

Agricultural Cooperatives as Institutional Infrastructures for Agroecological Transition: Determinants and Adoption Mechanisms among Smallholder Farmers in Luebo, Democratic Republic of the Congo

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Publication Date: 2026/09/28

Abstract: This study develops a conceptual and analytical framework for examining agricultural cooperatives as institutional infrastructures for agroecological transition in Luebo Territory, Kasai Province, Democratic Republic of the Congo. It integrates diffusion of innovations, collective-action theory, and contemporary agroecological-transition approaches to explain how collective organization can convert rules, resources, and relationships into services that enable adoption. Agroecological progress is operationalized through an Agroecological Adoption Index (AAI) based on twelve observable practices. The quantitative demonstration uses a synthetic analytical dataset of 384 producers, equally divided between cooperative members and non-members; it illustrates the statistical protocol and does not constitute field evidence. Within this synthetic dataset, the mean AAI is higher among members (64.3%) than among non-members (41.7%), while access to training, advisory services, credit, inputs, and collective marketing is more frequent among cooperative members. The demonstrative logistic model positively associates cooperative membership, training, credit, agronomist contact, and farm size with substantive adoption of at least six practices. The central interpretation does not attribute causality to membership status. Instead, it advances the concept of cooperative capacity for agroecological transition: the ability to coordinate knowledge, advice, finance, productive resources, peer learning, and market outlets. Territorial constraints, particularly remoteness, condition this capacity. The study contributes a multi-practice perspective on adoption and conceptualizes the cooperative as an institutional infrastructure for transition while explicitly delimiting the empirical scope of the demonstration.

Keywords: Agricultural Cooperatives; Agricultural Services; Agroecological Transition; Agroecology; Collective Action; Luebo; Multi-Practice Adoption; Smallholder Farmers.

How to Cite: Kuyunsa Mayu Alain; Ngalamulume Kalala Jean-Pierre; Banze Mukanya Anjou (2026) Agricultural Cooperatives as Institutional Infrastructures for Agroecological Transition: Determinants and Adoption Mechanisms among Smallholder Farmers in Luebo, Democratic Republic of the Congo. *International Journal of Innovative Science and Research Technology*, 11(9), 1671-1683. <https://doi.org/10.38124/ijisrt/26sep381>

I. INTRODUCTION

The transition toward more sustainable agricultural systems is a central challenge for rural territories simultaneously affected by natural-resource degradation, inadequate agricultural services, weak infrastructure, and unstable market outlets. Agroecology cannot be reduced to the introduction of an isolated production technique. Rather, it involves a progressive transformation of production systems and of the relationships that sustain them, based on

diversification, recycling, resilience, co-creation of knowledge, and responsible governance (Wezel et al., 2009; Méndez et al., 2013; FAO, 2018; Wezel et al., 2020).

This perspective requires adoption to be understood as a cumulative process. A farmer may know a practice without being able to test it, or may test it without being able to sustain it. The transition from awareness to sustained use depends on perceived relative advantage, compatibility with household needs, complexity, trialability, and observability (Rogers,

2003), but also on access to advisory services, inputs, finance, labor, and markets.

In the Democratic Republic of the Congo (DRC), these dimensions are especially important in areas where family farming is a major source of income and food security. Recent work on Congolese smallholders emphasizes that technical support, resource constraints, and the broader socioeconomic environment can shape the adoption of more sustainable practices (Chuma Basimine et al., 2025). In Luebo, road accessibility, finance, equipment, inputs, agricultural advice, and market outlets jointly condition farmers' ability to experiment with and stabilize new practices.

Agricultural cooperatives can act as intermediary organizations in this setting. By grouping dispersed producers, they may reduce transaction costs, organize training and demonstrations, connect farmers with technical services, pool equipment, facilitate input access, aggregate supply, and strengthen bargaining power. African evidence nevertheless shows that cooperative outcomes vary substantially according to governance, inclusion, and the quality of services delivered (Bernard & Spielman, 2009; Abebaw & Haile, 2013; Verhofstadt & Maertens, 2014; Mojo et al., 2017; Manda et al., 2020). A broader scoping review likewise documents the diversity of functions through which farmers' organizations can support smallholders (Bizikova et al., 2020).

Recent agroecology research further strengthens this institutional interpretation. In Burkina Faso, farmers' organizations have been analyzed as innovation intermediaries that facilitate the circulation, adaptation, and appropriation of agroecological innovations (Iyabano et al., 2022, 2023). This literature invites a move beyond the binary "member/non-member" variable toward the concrete mechanisms through which collective organization can make adoption technically understandable, economically manageable, and socially credible.

The scientific gap therefore lies less in asking whether producer organizations matter in general than in examining three dimensions jointly: (i) cooperative membership and the functional capacity of the organization; (ii) the combination of multiple transition services; and (iii) the simultaneous adoption of several practices under territorial constraints. This gap is particularly relevant in rural territories of the DRC, where these interactions remain insufficiently documented.

In this study, the cooperative is conceptualized as an institutional infrastructure for agroecological transition: an organization capable of connecting producers to knowledge, technical services, financial resources, inputs, equipment, peers, and market outlets while creating mechanisms of coordination and trust. The central research question is therefore: to what extent is membership in an agricultural cooperative associated with more advanced adoption of agroecological practices in Luebo, and through which institutional, economic, and technical mechanisms can this relationship be understood?

The general objective is to analyze the cooperative as an institutional infrastructure for transition by examining the relationships among membership, services, and multi-practice adoption, and by identifying the territorial constraints that may limit these relationships. The contribution is threefold: to provide a synthetic measure of agroecological progression; to distinguish cooperative status from functional capacity; and to formalize cooperative capacity for agroecological transition as an intermediate mechanism between collective organization and adoption.

II. THEORETICAL FRAMEWORK AND CONCEPTUAL MODEL

➤ *Diffusion of Innovations and Learning*

Diffusion of innovations theory explains heterogeneous adoption trajectories through relative advantage, compatibility, perceived complexity, trialability, and observability (Rogers, 2003). In agroecological settings, these attributes are not determined solely by the intrinsic characteristics of a practice; they also depend on a producer's ability to observe, test, and adapt the practice under local conditions.

A cooperative can reduce uncertainty by creating learning opportunities through training, demonstration plots, peer exchange, and technical support. These mechanisms increase the observability of results and the density of interactions among farmers operating under comparable conditions. Such mediation is consistent with participatory approaches to agroecology, which emphasize knowledge co-creation and local adaptation (Méndez et al., 2013; Iyabano et al., 2022).

➤ *Collective Action, Governance, and Cooperative Capacity*

Collective-action theory helps explain why producers pool functions that would be costly or difficult to access individually. The durability of collective action depends, however, on understandable rules, participation, monitoring, conflict-resolution mechanisms, and trust (Ostrom, 1990). Within a cooperative, these dimensions directly shape the credibility of dues management, input distribution, equipment use, and collective financial arrangements.

A formal cooperative must therefore be distinguished from a functional cooperative. The former exists legally; the latter effectively converts rules, resources, and relationships into services accessible to members. This distinction is consistent with evidence on organizational heterogeneity among African cooperatives (Verhofstadt & Maertens, 2014) and on their uneven capacity to reach vulnerable farmers (Bernard & Spielman, 2009).

➤ *Agroecological Transition as Multidimensional Progression*

Agroecological transition is understood here as a staged process: improving resource-use efficiency, substituting selected inputs or techniques, and ultimately reconfiguring the production system more deeply (Gliessman, 2015; Duru et al., 2015). This perspective is consistent with TAPE, which proposes a multidimensional and progressive assessment of

agroecological transitions (FAO, 2019; Mottet et al., 2020).

The study retains twelve observable practices: intercropping, crop rotation, compost, organic manure, mulching, vegetative cover, agroforestry, biological control, soil conservation, diversification, pesticide reduction, and selected local seeds. Their combination is summarized through the Agroecological Adoption Index (AAI). The index measures a relative level of engagement in transition; it is not a certification of the agroecological status of an entire farm.

➤ Cooperative Capacity for Agroecological Transition

Cooperative capacity for agroecological transition is defined as the ability of a cooperative to mobilize, coordinate, and make effectively accessible the knowledge, technical advice, financial resources, productive means, peer learning, and market outlets required to adopt and sustain a set of agroecological practices. It is the central mechanism proposed in this article: the organization does not act directly on adoption; it acts on the conditions that make adoption possible.

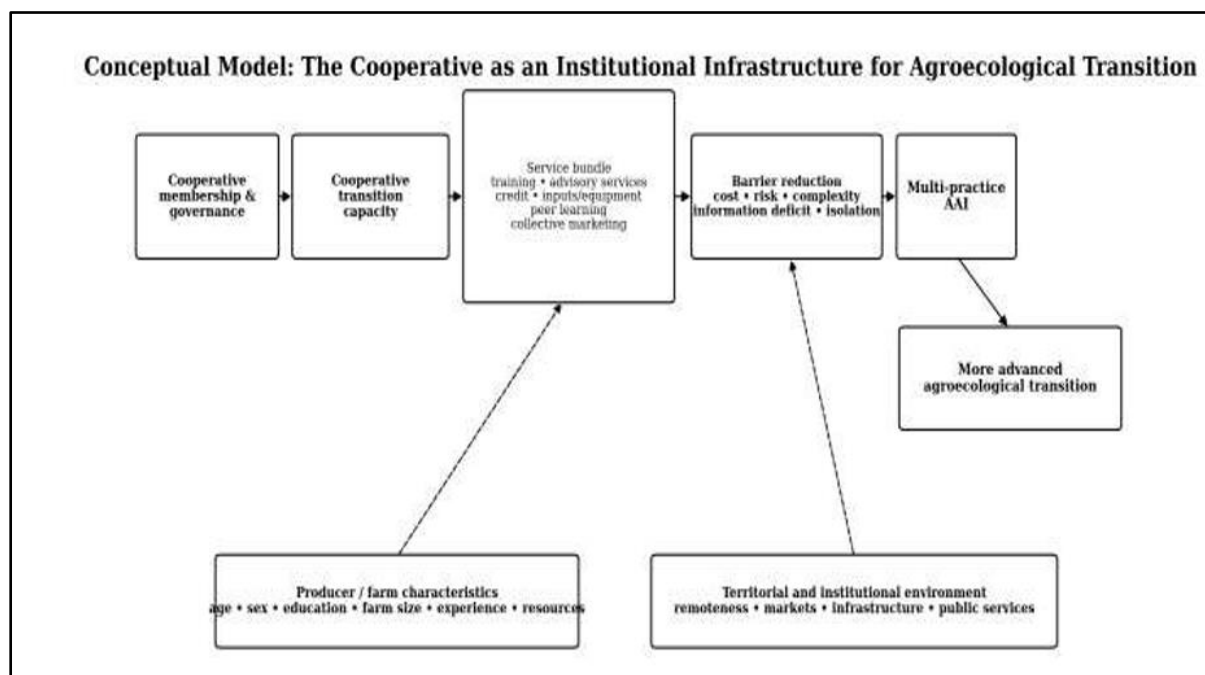


Fig 1 Conceptual Model of the Cooperative as an Institutional Infrastructure for Agroecological Transition

Source: Author's elaboration based on Rogers (2003), Ostrom (1990), Duru et al. (2015), and FAO (2019).

Figure 1 explicitly separates membership status, organizational capacity, the service bundle, and intermediate mechanisms. It also shows that the expected relationship is conditioned by two sets of factors: producer and farm characteristics, on the one hand, and the territorial and institutional environment, on the other. This representation prevents a mechanical or causal reading of cooperative membership.

➤ Analytical Hypotheses

- H1 — Membership in an agricultural cooperative is positively associated with a higher level of multi-practice adoption.
- H2 — Access to agroecological training, agricultural advisory services, and credit is positively associated with substantive adoption.
- H3 — The association between cooperative membership and adoption remains present after accounting for several individual and structural characteristics.
- H4 — Territorial constraints, particularly remoteness, financing, access to equipment and inputs, and technical support, limit the capacity of cooperatives to sustain agroecological transition.

III. METHODOLOGY AND ANALYTICAL ARCHITECTURE

➤ Study Design and Positioning

The proposed research design is cross-sectional, comparative, and mixed-method. The quantitative component compares cooperative members and non-members and examines factors associated with the level of agroecological adoption. The qualitative protocol envisages interviews, focus-group discussions, direct observation, and documentary analysis to illuminate mechanisms related to governance, learning, finance, and marketing. However, the available materials do not document a completed qualitative corpus (number of interviews, traceable quotations, saturation, and coding matrix); consequently, this version does not invent or report qualitative findings.

➤ Analytical Population and Sampling

The theoretical sample size is based on Cochran's formula for estimating a proportion at a 95% confidence level, with $p = 0.50$ and a 5% margin of error, yielding approximately 384 observations. The analytical architecture allocates these observations equally between 192 cooperative members and 192 non-members. This balanced allocation is designed for group comparison; it does not reproduce the true

territorial prevalence of cooperative membership and should not be used to estimate territorial prevalence without appropriate weighting.

$$n_0 = Z^2 \times p(1 - p) / e^2$$

The survey protocol envisages stratified multistage sampling: selection of areas with contrasting accessibility and cooperative presence, selection of villages, and then sampling of producers from separate member and non-member lists. Geographic comparability between the two strata is essential to reduce confounding between organizational effects and accessibility effects.

➤ Instruments and Variables

The questionnaire is structured into five blocks: producer and household characteristics; cooperative membership and participation; twelve agroecological practices; access to training, credit, technical advice, inputs, and markets; and constraints and perceived effects. Closed questions facilitate standardization, while the protocol also includes targeted observation to distinguish declared practices from observable implementation.

➤ Construction of the Agroecological Adoption Index

Each practice is coded 1 when it is reported as effectively implemented during the reference period and 0 otherwise. For producer i , the AAI is computed as the proportion of the twelve practices adopted:

$$AAI_i = (\sum_{j=1}^{12} P_{ij} / 12) \times 100$$

Descriptive categories are defined as low (0–25%), moderate (>25–50%), high (>50–75%), and very high (>75%). To preserve the available results without artificial recalculation, the binary outcome used in the logistic model is renamed substantive adoption and defined as the adoption of at least six practices out of twelve ($AAI \geq 50\%$). This binary outcome must not be confused with the descriptive “high” category, which begins above 50%. A sensitivity analysis using a $\geq 7/12$ threshold should be performed once a real empirical dataset becomes available.

➤ Statistical Analysis

Descriptive comparisons use frequencies, proportions, means, and standard deviations. Categorical variables are examined using chi-square tests, while the difference in mean AAI between members and non-members is assessed with Welch’s t-test. Multivariable logistic regression estimates the associations between substantive adoption and cooperative membership, training, credit, contact with an agronomist, market access, farm size, education, age, and sex. Exponentiated coefficients are reported as odds ratios (ORs) with 95% confidence intervals where available.

Interpretation is strictly associative. Cooperative membership is not randomly assigned, and self-selection or unobserved factors may simultaneously influence membership and adoption. With empirical data, the analysis would be strengthened by nested models, cluster-robust standard errors for geographic grouping, and sensitivity analyses using weighting or balancing methods to reduce selection bias.

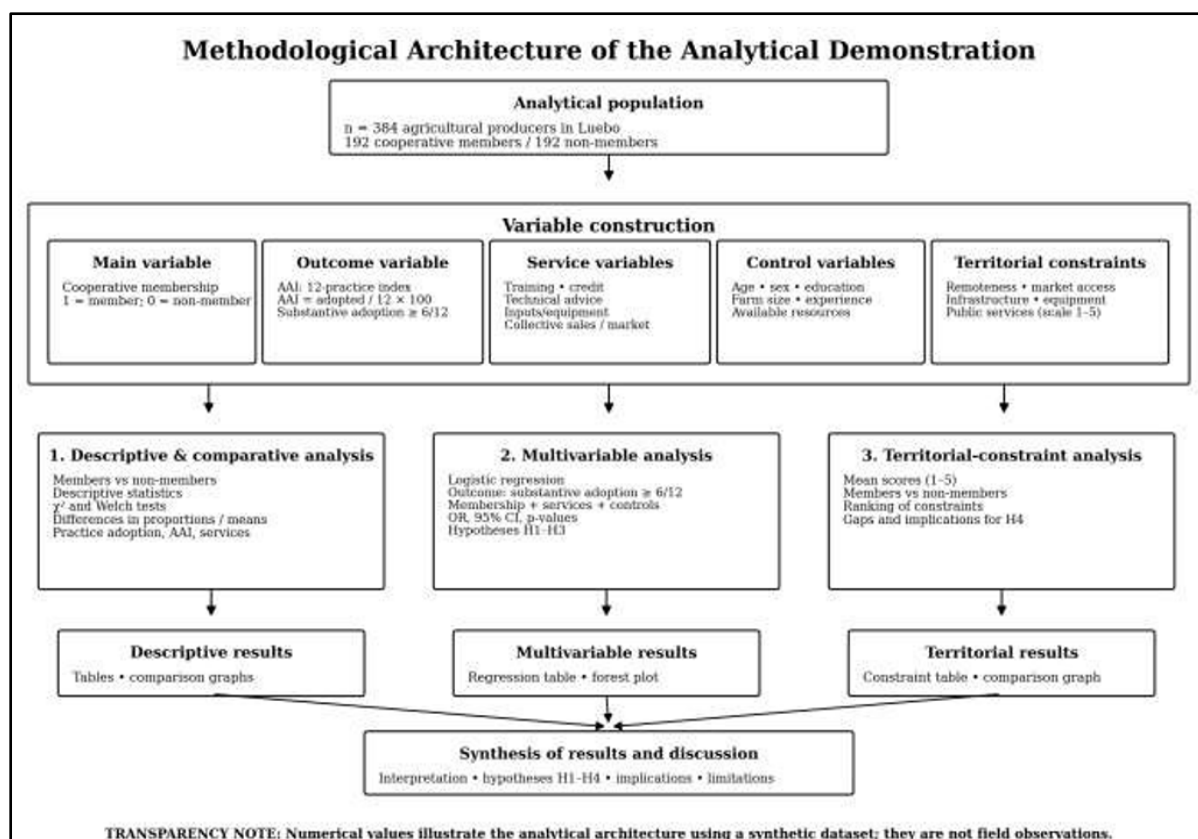


Fig 2 Methodological Architecture of the Analytical Demonstration

Source: Author's elaboration. Numerical values refer to the synthetic analytical dataset.

➤ *Ethics, Reliability and Data Status*

The protocol specifies voluntary consent, omission of personal identifiers from the analytical dataset, and consistency checks for impossible values, duplicates, missing data, and contradictory responses. No formal ethics-approval identifier is documented in the available materials; this information would therefore need to be completed before any submission presenting empirical field data.

The principal limitation of the current manuscript is the synthetic status of the numerical dataset. The tables, statistics, and graphs provide a coherent demonstration of the analytical protocol, but they do not authorize empirical inference about

the population of Luebo. This qualification is maintained throughout the results and transparency statements.

IV. RESULTS OF THE ANALYTICAL DEMONSTRATION

➤ *Reading Principle:*

All numerical results in this section refer to the synthetic analytical dataset ($n = 384$). They are used to test the internal coherence of the statistical framework and illustrate the expected form of the analyses; they must not be presented as field observations.

Table 1 Comparative Profile of Producers in the Analytical Dataset

Indicator	Members	Non-members	Overall
Mean age (years)	42.3	45.3	43.8
Women (%)	38.5%	46.4%	42.4%
Household size	6.4	6.3	6.3
Farming experience (years)	22.5	25.3	23.9
Mean farm size (ha)	2.39	2.61	2.50

Source: Synthetic Analytical Dataset, $n = 384$; Author's Calculations.

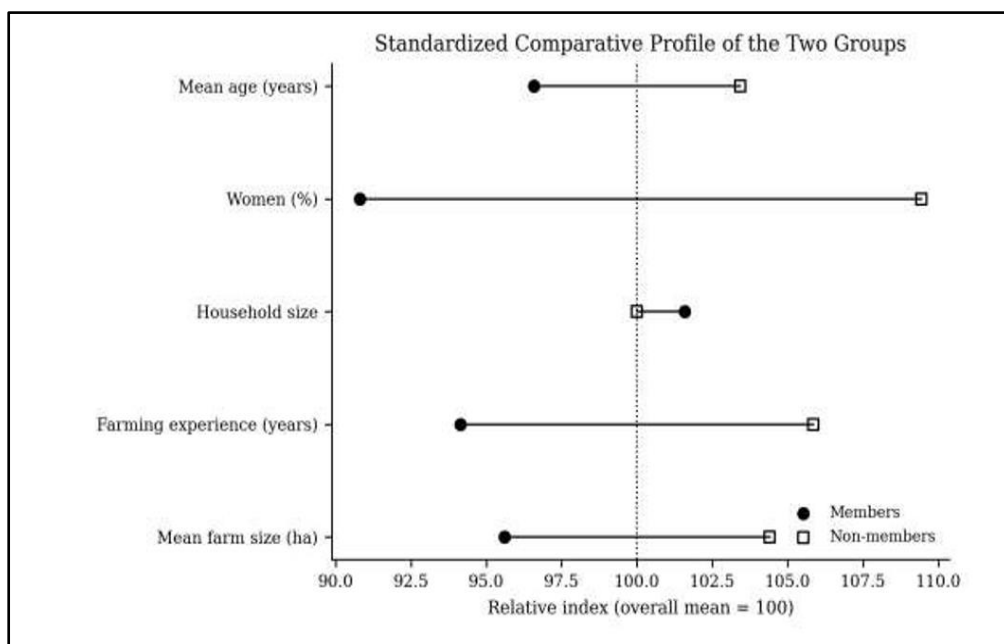


Fig 3 Graph 1 Standardized Comparative Profile of the Two Groups

Note: Each Value is Expressed Relative to the Overall Mean (= 100), Allowing Comparison across Variables Measured in Different Units.

Source: Calculations Derived from the Synthetic Dataset.

➤ *Scientific Interpretation:*

The two groups do not exhibit a major imbalance in farm size or household size. Members are, on average, younger and operate slightly smaller farms; women also represent a lower share of the member group. This profile

matters because the subsequent adoption gap cannot simply be attributed to a mean farm-size advantage among cooperative members. Differences in composition nevertheless justify multivariable adjustment.

Table 2 Access to Major Agricultural and Cooperative Services

Service or Condition	Members	Non-Members	Overall
Agroecological training	57.8%	23.4%	40.6%
Access to credit	25.5%	15.1%	20.3%
Contact with an agronomist	52.6%	22.4%	37.5%

Market access	56.2%	60.4%	58.3%
Collective sales	53.6%	6.8%	30.2%
Facilitated access to inputs	46.9%	29.2%	38.0%

Source: Synthetic Analytical Dataset, n = 384; Author's Calculations

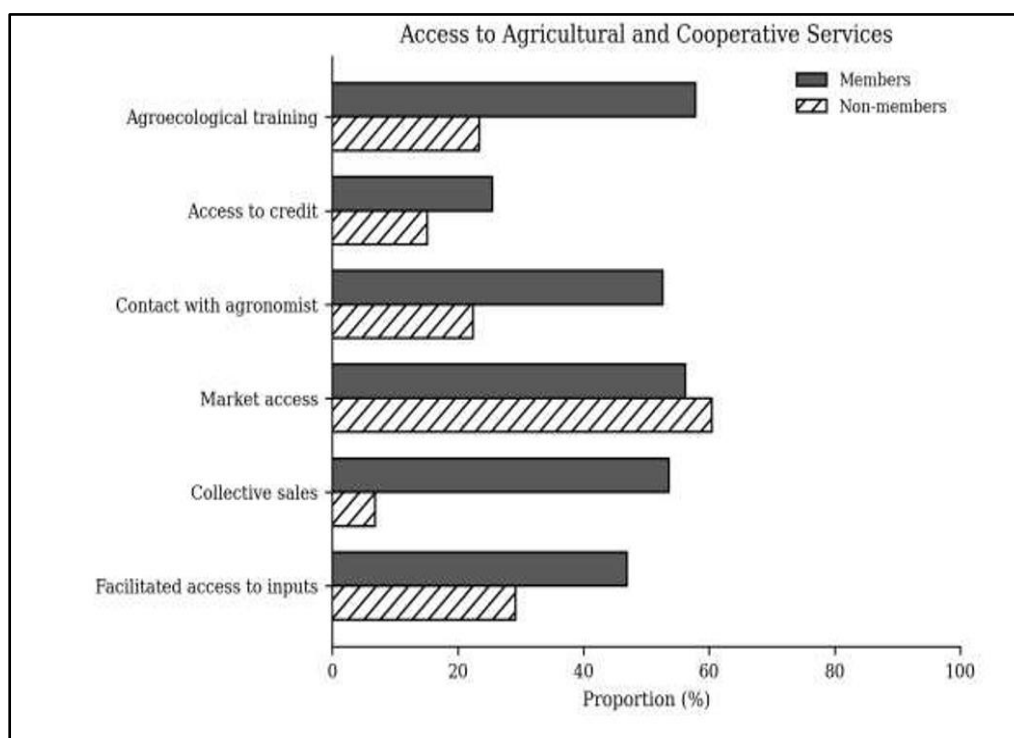


Fig 4 Graph 2 Comparative Access to Agricultural and Cooperative Services

Source: Synthetic Analytical Dataset, n = 384.

➤ **Scientific Interpretation:**

The largest gaps concern collective sales (+46.8 percentage points in favor of members), agroecological training (+34.4 points), and contact with an agronomist (+30.2 points). Facilitated access to inputs and credit is also

more frequent among members. By contrast, the binary market-access indicator is slightly higher among non-members. This structure supports the interpretation of a cooperative advantage based on a bundle of services rather than universal superiority across all resources.

Table 3 Adoption of Agroecological Practices by Cooperative Status

Practice	Members	Non-members	p (χ^2)
Intercropping	74.5%	54.7%	< 0.0001
Crop rotation	64.6%	42.7%	< 0.0001
Compost	76.0%	39.1%	< 0.0001
Organic manure	66.1%	45.8%	< 0.0001
Mulching	68.2%	36.5%	< 0.0001
Vegetative cover	56.2%	34.9%	< 0.0001
Agroforestry	50.5%	36.5%	0.0074
Biological control	56.8%	28.6%	< 0.0001
Soil conservation	69.8%	46.4%	< 0.0001
Diversification	68.8%	53.1%	0.0024
Pesticide reduction	62.0%	39.6%	< 0.0001
Selected local seeds	58.3%	42.7%	0.0031

Source: Synthetic Analytical Dataset, n = 384; Author's Calculations

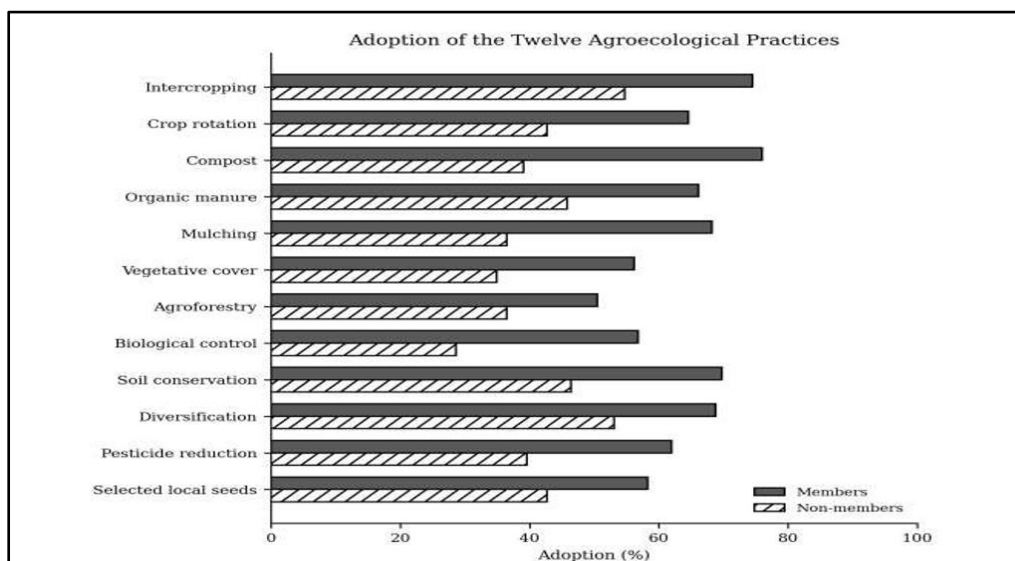


Fig 5 Graph 3 Comparative Adoption of the Twelve Agroecological Practices

Source: Synthetic Analytical Dataset, $n = 384$.➤ *Scientific Interpretation:*

In the synthetic dataset, adoption rates are higher among members for all twelve practices. The largest absolute difference concerns compost (+36.9 percentage points), followed by mulching (+31.7), biological control (+28.2), and soil conservation (+23.4). Intercropping and diversification remain relatively common among non-members, suggesting that some practices are already embedded in local farming systems and that the potential role of the cooperative may lie primarily in their systematization and combination.

➤ *Statistical Caution:*

Twelve bivariate tests are conducted. Under a strict Bonferroni correction ($\alpha \approx 0.0042$), agroforestry ($p = 0.0074$) would no longer meet the adjusted threshold, whereas diversification ($p = 0.0024$), selected local seeds ($p = 0.0031$), and the comparisons reported with $p < 0.0001$ would remain compatible with this criterion. This nuance prevents overstatement of uniform statistical evidence across all practices.

Table 4 Mean Agroecological Adoption Index

Group	Mean AAI	SD	n
Members	64.3%	15.1	192
Non-members	41.7%	14.1	192
Overall	53.0%	18.5	384

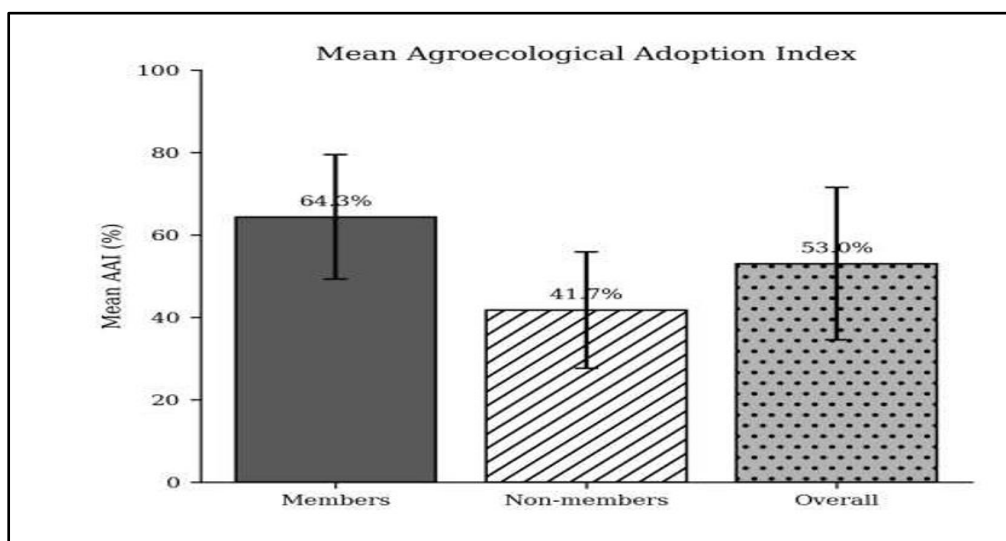
Source: Synthetic Analytical Dataset; Author's Calculations. Welch Test: $t = 15.17$; $p < 0.001$ 

Fig 6 Graph 4 Mean AAI by Cooperative Status

Error Bars: ± 1 Standard Deviation.

Source: Synthetic Analytical Dataset.

➤ *Scientific Interpretation:*

The mean AAI gap is 22.6 percentage points. Based on the reported summary statistics, the approximate 95% confidence interval for this difference is 19.7 to 25.5 points,

and the standardized Hedges effect size is approximately $g = 1.54$, indicating a very large contrast within the synthetic dataset. These measures quantify the separation between groups without converting the association into a causal effect.

Table 5 Substantive Adoption (≥ 6 Practices out of 12) by Cooperative Status

Status	≥ 6 practices	< 6 practices	Total	Share ≥ 6
Members	167	25	192	87.0%
Non-members	66	126	192	34.4%
Total	233	151	384	60.7%

Source: Synthetic Analytical Dataset; $\chi^2 = 109.14$; $p < 0.001$

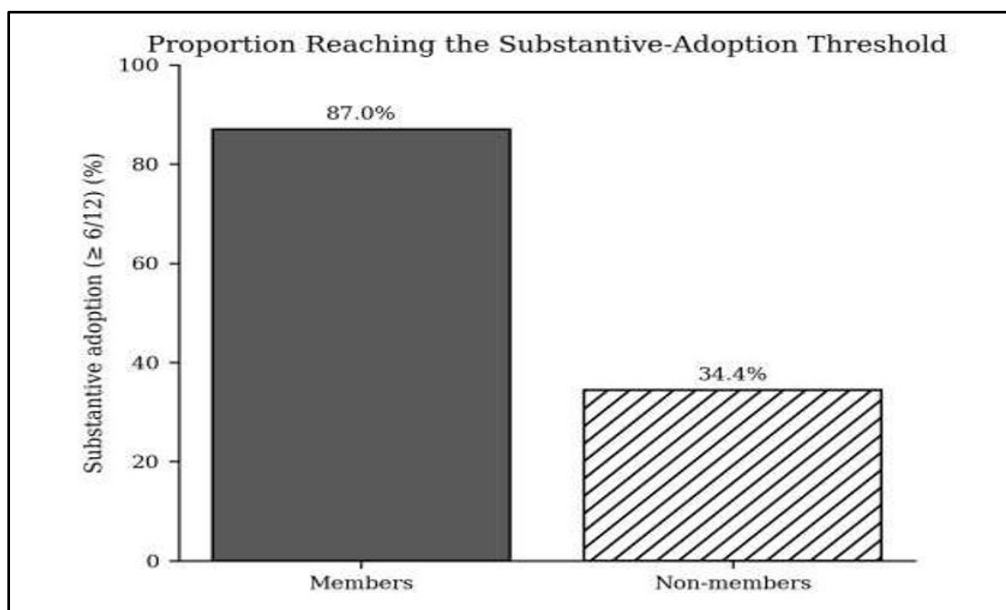


Fig 7 Graph 5 Proportion Reaching the Substantive-Adoption Threshold

Source: Synthetic Analytical Dataset.

➤ *Scientific Interpretation:*

In the analytical dataset, 87.0% of members reach at least six practices compared with 34.4% of non-members. The association is strong (Cramér's $V \approx 0.53$). The relative risk is approximately 2.53 (95% CI ≈ 2.07 –3.10), the absolute

difference in proportions is 52.6 percentage points (95% CI ≈ 44.4 –60.8), and the crude odds ratio is approximately 12.75. These effect measures strengthen the analytical contrast but apply only to the synthetic dataset.

Table 6 Logistic Regression of Substantive Adoption

Factor	OR	95% CI	p
Cooperative membership	8.76	4.86–15.80	< 0.001
Training	6.55	3.55–12.06	< 0.001
Access to credit	2.25	1.08–4.66	0.030
Agronomist contact	2.25	1.24–4.07	0.008
Market access	1.01	0.58–1.75	0.977
Farm size (log)	2.20	1.05–4.62	0.038
Education level	1.17	—	0.333
Age	1.00	—	0.706
Female	1.00	—	0.999

Source: Logistic Model Using the Synthetic Analytical Dataset, $n = 384$. Dependent Variable: Adoption of at Least Six Practices.

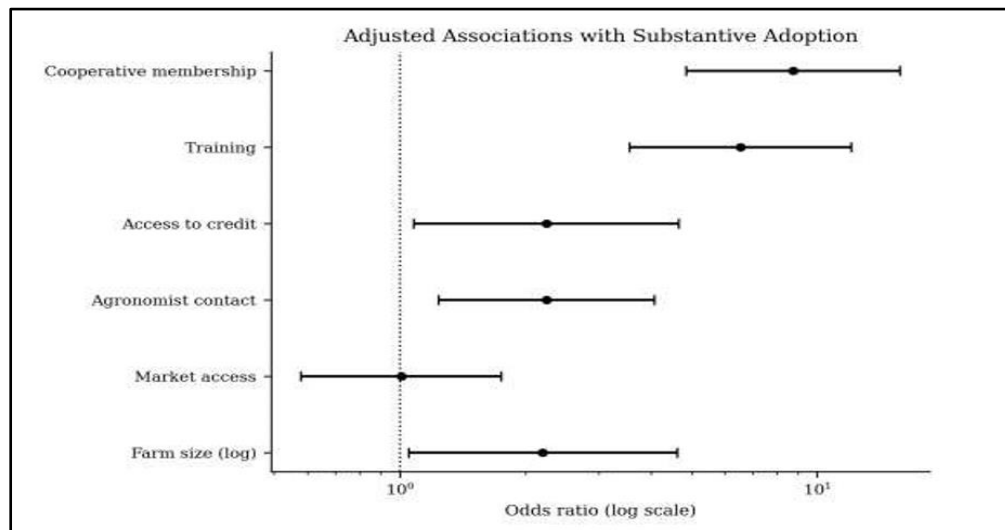


Fig 8 Graph 6 Forest Plot for Factors with Reported Confidence Intervals

Note: The vertical line at OR = 1 Denotes no Association. Variables without Reported Confidence Intervals are not Plotted.

Source: Synthetic Analytical Dataset.

➤ Scientific Interpretation:

Cooperative membership has the strongest adjusted association (OR = 8.76), followed by training (OR = 6.55). Credit, agronomist contact, and farm size also show positive associations. By contrast, market access as coded in the model is not associated with the outcome (OR = 1.01; $p = 0.977$). An odds ratio should not be read as a direct multiplier of probability; it refers to conditional odds in the fitted model.

The persistence of a high cooperative OR after the inclusion of service variables suggests, within the synthetic construction, possible complementary mechanisms such as horizontal learning, trust, coordination, and synchronization of services. With real data, nested models would be required to distinguish the total association of cooperative status from the conditional association after introducing potential mediators.

Table 7 Major Constraints to Agroecological Transition

Rank	Constraint	Overall	Members	Non-members
1	Remoteness and market access	4.09	4.07	4.11
2	Access to credit	3.94	3.65	4.22
3	Cost/access to equipment	3.77	3.62	3.92
4	Access to seeds/inputs	3.54	3.41	3.67
5	Weak technical support	3.52	3.24	3.79
6	Insufficient training	3.45	3.19	3.71
7	Storage/conservation	3.36	3.22	3.50

Scale: 1 to 5. Source: Synthetic Analytical Dataset; Author's Calculations.

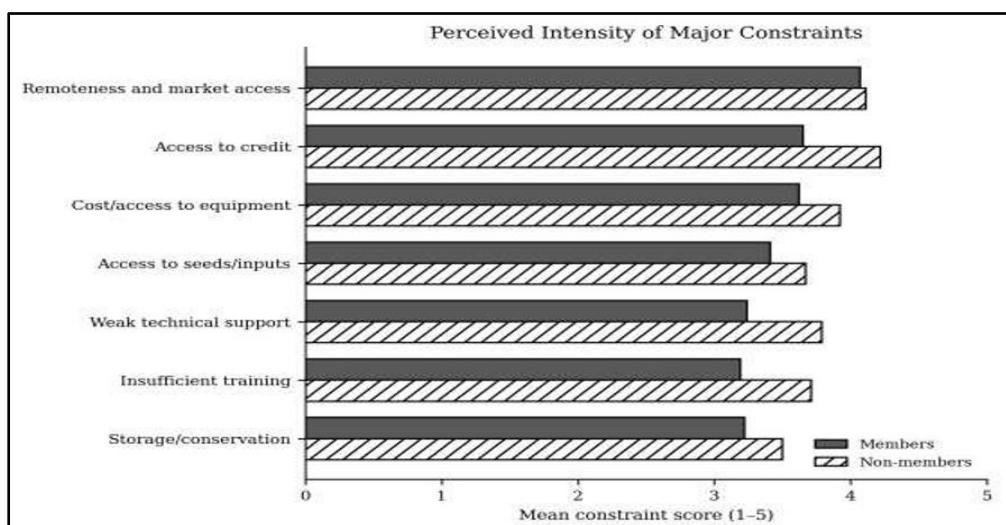


Fig 9 Graph 7 Perceived Intensity of Major Constraints

Source: Synthetic Analytical Dataset.

➤ *Scientific Interpretation*

Remoteness and market access constitute the highest-rated constraint for both groups, with an almost negligible gap between members and non-members (0.04 point). By contrast, non-members report greater difficulty in access to credit (+0.57 point), weak technical support (+0.55), and insufficient training (+0.52). This pattern is consistent with the idea that collective organization may attenuate selected service barriers while being unable, on its own, to solve a territorial infrastructure constraint.

➤ *Analytical Synthesis*

The demonstration forms a coherent chain: members have more frequent access to several services; they display a higher mean AAI and a larger share reaching substantive adoption; several service variables remain associated with the outcome in the adjusted model; and constraints that an organization can theoretically influence are rated as less severe among members, whereas remoteness remains shared by both groups. This internal consistency supports the conceptual framework without constituting empirical validation for Luebo.

V. DISCUSSION

➤ *From Cooperative Status to a System of Services*

The principal contribution is not the general claim that cooperatives are favorable to adoption. Such an association has already been documented in different African settings (Abebaw & Haile, 2013; Manda et al., 2020). The analytical value of the present model is to shift attention toward functional capacity: training, technical advice, credit, inputs, equipment, peer learning, and collective marketing form a service system whose value lies in complementarity.

This interpretation is consistent with recent work describing farmers' organizations as intermediaries for agroecological innovation (Iyabano et al., 2022, 2023). It nevertheless goes one step further by emphasizing the infrastructure function: a cooperative does not merely transmit an innovation; it may synchronize several conditions required for experimentation, adoption, and sustained use.

➤ *Multi-Practice Transition Rather than a Single Technology*

Using the AAI treats agroecological transition as a combination of practices. This choice is consistent with systemic approaches to agroecology (Duru et al., 2015; Wezel et al., 2020) and with the multidimensional assessment proposed by TAPE (Mottet et al., 2020). The difference between groups therefore has a richer meaning than a comparison based on a single technology: it concerns the breadth of the practice bundle.

The index should nevertheless be interpreted as formative. The twelve practices are not necessarily interchangeable and do not have identical agronomic weight. Future empirical validation should examine alternative weights, the local relevance of individual practices, and the robustness of conclusions across different thresholds.

➤ *Horizontal Learning, Trust and Coordination*

Three mechanisms are particularly plausible. First, horizontal learning enables producers to observe outcomes among peers operating under similar conditions. Second, trust may reduce the perceived risk associated with an innovation or collective commitment. Third, coordination may align training, input availability, the cropping calendar, technical advice, and marketing. This synchronization explains why a bundle of services can create more value than an isolated intervention.

➤ *The Market Paradox: Individual Measure and Territorial Constraint*

The logistic model detects no association with the binary market-access variable, whereas remoteness is the highest-rated constraint. This divergence is not necessarily contradictory. A binary indicator can poorly represent distance, travel time, transport cost, seasonality, and competition among buyers, post-harvest losses, and farm-gate prices. Future fieldwork should therefore measure market access as a multidimensional construct.

The result also highlights the boundary of cooperative action. A cooperative can aggregate volumes, organize collection points, and negotiate transport, but it cannot substitute for public investment in roads. The PNDA, which links agricultural development with the opening up of production basins, provides a relevant territorial framework in this respect (PNDA, 2025).

➤ *Inclusion and Performance*

The absence of a statistical association for sex in the model is insufficient to conclude that the cooperative is inclusive. Women represent a smaller share of the member stratum than of the non-member stratum. An organization may therefore be effective for those who gain access while remaining selective in access to membership or leadership. This distinction between effects on members and coverage of the target population lies at the center of research on inclusion in producer organizations (Bernard & Spielman, 2009).

➤ *Scientific Limitations*

First, the numerical results are synthetic and do not constitute empirical data. External validity, confidence intervals, and significance levels should therefore be interpreted only as properties of the constructed dataset.

Second, the proposed design is cross-sectional and would not, even with real data, establish causality without additional assumptions. Self-selection into cooperative membership remains a central threat to causal interpretation.

Third, the qualitative component is not sufficiently documented in the available materials to be reported as findings. Any mixed-method empirical submission would need to provide the number of interviews, saturation strategy, coding procedure, and traceable quotations.

Fourth, the practice-by-practice comparisons raise a multiplicity issue, and the AAI uses equal weights. Both choices should be examined through sensitivity analyses in a

real empirical dataset.

➤ *Scientific Contribution*

Subject to these limitations, the framework makes three contributions. It operationalizes transition as multi-practice adoption; it distinguishes simple membership from functional capacity; and it formalizes cooperative capacity for agroecological transition as the ability to coordinate a set of resources and relationships that reduce barriers to adoption. The central proposition is therefore that the cooperative does not create transition by virtue of its existence; it may facilitate transition when it becomes an institutional infrastructure capable of making change technically understandable, economically manageable, socially credible, and territorially coordinated.

VI. IMPLICATIONS FOR COOPERATIVES AND PUBLIC POLICY

The implications below should be interpreted as propositions derived from the conceptual framework and analytical demonstration, not as an evaluation of an observed program. They translate the notion of institutional infrastructure into operational criteria for action and monitoring.

➤ *Evaluate Functional Capacity, Not Only Legal Existence*

Membership counts and legal registration are insufficient indicators of contribution to agricultural development. Support programs should track the regularity of training, frequency of advisory support, financial transparency, participation, access to inputs, use of pooled equipment, volumes marketed collectively, and changes in

the AAI. The OHADA framework and international principles on cooperative promotion provide an institutional basis, but actual performance depends on management and service-delivery capacity (OHADA, 2010; ILO, 2002).

➤ *Institutionalize Training and Local Advisory Services*

Training should become a regular function aligned with the cropping calendar. Farmer facilitators can sustain learning between professional technical visits without substituting for agronomists. Coordination with public agricultural services can reduce dependence on temporary project arrangements.

➤ *Link Finance, Support and Markets*

Productive credit is more secure when linked to a farm-season budget, a production calendar, technical support, and an identifiable outlet. Likewise, pooled equipment should be financed around an explicit logic of use, maintenance, and recurrent costs to reduce dependence on subsidies.

➤ *Recognize the Complementarity between Institutional and Physical Infrastructure*

Cooperatives can reduce selected logistical costs but cannot sustainably compensate for territorial isolation. Territorial policies should jointly address advisory services, finance, producer organization, markets, and road investment. Congolese agricultural legislation and national development programs already situate finance, marketing, and infrastructure within the same policy environment (Democratic Republic of the Congo, 2011; PNDA, 2025).

➤ *Seven-Pillar Operational Model*

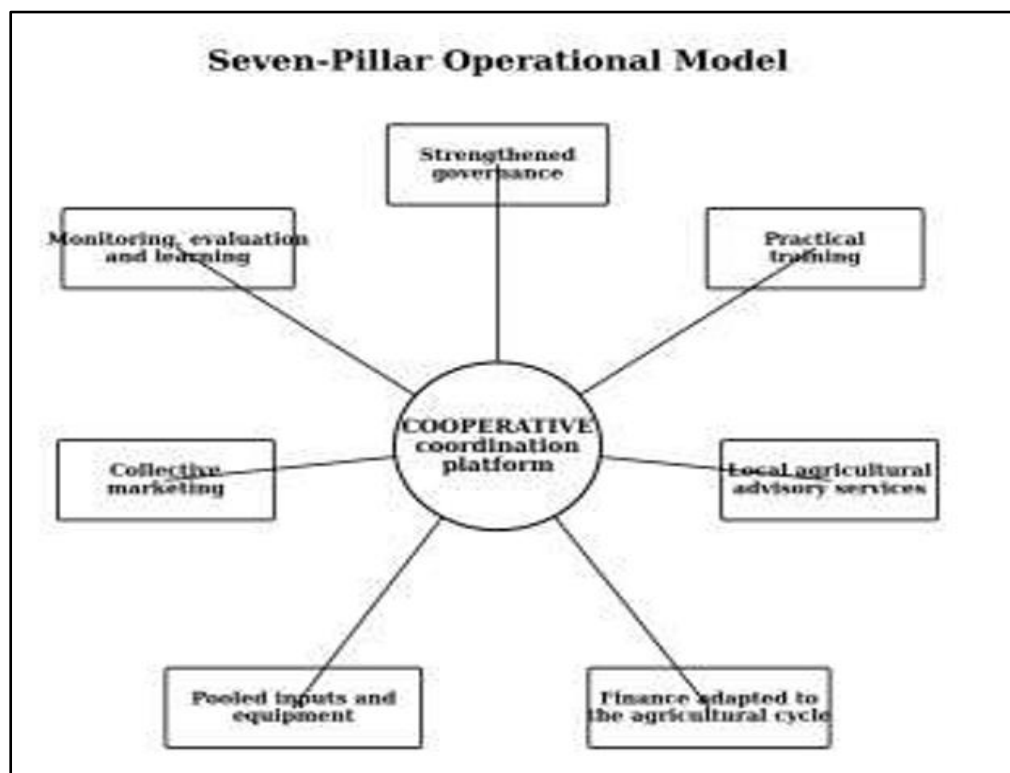


Fig 10 Seven-Pillar Operational Model of Cooperative Transition Capacity
Source: *Synthesis of the Strategic Architecture Developed in the DEA Dissertation.*

Fig 10 translates the concept into an operational architecture comprising governance, practical training, local advisory services, finance adapted to the agricultural cycle, pooled inputs and equipment, collective marketing, and monitoring, evaluation, and learning. No pillar should be interpreted in isolation. The cooperative functions as a coordination platform, while technical expertise, finance, public infrastructure, and market outlets require distinct partners.

➤ *Implement Progressively*

Capacity building can be organized in three phases:

- Establish governance, member registers, and learning arrangements;
- Consolidate advisory services, group purchases, finance, and collective sales; and
- When management capacity permits, develop processing, contracting, and more advanced monitoring and evaluation. This sequencing reduces the risk that an organization accumulates functions faster than it can manage them.

VII. CONCLUSION

This study reframes agricultural cooperation around a more demanding question than the simple comparison of members and

Non-members: under what organizational conditions can a cooperative support the combination and sustained use of agroecological practices?

The theoretical framework integrates diffusion of innovations, collective action, and agroecological transition. It yields an analytical chain in which membership and governance influence cooperative transition capacity; this capacity organizes a bundle of services; the services may reduce barriers related to cost, risk, complexity, and information; and multi-practice adoption can progress when farm characteristics and the territorial environment permit.

The synthetic-data demonstration illustrates this architecture without constituting empirical evidence for Luebo. It shows the expected structure of a rigorous analysis: group comparability, multi-practice measurement, quantification of gaps, effect-size estimation, adjusted regression, analysis of constraints, and cautious interpretation of causality.

The central conceptual contribution is the notion of cooperative capacity for agroecological transition. It distinguishes a formal cooperative from a functional cooperative and evaluates the organization by its capacity to coordinate knowledge, advisory services, finance, productive resources, collective learning, and market outlets. The territorial environment nevertheless remains decisive: collective action may attenuate selected barriers, but it cannot replace public infrastructure or a functioning market.

DATA TRANSPARENCY AND ETHICAL STATEMENT

The numerical dataset used in this manuscript is synthetic and was constructed to demonstrate the analytical protocol. It is not a field dataset and must not be interpreted as direct empirical evidence concerning agricultural producers in Luebo. The source materials specify a voluntary-consent and confidentiality protocol but do not document a formal ethics-approval identifier. No such approval is therefore claimed in this manuscript.

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