is acknowledged as a limitation.

Model 1 (H_1) regressed yield (tons/ha) on perceived infrastructure quality, controlling for age and PO membership duration. Model 2 (H_2) regressed price (TZS per 100-kg bag) on sustained collective engagement with the same controls. Education was excluded from all models for the data-integrity reason documented in Section 3.4. Cultivated area was not available in the analytic dataset and therefore could not be included as a control variable. Model 3 (H_3) used logistic regression to examine sustained collective engagement as a function of perceived leadership quality, controlling for age. PO membership duration was excluded from Model 3 because it induced quasi-complete separation: no member with two years of membership met the engagement definition, whereas all members with four or more years did; consequently, its coefficient is not identifiable by maximum likelihood. H_4 was tested with a chi-square test of association between scheme-level storage utilization class and farmer-level credit access, supplemented by Cramér's V; because storage class is constant within schemes, this test is presented as descriptive of the association pattern rather than as farmer-level inference.

All expected cell frequencies exceeded 14, satisfying the validity condition. Regression diagnostics comprised variance inflation factors (all VIFs ≤ 1.6, indicating no problematic multicollinearity), Jarque–Bera tests of residual normality, Breusch–Pagan tests of homoscedasticity (which indicated heteroskedasticity in Models 1 and 2, providing an additional justification for robust inference), and, for Model 3, the Hosmer–Lemeshow test. Exact *p*-values are reported except where $p < .001$. Unstandardized coefficients are denoted as *B* (or *b* for logit coefficients), standardized coefficients as β,

and odds ratios as OR. Coefficients are interpreted in the units of the variables rather than as percentages.

Qualitative data were analyzed thematically (Braun & Clarke, 2006) in NVivo. An initial codebook was derived from the theoretical framework and extended inductively. Two researchers independently coded 20% of transcripts (Cohen's κ = .82); disagreements were resolved through discussion and codebook refinement before single-coding the remainder. Analysis deliberately sought contrasting cases across schemes and between leaders and ordinary members and attended to gendered experiences. Counts from FGDs are reported as the number of groups in which a theme arose (for example, "in five of seven FGDs"), not as population percentages, because FGD participants are not a probability sample.

Ethical considerations

Ethical approval was granted by the University Research Review and Ethics Committee. Verbal informed consent in Swahili to accommodate participants with low literacy. Confidentiality was protected through unique participant codes and secure storage. Participants could withdraw at any time without repercussions, and no financial incentives were offered. Member checking was conducted during FGDs, and findings were cross verified against secondary sources. The study adhered to the principles of the Declaration of Helsinki.

III. RESULTS

1. Respondent characteristics

Table 2 presents descriptive statistics. Respondents averaged 42.6 years of age (SD = 3.6, range 37–50) and 3.7 years of PO membership (SD = 1.2, range 2–6); education is not reported for the data-integrity reason given in Section 3.4. Overall, 137 of 210 respondents (65.2%) met the definition of sustained collective engagement, and 111 of 210 (52.9%) had accessed credit in the previous 12 months. The farmer-level mean yield was 4.24 tons/ha (SD = 1.16, range 2.4–6.5), and the mean farm-gate price was 85,024 TZS per 100-kg bag (SD = 20,300, range 50,000–110,000). Mean perceived infrastructure quality was 3.69 (SD = 0.75) and mean perceived leadership quality 3.39 (SD = 0.68) on the 5-point scales.

Table 2.

Respondent and scheme characteristics (N = 210; 30 per scheme)

Variable	Mean (SD) or n (%)	Range
Age (years)	42.6 (3.6)	37–50
PO membership (years)	3.7 (1.2)	2–6
Yield (tons/ha)	4.24 (1.16)	2.4–6.5
Price (TZS per 100-kg bag)	85,024 (20,300)	50,000–110,000
Perceived infrastructure quality (1–5)	3.69 (0.75)	2.3–5.0
Perceived leadership quality (1–5)	3.39 (0.68)	2.3–4.7
Sustained collective engagement	137 (65.2%)	—
Credit access	111 (52.9%)	—

2. Collective production and infrastructure

Table 3 profiles the schemes. Of the combined potential command area of 12,557 ha, approximately 2,614 ha (20.8%) was harvested to paddy in the reference season, with utilization ranging from 5.6% in Mkombozi to 88.0% in Magozi. (Harvested areas are derived from scheme production totals divided by survey-based mean yields and were cross-checked against District Agricultural Office records; an arithmetic and unit inconsistency in the earlier version of this table, which mixed bags per acre with tons per hectare, has been corrected by dropping the bags-per-acre column.) Luganga recorded the highest mean yield (6.23 tons/ha, SD = 0.18) and Idodi the lowest (2.55 tons/ha, SD = 0.11); Magozi combined a high mean yield (5.25 tons/ha, SD = 0.11) with by far the largest harvested area (1,144 ha) and total output (6,004 tons). The production-weighted mean yield across schemes was 4.50 tons/ha, compared with the unweighted farmer-level mean of 4.24 tons/ha.

Table 3.

Production profile of the seven schemes (reference season)

Scheme	Potential area (ha)	Harvested area (ha)	Mean yield, tons/ha (SD)	Total output (tons)	Utilization (%)
Luganga	1,500	228	6.23 (0.18)	1,420.0	15.2
Tungamalenga	1,500	262	4.39 (0.16)	1,148.4	17.4
Makifu	500	233	4.39 (0.16)	1,023.1	46.6
Mkombozi	5,000	279	3.25 (0.11)	907.2	5.6
Idodi	2,157	421	2.55 (0.11)	1,075.2	19.5
Magozi	1,300	1,144	5.25 (0.11)	6,004.2	88.0
Mafuruto	600	48	3.65 (0.11)	173.3	7.9
Total	12,557	2,614	4.50 (weighted); 4.24 (unweighted)	11,751.4	20.8

Note. Yields are survey-based scheme means (n = 30 per scheme). Harvested area was calculated as total output ÷ mean yield and verified against District Agricultural Office seasonal reports. The overall weighted yield is production-area weighted, whereas the unweighted figure is the farmer-level mean. Utilization is defined as harvested rice area divided by potential command area for the single reference season; in schemes that double-crop, annualized utilization would be higher.

Model 1 results appear in Table 4. Perceived infrastructure quality was strongly and positively associated with yield: B = 1.42 tons/ha per scale point (conventional SE = 0.04, $t(206) = 36.50$, $p < .001$; $\beta = .92$), with the model explaining most of the yield variance ($R^2 = .88$, adjusted $R^2 = .88$, $F(3, 206) = 505.39$, $p < .001$). With cluster-robust inference, the association remained large (cluster SE = 0.24, $t(6) = 5.95$, $p = .001$, 95% CI [0.83, 2.00]); however, the wild-cluster bootstrap, the most conservative test available with only seven schemes, yielded $p = .078$, so H_1 receives qualified rather than unqualified support.

Two further cautions apply. Because infrastructure quality varies almost entirely between schemes (ICC = .96), the data cannot fully distinguish the infrastructure–yield association from other scheme-level differences, such as external support, market location, or ecology. Moreover, the very high R^2 should not be interpreted as evidence of a near-deterministic production relationship. As documented in Sections 3.4 and 3.6, coarse recall units and record-anchored verification compress within-scheme yield variance, thereby mechanically increasing the model's apparent fit. Neither age (B =

−0.02, cluster p = .252) nor PO membership duration (B = 0.07, cluster p = .426) was robustly associated with yield.

Table 4.

Model 1: OLS regression of rice yield (tons/ha) on perceived infrastructure quality (N = 210)

Panel A. Conventional inference

Predictor	B	SE	t(206)	p	95% CI	β
Constant	−0.49	0.38	−1.30	.194	[−1.23, 0.25]	—
Infrastructure quality	1.42	0.04	36.50	< .001	[1.34, 1.49]	.92
Age	−0.02	0.01	−1.88	.061	[−0.04, 0.00]	−.06
Membership years	0.07	0.03	2.36	.019	[0.01, 0.13]	.07

Panel B. Cluster-robust inference (scheme as cluster, G = 7)

Predictor	B	Cluster SE	t(6)	p	95% CI
Constant	−0.49	0.53	−0.92	.395	[−1.80, 0.82]
Infrastructure quality	1.42	0.24	5.95	.001	[0.83, 2.00]
Age	−0.02	0.01	−1.27	.252	[−0.05, 0.02]
Membership years	0.07	0.09	0.85	.426	[−0.14, 0.28]

Note. R^2 = .880, adjusted R^2 = .879, $F(3, 206) = 505.39$, $p < .001$. VIF ≤ 1.6. Jarque–Bera = 5.66, p = .059. Breusch–Pagan LM = 107.04, $p < .001$ (heteroskedasticity present; robust inference emphasized). Wild-cluster bootstrap p for infrastructure = .078 (128 enumerated Rademacher draws). Cluster-robust statistics use scheme as cluster (G = 7).

Qualitative findings converged with this pattern while also revealing its underlying mechanisms and limits. POs organize farmers into groups of 10 to 15 members to coordinate land preparation, planting, and water allocation, and collective input procurement was reported by leaders to reduce input costs relative to individual purchasing. Participants in five of the seven FGDs cited inadequate capital for inputs and, in four of the seven FGDs, inadequate mechanization as constraints on land utilization. In Idodi, discussants attributed low yields to unrepaired canals: "The canal above our block broke two seasons ago. Water reaches the far plots late, and those farmers harvest half of what we harvest near the intake" (male farmer, Idodi FGD). Conversely, a Magozi leader linked higher yields to the consistent enforcement of maintenance rules: "Every member contributes maintenance labor before the season opens. If you do not appear, you pay the fee before water is allocated" (PO leader, Magozi).

3. Collective Storage and Credit Access

The seven schemes have a combined storage capacity of 11,620 MT, developed largely with MIVARF support. Utilization varies widely: Magozi stored 2,014 MT in the reference year and, uniquely among the schemes, operates within a warehouse receipt system that enables post-harvest credit, whereas Idodi and Makifu each utilized fewer than 300 MT. Credit access was strongly patterned by storage utilization class: 78.9% (71/90) of farmers in high-utilization schemes (Luganga, Tungamalenga, Magozi) had accessed credit, compared with 50.0% (15/30) in the medium-utilization scheme (Mkombozi) and 27.8% (25/90) in low-utilization schemes (Idodi, Makifu, Mafuruto); $\chi^2(2, N = 210) = 47.29$, $p < .001$, Cramér's V = .48 (all expected cell counts ≥ 14.1). Because storage utilization is a scheme-level attribute, this association is descriptive and may

reflect other scheme-level differences; therefore, it should not be interpreted as evidence that storage utilization directly affects any individual farmer's access to credit.

In FGDs at Idodi, Makifu, and Mafuruto, mistrust of collective storage was a recurrent theme, rooted in fears of mismanagement and opaque pricing: "You deposit your bags and you are given a paper. Then you hear the price was decided in a meeting you never attended. People prefer to keep rice at home even if it spoils" (female farmer, Makifu FGD). Key informants estimated post-harvest losses of roughly 10–15% in the underperforming schemes, consistent with regional evidence on storage-related losses (Shepherd, 2007; World Bank, 2022). Warehouse receipt arrangements of the kind operating in Magozi have been associated elsewhere in Africa with improved marketing and access to finance, although their effectiveness depends heavily on trust and management quality (Coulter & Onumah, 2002).

4. Collective Marketing and Prices

Table 5 reports farm-gate prices by scheme. Mean prices ranged from 75,000 TZS per 100-kg bag in Mkombozi and Idodi to 94,167 TZS in Magozi, with substantial within-scheme dispersion (overall range: 50,000–110,000 TZS), reflecting seasonal price volatility and the mix of collective and individual sales. (In a previous draft, this table mistakenly included a column labeled "Igodikafu," a transcription error for Mkombozi, and incorrectly implied that collective marketing increased prices to a uniform 100,000 TZS. These errors have been corrected and are not reflected in the analyses reported here.)

Table 5.

Farm-gate paddy prices by scheme (TZS per 100-kg bag; N = 210)

Scheme	Mean	SD	Min	Max	Collective engagement (%)
Luganga	94,000	9,861	75,000	100,000	80.0
Tungamalenga	93,000	16,897	65,000	110,000	80.0
Makifu	84,000	17,140	60,000	100,000	70.0
Mkombozi	75,000	25,427	50,000	100,000	50.0
Idodi	75,000	25,427	50,000	100,000	50.0
Magozi	94,167	10,755	75,000	100,000	76.7
Mafuruto	80,000	20,342	60,000	100,000	50.0
All schemes	85,024	20,300	50,000	110,000	65.2

Farmers meeting the sustained-engagement definition, all of whom marketed through the PO, received a mean price of 98,686 TZS (SD = 6,677, n = 137), compared with 59,384 TZS (SD = 9,499, n = 73) among those who sold individually, representing an unadjusted difference of 39,303 TZS (66.2% higher). In Model 2 (Table 6), sustained collective engagement remained strongly associated with price after adjustment: B = 37,114 TZS (conventional SE = 1,806, $t(206) = 20.55$, $p < .001$; $\beta = .87$; $R^2 = .858$, $F(3, 206) = 413.68$, $p < .001$). The association was robust to clustering (cluster SE = 6,659, $t(6) = 5.57$, $p = .001$, 95% CI [20,820, 53,408]) and to the wild-cluster bootstrap ($p = .016$), reflecting the fact that engaged and individual sellers coexist within every scheme (price ICC = .15). Two interpretive limitations should be acknowledged. First, because engagement is a composite measure, the estimate captures the price advantage associated with the

combined effect of collective behaviors—meeting attendance, maintenance contributions, and PO marketing—rather than the marketing channel in isolation. Second, the estimate represents an association rather than a causal effect. Farmers who engage may differ from those who do not in unobserved ways (for example, output quality, urgency of cash needs, or trust in leadership); therefore, the coefficient should not be interpreted as the effect of switching an individual seller from individual to collective marketing.

Table 6.

Model 2: OLS regression of paddy price (TZS per 100-kg bag) on sustained collective engagement (N = 210)

Panel A. Conventional inference

Predictor	B	SE	t(206)	p	95% CI	β
Constant	67,069	6,885	9.74	< .001	[53,495, 80,642]	—
Collective engagement	37,114	1,806	20.55	< .001	[33,553, 40,675]	.87
Age	−292	182	−1.60	.110	[−652, 67]	−.05
Membership years	1,682	812	2.07	.040	[82, 3,282]	.10

Panel B. Cluster-robust inference (scheme as cluster, G = 7)

Predictor	B	Cluster SE	t(6)	p	95% CI
Constant	67,069	7,998	8.39	< .001	[47,499, 86,638]
Collective engagement	37,114	6,659	5.57	.001	[20,820, 53,408]
Age	−292	196	−1.49	.187	[−773, 188]
Membership years	1,682	2,388	0.70	.508	[−4,161, 7,524]

Note. R^2 = .858, adjusted R^2 = .856, $F(3, 206) = 413.68$, $p < .001$. VIFs ≤ 3.1. Jarque–Bera = 8.79, $p = .012$. Breusch–Pagan LM = 27.04, $p < .001$ (therefore, robust inference is emphasized). Wild-cluster bootstrap p-value for sustained collective engagement = .016. Cluster-robust statistics use the scheme as the clustering unit (G = 7).

FGDs provided insight into why approximately one third of farmers nonetheless sold individually. In the Idodi and Mafuruto groups, discussants linked individual sales to delayed payments and mistrust of PO pricing: "The trader pays cash at the farm. The PO pays after one month, sometimes two. When school fees are due, you cannot wait" (male farmer, Mafuruto FGD). Others cited experiences of unequal treatment: "Those close to the committee sell first when the price is good. The rest of us sell what remains" (female farmer, Idodi FGD). Tungamalenga's comparatively high maximum price (110,000 TZS) was attributed by its leaders to the strategic release of stored paddy during the low-supply season, illustrating the complementarity between collective storage and marketing functions.

5. Leadership, Participation, and Sustainability Challenges

Sustained collective engagement ranged from 50.0% of respondents in Mkombozi, Idodi, and Mafuruto to 80.0% in Luganga and Tungamalenga (Magozi: 76.7%; Makifu: 70.0%). In the logistic model (Table 7), perceived leadership quality was positively associated with sustained engagement: $b = 1.43$ (SE = 0.31, $z = 4.67$, $p < .001$), OR = 4.19 (95% CI [2.30, 7.65]; cluster-robust 95% CI [1.72, 10.23], $p = .002$). Older farmers were also more likely to sustain engagement (OR = 1.40 per year, 95% CI [1.25, 1.57]). Given the restricted age range of the sample (37–50 years), this per-year odds ratio is implausibly

large to reflect the effect of age alone and more likely reflects unmeasured cohort and life-cycle factors, such as asset security, established plots, and accumulated standing within the organization; accordingly, it should not be extrapolated beyond the observed range. The model demonstrated adequate fit (likelihood-ratio $\chi^2(2) = 75.26$, $p < .001$; McFadden pseudo-$R^2 = .28$; Nagelkerke $R^2 = .42$; Hosmer–Lemeshow $\chi^2(8) = 9.44$, $p = .306$; 79.0% correctly classified). As noted in Section 3.6, PO membership duration was excluded owing to quasi-complete separation. Descriptively, no respondent with two years of membership met the engagement definition, whereas all respondents with four or more years did, suggesting that early-tenure members constitute a distinct attrition-risk group, although this pattern could not be modeled formally.

Table 7.
Model 3: Logistic regression of sustained collective engagement (N = 210)

Panel A. Conventional inference

Predictor	b	SE	z	p	OR	95% CI (OR)
Constant	−18.29	2.80	−6.52	< .001	—	—
Leadership quality	1.43	0.31	4.67	< .001	4.19	[2.30, 7.65]
Age	0.34	0.06	5.77	< .001	1.40	[1.25, 1.57]

Panel B. Cluster-robust inference (scheme as cluster, G = 7)

Predictor	b	Cluster SE	p	OR	95% CI (OR)
Constant	−18.29	2.81	< .001	—	—
Leadership quality	1.43	0.46	.002	4.19	[1.72, 10.23]
Age	0.34	0.05	< .001	1.40	[1.28, 1.54]

Note. Likelihood-ratio $\chi^2(2) = 75.26$, $p < .001$; McFadden pseudo-$R^2 = .277$; Nagelkerke $R^2 = .415$; Hosmer–Lemeshow $\chi^2(8) = 9.44$, $p = .306$; 79.0% correctly classified. Cluster-robust statistics use the scheme as the clustering unit (G = 7). PO membership duration was excluded due to quasi-complete separation.

Qualitative data placed these associations within their broader structural conditions rather than attributing them solely to individual shirking. Weak and inconsistently enforced rules were raised in five of the seven FGDs, but discussants repeatedly traced nonparticipation to poverty, care burdens, tenure insecurity, and past disappointments rather than unwillingness. Women in three FGDs described meeting times and labor obligations that conflicted with domestic responsibilities: "Meetings are called in the afternoon when we are fetching water and cooking. Then they say the women are not serious" (female farmer, Idodi FGD). PO records indicate that women hold about 20% of leadership positions across the seven organizations. Members in renter and borrower tenure positions saw little return from long-term contributions: "Why should I dig the canal for a plot the owner can take back next season?" (male farmer, Mkombozi FGD). This form of tenure insecurity is well documented in Iringa (Odgaard, 2002).

Key informants noted that most of the POs were established through external projects and that project-era subsidies created expectations that membership fees now struggle to replace: "When the programme ended, people waited for the next one. Paying for maintenance from our own pockets was a new idea" (extension officer, interview).

Membership fees (TZS 10,000–20,000 annually) were described by leaders as erratic and insufficient for maintenance, which a Magozi leader estimated to cost TZS 50,000–100,000 per hectare annually. Moreover, the absence of formal operation and maintenance plans in most schemes has led to reactive, and often more expensive, repairs (Mdemu et al., 2017). Climate-related water variability was also raised in the Idodi FGD as compounding these pressures (Morton, 2007).

Integration of the quantitative and qualitative strands indicates convergence: schemes combining well-maintained infrastructure, credible leadership, storage-linked finance, and enforced but fair rules (Magozi, Luganga, Tungamalenga) consistently exhibited higher yields, prices, participation, and credit access than schemes where mistrust, tenure insecurity, and weak enforcement coincided (Idodi, Mkombozi, Mafuruto). The qualitative strand also highlights that these clusters of advantage may additionally reflect differential external support and market location, which the quantitative models cannot disentangle.

IV. DISCUSSION

The findings are consistent with the proposition that collective action is associated with higher productivity and better market outcomes for smallholder rice farmers, while also underscoring that these associations are conditional on governance quality, trust, and material support. The strong infrastructure–yield association (H_1) aligns with Ostrom's (1990) argument that durable resource governance requires rules that are matched to local conditions, as well as with evidence that irrigation performance in Tanzanian schemes depends as much on maintenance institutions as on physical capital (Mdemu et al., 2017; Nakawuka et al., 2018; Burney & Naylor, 2012). Two caveats should be noted. First, because infrastructure quality is primarily a scheme-level attribute observed in only seven schemes, the wild-cluster bootstrap *p*-value (.078) indicates that the data cannot rule out chance at conventional significance thresholds once clustering is fully accounted for. Second, the cross-sectional design cannot establish the direction of the association: productive, well-organized schemes may maintain infrastructure better, rather than infrastructure itself leading to higher yields.

The price advantage associated with sustained collective engagement (H_2) is consistent with transaction cost theory (Williamson, 1985) and with evidence from Africa that marketing groups improve smallholder terms of trade under supportive conditions (Barham & Chitemi, 2009; Kaganzi et al., 2009; Markelova et al., 2009). Because engagement was measured as a composite that bundles PO marketing with meeting attendance and contributions, the transaction-cost interpretation is suggestive rather than direct: the data associate the composite engagement measure, not the marketing channel specifically, with higher prices. The estimated 37,114 TZS difference per 100-kg bag is likewise an adjusted association rather than a treatment effect. Selection into engagement based on unobserved factors, such as cash constraints or trust, is plausible and, indeed, was described directly by FGD participants who sold individually because they could not wait for PO payment cycles. This qualitative evidence points to a structural interpretation: delayed payments effectively price the poorest members out of the collective channel, so the observed premium partly reflects who can afford to participate.

Interventions that shorten payment delays (for example, warehouse-receipt-backed advances) are therefore plausible candidates for expanding access to this premium and thus merit further evaluation (Coulter & Onumah, 2002).

The leadership–engagement association (H_3) supports Olson's (1965) emphasis on institutions that make cooperation individually rational, but the qualitative findings caution against reducing nonparticipation to free-riding. Much of what appears as shirking is structurally constrained by care responsibilities, insecure tenure, poverty, and past experiences of unequal benefit-sharing (Agarwal, 2001; Bernard & Spielman, 2009; Meinzen-Dick & Zwarteveen, 1998). The finding that women hold only about one fifth of leadership positions, alongside FGD accounts of meeting schedules incompatible with domestic responsibilities, illustrates participatory exclusion in Agarwal's (2001) sense: formal membership without effective voice. Group heterogeneity in tenure and wealth similarly conditions members' capacity, not merely their willingness, to contribute (Poteete & Ostrom, 2004). Sanction-centered prescriptions that ignore these constraints risk punishing the least advantaged members while leaving the underlying causes of disengagement unaddressed.

The storage–credit association (H_4) is consistent with the role of warehouse receipt systems in facilitating post-harvest finance (Coulter & Onumah, 2002), and the concentration of both storage utilization and credit access in Magozi, Luganga, and Tungamalenga illustrates how financial, infrastructural, and trust mechanisms reinforce one another. At the same time, the association is descriptive and operates at the scheme level; schemes with functional storage also enjoy better market position and stronger leadership, and the study design cannot disentangle the contribution of these co-varying advantages.

Within the IAD framework, the contrast between Magozi and Idodi is instructive: national programs (URT, 2017, 2019) have supplied broadly similar physical investments across schemes, yet outcomes diverge according to local rules-in-use, enforcement credibility, and linkages to financial institutions. Reliance on erratic member fees and residual project support mirrors the post-liberalization trajectory of farmer organizations elsewhere in Africa, where externally created groups struggled once external support ended (Christoplos, 2010; Salifu et al., 2010). The external origin of most study POs, as reported by key informants, suggests that fostering ownership, not merely building organizational capacity, is central to sustainability. These propositions should be regarded as hypotheses for future institutional design and evaluation rather than as empirically demonstrated solutions.

V. CONCLUSION AND RECOMMENDATIONS

In seven irrigation-based rice POs in Iringa District, better-perceived infrastructure, collective marketing, credible leadership, and storage-linked finance were associated with higher yields, prices, participation, and credit access, while mistrust, delayed payments, gendered exclusion, and tenure insecurity emerged as recurring qualitative explanations for disengagement. The pattern is consistent with the integrated theoretical expectation that technical, economic, institutional, and social mechanisms operate jointly. Rather than any single factor distinguishing stronger schemes such as

Magozi and Luganga from weaker ones such as Idodi, their advantages appeared to cluster and reinforce one another. Because the evidence is cross-sectional, purposively sampled, and drawn from only seven schemes, these conclusions are associational and specific to the study context.

The following recommendations are advanced as proposals for piloting and rigorous evaluation, not as interventions of established effectiveness, and each identifies the actors best placed to lead. First, PO boards, supported by the district cooperative office, could clarify membership rules and introduce selective incentives for active participants. Any strengthening of sanctions should be preceded by an equity review, since members facing financial, household, health, or tenure constraints may be unable, rather than unwilling, to contribute. Accordingly, graduated, capacity-sensitive obligations are preferable to uniform penalties. Second, the district council and development partners could support leadership development for PO committees, covering participatory planning, transparent pricing, conflict resolution, and financial management. These initiatives should also include explicit targets for women's representation beyond the current one fifth of leadership positions, together with scheduling and quota reforms that address the barriers identified by women participants.

Third, the National Irrigation Commission and district authorities could prioritize the rehabilitation of canals and storage facilities in underperforming schemes, paired with formal operation and maintenance plans and dedicated maintenance funds, given the association between infrastructure condition and yields observed here and elsewhere (Mdemu et al., 2017; Nakawuka et al., 2018). Fourth, the Tanzania Warehouse Receipts Regulatory Board, commercial banks, and POs could pilot the extension of warehouse receipt systems beyond Magozi, with independent evaluation of their effects on credit access, payment delays, and participation (Coulter & Onumah, 2002). Fifth, land administration authorities could accelerate the issuance of certificates of customary right of occupancy in scheme areas, an intervention whose relationship with investment incentives should be evaluated in this context (Odgaard, 2002).

Finally, the Ministry of Agriculture and local government authorities could invest in feeder roads, market information systems, and climate-smart practices, such as water-efficient irrigation scheduling and drought-tolerant varieties (Morton, 2007). Rigorous evaluations of these pilot initiatives, ideally using longitudinal or experimental designs, are needed to determine whether the associations documented here reflect causal relationships that can inform policy.

VI. LIMITATIONS

Three groups of limitations bound the interpretations that can be drawn from these findings.

Design limitations

The study is cross-sectional and observational; therefore, all reported relationships are associations, and reverse or joint causation cannot be excluded. The seven POs were purposively selected, so the findings do not generalize to all Tanzanian POs. Moreover,

the equal allocation of 30 respondents per scheme means that pooled statistics do not weight members proportionally to PO size.

Measurement limitations

The outcome variables are coarse and partly anchored to scheme records. Yields were recalled in whole bags, rounded to 0.1 tons/ha, and cross-verified against PO records, while prices take only eight distinct values, largely reflecting uniform PO-negotiated prices. These measurement characteristics compress within-scheme variance and mechanically inflate model fit (Carletto et al., 2015); accordingly, the high R^2 values should not be overinterpreted. Perception-based predictors and self-reported outcomes collected in a single instrument raise the possibility of common-method bias (Podsakoff et al., 2003). Sustained collective engagement is a composite measure that bundles PO marketing with attendance and contributions, preventing the effect of the marketing channel from being isolated. The education variable was invalidated by a data-processing error (Section 3.4), and gender, cultivated area, and market distance were unavailable for adjustment. Per-subscale reliability coefficients from the pretest could not be reported, and storage utilization was measured at the scheme level, making the chi-square association descriptive.

Inference limitations

With only seven clusters, cluster-robust inference is approximate, and the wild-cluster bootstrap results (notably $p = .078$ for H1) should temper confidence accordingly. In addition, FGD-derived frequencies characterize the groups convened rather than the broader member population. Longitudinal designs incorporating more schemes, plot-level yield measurements, transaction-level price records, separately measured engagement components, and gender-disaggregated data would materially strengthen future research.

VII. DISCLOSURE STATEMENT

The author declares that there are no conflicts of interest.

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