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Scaling Climate-Smart Agriculture Through Participatory Action Research: Adoption Outcomes and Sustainability Pathways in Ghana

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Research Article

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Abstract

Food security and climate resilience sit in uncomfortable tension across sub-Saharan Africa, and climate-smart agriculture (CSA) has been promoted as the bridge between them. Whether participatory action research (PAR) interventions can close the knowledge-to-practice gap in a lasting way remains inadequately answered in West African smallholder contexts. This paper presents findings from the end-of-project evaluation of the ReDIAL project, a four-year (2020–2024) EU-funded initiative across five agroecologically diverse districts in Ghana. The evaluation used a convergent parallel mixed-methods design: 400 household surveys, 50 focus group discussions, and 60 key informant interviews. By endline, 96% of project beneficiaries had received CSA training and roughly nine in ten were actively applying at least one CSA practice on their farms. Village Savings and Loan Associations (VSLAs) proved central—not as peripheral financial add-ons, but as the institutional mechanism that converted knowledge into sustained practice by providing farmers the credit needed to act on what they had learned. Average monthly household income rose from GHS 413 (USD 38) at baseline to GHS 707.5 (USD 64) at endline, surpassing the national average for comparable occupations by 15.6%, with women's incomes more than doubling. Persistent challenges remain: agricultural credit is still too expensive for most smallholders, gender income gaps have narrowed but not closed, and no formal exit strategy was produced. Implications for the design, resourcing, and handover of PAR-driven CSA programmes are discussed.

1 Introduction

Smallholder farmers in sub-Saharan Africa are dealing with two problems at once: soils that have been losing fertility for decades, and a climate that is becoming less predictable every year. Both threaten the food security and livelihoods of hundreds of millions of rural households [1]. Climate-smart agriculture, defined by the FAO as practices that sustainably increase productivity, build resilience, and reduce or remove greenhouse gas emissions where possible, has become the internationally endorsed response framework [2]. Getting smallholder farmers to adopt CSA practices, and keep using them once a project ends, is one of the most contested challenges in agricultural development research [3, 4].

Participatory action research has attracted attention as a more promising vehicle for CSA adoption than conventional top-down technology transfer. By positioning farmers as co-producers of knowledge and embedding learning within community practice rather than delivering it from outside, PAR is supposed to generate higher uptake and more durable change [5, 6]. This makes intuitive sense in contexts where literacy is limited, indigenous knowledge systems are ecologically sophisticated, and trust in external institutions is hard-won. But the evidence on whether PAR-driven CSA interventions truly hold up once project support is withdrawn remains thin, particularly in West African smallholder systems [3].

This paper addresses that question through the ReDIAL project in Ghana, a four-year EU-funded initiative (July 2020 to October 2024) implemented across five districts spanning distinct agroecological zones, funded under the DeSIRA framework (Climate-relevant Development Smart Innovation through Research

in Agriculture and food systems). ReDIAL was built around a theory of change that linked scientific soil data generation, participatory technology deployment, community collective formation, and multi-stakeholder policy dialogue into an integrated agricultural transformation programme.

Three questions guide the analysis. Did ReDIAL achieve meaningful CSA adoption among smallholder beneficiaries? Which institutional and financial mechanisms drove adoption and sustainability? And what does the evidence tell us about the conditions under which PAR-driven CSA can persist and spread beyond project boundaries? In working through these questions, the paper contributes both to the empirical literature on CSA adoption in West Africa and to broader debates about what makes PAR-based interventions stick.

2 Theoretical Background

2.1 Climate-Smart Agriculture in Sub-Saharan Africa

CSA gained formal international traction after the 2010 Hague Conference on Agriculture, Food Security and Climate Change, and has since worked its way into major development frameworks such as Nationally Determined Contributions under the Paris Agreement, Sustainable Development Goal 2, and numerous national agricultural policies [9, 1]. In sub-Saharan Africa, the CSA label covers a heterogeneous bundle of practices such as conservation tillage, agroforestry, integrated soil fertility management, crop diversification, and organic composting whose relevance depends heavily on local agroecological and socio-economic conditions [1].

The adoption literature is consistent on what gets in the way: limited finance, weak market linkages, labour demands (felt most sharply by women), thin extension coverage, and a mismatch between promoted technologies and the risk tolerance of farmers operating close to the margins [1]. Adoption is also rarely all-or-nothing. Farmers pick and choose, weaving new practices into existing strategies according to what their assets, land conditions, and social relationships will support [4].

2.2 Participatory Action Research as a Scaling Mechanism

PAR, as conceptualized by Lewin (1946) [13] and developed for agricultural settings by Chambers (1994) and Pretty (1995), ties empirical investigation to deliberate practice change within communities of interest. Its defining features of iterative cycles of reflection and action, shared ownership of the research process, and genuine respect for local knowledge have been argued to produce higher adoption rates than conventional extension because they reduce the cognitive and social distance between scientific knowledge and practical application [7].

Recent scholarship has made this claim more precise. Antwi-Agyei and Amanor (2023) distinguish between first-order adoption (taking up a practice during a project) and second-order adoption (continuing and spreading it afterwards) and argue that PAR is necessary but not sufficient for the latter. Whether adoption survives beyond project exit depends on how PAR is institutionally embedded: whether

it activates governance structures that can take over, creates peer networks that carry knowledge forward, and links to financial mechanisms that give farmers the means to keep practising [8].

2.3 Village Savings and Loan Associations as Agricultural Finance Intermediaries

VSLAs, also known as savings groups, have grown considerably as community-level financial intermediaries across rural sub-Saharan Africa over the past two decades [7]. They work without formal banking infrastructure: members pool savings and extend small loans at community-determined interest rates for agricultural inputs, enterprise investment, and household needs. Evaluations in West Africa have found positive effects on agricultural input use, livelihood diversification, and women's economic empowerment [4].

What is less documented is VSLAs operating as active intermediaries in agricultural technology adoption as institutions that not only provide capital, but also shape the social networks through which technology knowledge and norms spread. ReDIAL offers an opportunity to examine this integrative function directly.

3 The ReDIAL Project: Context and Design

3.1 Project Context and Study Sites

ReDIAL worked across five districts spanning five regions of Ghana: Yendi Municipality (Northern Region), Techiman Municipality (Bono East Region), Ejura-Sekyeredumase Municipality (Ashanti Region), Sefwi-Wiawso Municipality (Western North Region), and Kwahu Afram Plains North District (Eastern Region). These sites were chosen to capture agroecological and socio-cultural diversity, from Guinea savanna in the north to transitional and forest zones in the south.

The target population was smallholder cereal and grain farmers predominantly growing maize, rice, sorghum, and millet on plots typically below two hectares. Soil degradation was a near-universal condition across all sites at baseline, with communities reporting falling yields in staple crops including maize, yam, and cassava. That shared diagnosis gave communities real motivation to engage with soil health interventions from the start.

3.2 Project Theory of Change and Intervention Logic

ReDIAL operated on the premise that agricultural transformation cannot happen through technology transfer alone but requires simultaneous investment in scientific knowledge, technology deployment, community governance, and policy dialogue. The project's six result areas reflected this logic: scientific soil nutrient data generation and dissemination (Result 1); research on alternative soil fertility improvement methods (Result 2); grain threshing improvement through Multi-Crop Thresher deployment (Result 3); Multi-Stakeholder Dialogue Platform establishment and policy influence (Result 4); youth employment and skills transfer through FarmSense and Multi-crop Thresher (MCT) technologies (Result

5); and climate resilience improvement through CSA and sustainable land management uptake (Result 6).

This paper focuses on Result 6 but treats it as inseparable from the broader project architecture, particularly the VSLA-mediated financial inclusion component and the multi-stakeholder governance mechanism, both of which shaped how CSA adoption played out.

3.3 CSA and SLM Practices Promoted

The project promoted an integrated package of CSA and sustainable land management (SLM) practices adapted to local agroecological conditions and built on existing indigenous knowledge: minimum and zero tillage, mulching, intercropping, crop rotation, organic fertilizers (including compost and liquid compost tea produced from household and animal waste), agroforestry, and climate-resilient crop varieties. A CSA manual was produced and distributed to District Departments of Agriculture, embedding CSA content within the formal extension system. Critically, composting methods were designed to use locally available materials and basic improvised infrastructure (239 community compost bins across 25 communities), deliberately keeping technology cost from becoming a barrier to adoption.

4 Methodology

4.1 Evaluation Design

The analysis draws on the end-of-project evaluation commissioned by Friends of the Nation (FoN) and conducted by Endogen Global Consult Ltd. (EGCL) in late 2024, for which the author was the lead consultant. The evaluation used a convergent parallel mixed-methods design [10] in which quantitative and qualitative data were collected simultaneously but analysed independently, then integrated at the interpretation stage. This allowed statistical measurement of outcome indicators and contextual explanation of the patterns those numbers revealed, with findings cross-validated across data streams. The evaluation framework followed the six Organization for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC) criteria of relevance, coherence, effectiveness, efficiency, sustainability, and impact.

4.2 Data Collection Methods and Sample

Data came from five complementary sources: documentation review, household survey, focus group discussions, key informant interviews, and direct on-site observation. All five methods were applied in each of the five project districts, with additional national-level key informant interviews in Accra.

The household survey sampled 80 respondents per district (400 in total) covering 94 of ReDIAL's 413 project communities (22.8%). That fraction sits within the 17–27% range conventionally accepted as statistically representative for large populations. The sampling frame was kept consistent with the baseline and midterm phases to enable longitudinal comparison, and both probability (simple random)

and purposive techniques were used to ensure women, youth, and people with disabilities were represented.

Fifty focus group discussions were held across the five districts (10 per district) with purposively selected farmer groups. Sixty key informant interviews covered policymakers, district government officials, traditional leaders, civil society representatives, and financial institution managers (10 per district plus 10 at national level). Field teams comprised 15 locally recruited research assistants (three per district), trained in survey administration, ethical data collection, and local language use. Data were collected electronically via KoboCollect.

This study did not use a randomized controlled design, and without a matched control group, definitive causal attribution is not possible. Broader economic, climatic, and policy factors may have independently influenced outcomes. Results are interpreted as evidence of association and plausible contribution rather than definitive impact.

4.3 Analytical Approach

Survey data were analyzed descriptively, with change assessed against documented baseline and midterm indicators. District-level disaggregation enabled spatial comparison across agroecological and socio-cultural contexts. Qualitative data from focus groups and key informant interviews went through thematic content analysis, with emergent themes cross-validated against quantitative findings. Data quality assurance included pre-testing of instruments, real-time supervisor dashboards, and random back-checks with a subset of respondents.

5 Results

5.1 CSA Knowledge Acquisition and Training Reach

By endline, 96% of project beneficiaries confirmed receiving CSA training, a substantial change from baseline, where systematic CSA knowledge was largely absent in project communities. Radio sensitization programmes broadcast through ten community stations across the five districts extended CSA awareness well beyond those who participated directly in training, widening the enabling environment for practice diffusion.

The three most widely received training packages were Kintampo Centre for Agriculture Research and Practice (KCARP) compost making (96% of trained beneficiaries), minimum and zero tillage (89%), and mulching (80%). A pattern runs through all three: they build on or modify existing farming routines rather than requiring wholesale adoption of unfamiliar technologies, which likely explains their high uptake. In addition, 1,724 smallholder farmers (712 male; 1,012 female) received specific training in organic liquid fertilizer production—one of the more clearly gender-responsive elements of the programme design.

The breadth of training reach across all five districts was achieved through a deliberate multi-channel approach: community sensitization sessions, field demonstrations at learning sites, and CSA manual

distribution through local government extension officers. By endline, District Departments of Agriculture reported actively incorporating CSA content into their routine field visits, suggesting that the knowledge delivery system was no longer dependent on the project to keep running.

5.2 CSA Practice Adoption at Endline

Knowledge and practice are not the same, and the figures on actual adoption are what count. Roughly nine in ten project participants reported actively practicing CSA on their farms at endline. In the sustainable land management domain specifically, all respondents (99%) confirmed receiving capacity support, and cover cropping, crop rotation, and conservation tillage were each practiced by more than 90% of trained beneficiaries.

Participants' own assessments of the training were strongly positive: 62% rated CSA capacity support as 'very effective' and a further 19% as 'highly effective'. On sustainability intentions, 93% expressed confidence that their CSA practices would continue after the project ended. In focus groups, farmers explained this confidence through three things: the practices were close enough to what they already did that adoption felt natural rather than disruptive; organic composting materials were readily available in the community; and they trusted that VSLA networks and the agricultural extension service would provide ongoing support.

A genuine tension also surfaced in focus group discussions. Organic and low-external-input practices were seen as environmentally sound and long-term sensible, but slower to show yield gains than high-input approaches like chemical herbicide application. That perception is consistent with the productivity transition costs that the CSA adoption literature has documented [1], and it underscores why complementary financial support during the transition period is not optional.

5.3 The Role of VSLAs in Mediating Technology Adoption

The most important institutional finding of the study is how central VSLAs were to turning CSA knowledge into sustained practice. By endline, 19 VSLA groups with 581 members (409 female; 172 male) had collectively saved and circulated over GHS 1.2 million (approximately USD 109,354) within their membership networks.

Project staff and beneficiaries consistently described VSLA credit access as the decisive factor in CSA adoption, particularly in year three of the project when revolving funds had accumulated enough for meaningful agricultural investment. Loans went into CSA input procurement such as seeds, organic fertilizer materials, composting equipment, and into threshing service use and livelihood diversification. In seven communities, focus group evidence showed VSLA loans also funding climate adaptation assets: motor-tricycles, mobile phones for climate information access, and household improvements. That is a more compound effect than simply funding input purchases; it is financial inclusion generating ecological and social resilience at the same time.

The VSLA model also showed a function that is rarely documented: members used emergency trigger provisions written into their VSLA constitutions to access emergency funds during climate-related shocks such as floods, droughts, and pest events, enabling rapid recovery rather than distress sales or asset depletion. This is the absorb, adapt, and anticipate logic of climate resilience [8] operationalized at community level through a savings group constitution.

5.4 Livelihood and Income Outcomes

CSA adoption translated into measurable economic change. Average monthly household income rose from GHS 413 (approximately USD 38) at baseline to GHS 707.5 (approximately USD 64) at endline, a 71.4% nominal increase over four years, and 15.6% above the national average monthly income for elementary occupations (GHS 597, per Ghana Living Standards Survey 7 [11]).

Women's income gains were the most striking single finding. Average monthly income among female participants rose from GHS 310 (approximately USD 28) at baseline to GHS 703 (approximately USD 64) at endline, more than doubling within four years. Women made up 63.4% of beneficiaries targeted for income improvement, which reflects a deliberate gender-mainstreaming design rather than an incidental outcome. Post-harvest loss management also improved sharply, from a baseline of 90% to 98.8% at endline, driven primarily by Multi-Crop Thresher deployment alongside improved soil management.

Soil fertility outcomes were notable in scale. The number of hectares with soil fertility profiled rose from zero at baseline to 12,725,064.63 ha by project end, far exceeding the 50,000 ha target through the integration of FarmSense technology data with national soil mapping. The proportion of farmers exposed to alternative soil nutrient improvement technologies moved from 20% at baseline to 98.8% at endline.

5.5 Multi-Stakeholder Dialogue and Policy Influence

Multi-Stakeholder Dialogue Platforms (MSDPs), established in each district, served as the governance backbone for scaling CSA knowledge and translating project evidence into policy engagement. They brought farmers, traditional authorities, district government officials, civil society organizations, and private sector technology providers into structured dialogue that went beyond information sharing—agenda-setting, advocacy, and commitment-making were all part of what happened in those rooms.

The policy influence dimension of ReDIAL is significant for CSA scaling beyond the project itself. By generating credible scientific evidence on soil nutrient deficiency and presenting it through multi-stakeholder processes with institutional legitimacy, the project managed to engage the Ministry of Food and Agriculture at national level and secure commitments to integrate soil testing services into routine agricultural extension. That embeds CSA knowledge infrastructure within the state system and creates a pathway for continuation that does not depend on sustained donor funding.

6 Discussion

6.1 PAR and Durable CSA Adoption: What Explains the Results

The findings give substantial support to the idea that PAR, when embedded in multi-level institutional architecture, can produce durable CSA adoption. Three mechanisms appear to drive it.

The foremost is knowledge alignment with existing practice. The decision to design composting methods around materials already in community environments rather than around inputs requiring supply chain access was not a compromise—it was a strategic choice that directly reduced adoption barriers. Demonstration plots gave farmers observable proof of concept in real growing conditions before they were asked to commit. This is what Chambers [5] means by meaningful participation: genuine knowledge co-production, not participatory packaging of solutions designed elsewhere.

The next is sequencing financial access to coincide with the adoption window. VSLA maturation in year three of the project aligned with the peak CSA scaling phase, which means knowledge availability and financial readiness hit at the same time. That synchronization is not accidental, and it is replicable. Projects that introduce CSA technologies before community financial mechanisms are operational may achieve knowledge transfer without practice-change because farmers know what to do but cannot afford to do it.

The last is embedding knowledge within state systems before exit. Distributing CSA manuals through Departments of Agriculture, training extension officers in FarmSense soil testing, and establishing Post-ReDIAL Management Committees (PRMCs) anchored to District Assemblies collectively created institutional homes for project knowledge that do not disappear when project staff leave.

6.2 The VSLA as a Socio-Ecological Practice Institution

One of this study's more original contributions is the documentation of VSLAs functioning as socio-ecological practice institutions with collective structures that simultaneously manage financial risk, govern technology adoption norms, and structure the social networks through which CSA knowledge and practice spread. The conventional characterization of VSLAs as safety nets or credit pools does not capture this.

When VSLAs are deliberately linked to agricultural technology promotion and multi-stakeholder governance platforms, their impact compounds across economic, social, and ecological dimensions. The implication for programme design is direct: VSLAs should be treated as central organizational infrastructure around which CSA scaling strategies are built, not as financial components bolted onto an otherwise separate technical programme.

The study also reveals a real ceiling in the current VSLA model. The unit cost of FarmSense devices (GHS 6,000 or USD 547) and Multi-Crop Threshers (GHS 53,000 or USD 4,830), combined with prevailing commercial lending rates of 36–42%, placed individual technology ownership well beyond what VSLA-

financed smallholders could reach. This is a structural constraint on the project's vision for youth employment through agricultural technology entrepreneurship, which, by the evaluation's assessment, registered the weakest performance of any result area. Future programming needs concessional finance or blended finance mechanisms to bridge this gap.

6.3 Gender, Sustainability, and Equity

The gender findings in ReDIAL are among the most substantively important in the dataset. Women's incomes more than doubling within the project span, and women making up 63.4% of beneficiaries targeted for income improvement, are meaningful indicators of equity impact, not peripheral results.

But the evaluation also surfaces where the limits lie. Women's lower literacy levels within VSLAs required ongoing support for entrepreneurship and financial record-keeping, and their access to formal financial products remained constrained even with VSLA membership. Closing gender gaps in CSA adoption and benefit distribution requires working at multiple levels simultaneously: individual skills, household norms, community structures, and institutional policy. ReDIAL's integration of gender strategies across all result areas is a model worth documenting. The evidence equally suggests that deeper change in financial access and land rights will be needed before the gains become structurally self-sustaining.

6.4 Scaling Pathways and Their Constraints

Four plausible pathways for scaling ReDIAL's CSA approach emerge from the analysis. Geographic replication across additional districts or regions with similar agroecological and socio-economic profiles. Sectoral deepening through expanded soil testing coverage, additional CSA practice variants, and integration with market systems. Institutional scaling through formalization of VSLAs as registered cooperatives with improved access to formal finance. And policy scaling through consolidation of multi-stakeholder platform influence on national agricultural policy frameworks.

Each pathway has real constraints. Geographic replication cannot shortcut the local relationship-building and cultural contextualization that drove adoption in ReDIAL communities - attempt it and adoption rates will fall. VSLA formalization runs into the interest rate environment discussed earlier, as well as district-level governance capacity limitations. Policy scaling depends on sustained advocacy that is difficult to maintain without dedicated project-funded facilitation.

Running across all four pathways is the most correctable failure the evaluation identified: no formal written exit strategy was produced or disseminated. Verbal assurances from the ReDIAL consortium about post-project arrangements were not enough, stakeholder clarity on roles and responsibilities was inconsistent across districts, and that uncertainty is a real threat to institutional continuity. Future PAR-based CSA programmes should treat exit strategy documentation as mandatory, not optional, and produce it well before project closure with meaningful community input.

7 Conclusions

This paper has examined the adoption outcomes and sustainability pathways of a PAR-driven CSA intervention in rural Ghana, using evidence from the ReDIAL end-of-project evaluation. The results show that high CSA adoption, approximately 90% active practice at endline, is achievable when PAR is combined with community-embedded technology deployment, VSLA-mediated financial access, and multi-stakeholder governance. That combination matters, none of the three on its own would likely have produced the same outcome.

Three conclusions carry the most weight for future programming. VSLA-mediated financial inclusion is not complementary to CSA promotion; it is functionally integral to sustained adoption in low-income smallholder contexts where capital access is what truly determines whether knowledge becomes practice. Institutionalization through state extension systems and community governance structures is essential for post-project sustainability, and it cannot be left to emerge organically; it must be explicitly designed, resourced, and operational before project exit. And the gender dimensions of CSA adoption are simultaneously an equity issue and a productivity argument: the income gains documented among female participants demonstrate that gender-transformative programming generates agricultural dividends, not just social ones.

The limitations matter too. Without a matched control group, causal attribution is not provable. A four-year project cannot fully assess second-order adoption. Systematic farm-level productivity and yield data were not collected, which leaves the link between CSA adoption and agronomic outcomes unmeasured. Longitudinal follow-up studies tracking adoption and income trajectories in ReDIAL communities two to five years after project close, alongside comparative analysis with non-project communities, would substantially strengthen what can be concluded from this evidence and should be built into future programme design from the start.

At the policy level, the ReDIAL experience points toward a clearer principle for EU-funded agricultural development: sustainability impact is higher when investment goes into community governance architecture such as VSLAs, MSDPs, PRMCs, alongside technology transfer, and when budgets explicitly cover exit planning, post-project institutional support, and longitudinal evaluation. The DeSIRA framework's emphasis on climate-relevant smart innovation provides a productive institutional home for advancing these priorities across West Africa and beyond.

Declarations

Ethics Approval and Consent to Participate

This study involved the collection of primary data from human participants (household surveys, focus group discussions, and key informant interviews). All participants provided informed consent prior to data collection. This study was approved by the University for Development Studies' Institutional Review Board (IRB) in accordance with the guidelines and regulations set forth in the UDS Research Ethics Policy of 2022. The protocol number for this approval is UDS/RB/108/26. All data were collected and

processed in accordance with applicable national and international ethical standards for social science research involving human subjects. Participants were informed of their right to withdraw at any time without consequence.

Clinical Trial Number

Not applicable

Consent for Publication

Not applicable.

Competing Interests

The author declares no competing financial or non-financial interests in relation to the work described in this paper. The author served as the lead consultant on the ReDIAL end-of-project evaluation; this role is disclosed in the manuscript.

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Author Contribution

J.A is the sole author of this paper.

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Data Availability

The quantitative data (household survey) and anonymized qualitative data summaries that support the findings of this study are available from the corresponding author upon reasonable request. Primary data were collected under a consultancy agreement with Friends of the Nation (FoN); any data sharing is subject to their approval. Aggregate results are reported in full in this manuscript.

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