



Research Article

Agroecological Zoning and Credit Demand Heterogeneity: Implications for CGSL Product Design in South Sudan

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ABSTRACT



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Community Group Saving and Lending (CGSL) mechanisms are increasingly becoming important in rural South Sudan because formal financial institutions remained thinly distributed outside urban and pro-urban markets. Yet, many CGSL products still treat rural borrowers as if they face the same production calendar, risk profile and capital requirement. This study argues that credit demand in South Sudan is heterogeneous because agroecological zones differ in production potential, population density, crop and livestock systems, flood or drought exposure, market access and the timing of seasonal cash needs. Using mixed-methods field data from Eastern Equatoria, Jonglei and Lakes states, the study developed an agroecological credit-demand framework for CGSL product design. The study covered 85 administered questionnaires, 81 valid responses and 17 qualitative interviews. Descriptive evidence shows clear differences across state contexts: Eastern Equatoria was represented by Magwi County with crop production around maize and ground nuts; Jonglei by Bor County with agropastoral activities around cattle and sorghum; and Lakes by Rumbek, Yirol Town and surrounding areas with pastoralism and mixed farming. The state-level evidence indicates that rural finance was perceived to matter strongly for agricultural productivity (overall mean = 4.58), that productivity gains were linked to investment (overall mean = 4.49), and that working capital remained a major constraint (overall mean = 4.68 in the technology-adoption block). Hypothesis testing confirmed significant associations between CGSL participation and transformation into market-oriented production, improved productivity through technology and access to credit for technology (chi-square = 15.92, $p = .0001$). Logistic regression further showed that access to credit had a significant positive effect on the probability of technology investment (beta = 1.9459, $p = .026$). The study concludes that CGSL should move from one-size-fits-all lending to zone-sensitive product menus. Seasonal input loans, livestock loans, flood-recovery loans, savings-linked insurance, equipment-hire finance and harvest-aligned repayment schedules should be matched to agroecological realities. This reframes CGSL from informal emergency finance into adaptive rural financial institutions capable of supporting agricultural transformation.

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Introduction

Agricultural finance in rural South Sudan is commonly discussed as a problem of insufficient credit. This is partly true, but it is not the whole problem. Credit is not a single homogeneous good. A loan that is useful for a maize farmer before planting may be poorly suited to a cattle keeper facing a livestock disease outbreak, and a short-tenor consumption loan may not finance land preparation, improved seed, fertilizer, tools or transport. The development challenge is therefore not only how to increase the volume of rural credit, but also how to design credit products that fit the agroecological realities of borrowers. This study therefore examines design challenge through the lens of Community Group Saving and Lending (CGSLs) mechanisms in South Sudan. CGSLs are self-managed community finance groups

through which members mobilize savings, borrow from a group fund and sometimes receive support from NGOs, churches, development agencies or local financial institutions. Such groups matter in South Sudan because formal banks and microfinance institutions have limited rural reach, while insecurity, road conditions, market fragmentation and weather-related risk discourage conventional lending. Community finance fills part of this gap by relying on social collateral, peer monitoring and locally known repayment norms. However, the very informality that makes CGSLs accessible can also produce narrow product menus: small short-term loans, uniform interest rules and repayment schedules that may not reflect the production cycle.

Agroecological zoning offers a practical way to rethink this limitation. An agroecological zone is not merely a map category.

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For finance design, it represents a bundle of production potential, rainfall, soil, market distance, crop possibilities, livestock pressures, labor timing and shock exposure. In rural credit markets, these factors determine when farmers need cash, how much they need, what they can usefully invest in, how long they require before repayment, and which risks can disrupt repayment. When CGSLs ignore these differences, they may provide credit that is formally available but economically mismatched. While the study investigated CGSL mechanisms and rural agricultural development in Eastern Equatoria, Jonglei and Lakes states, it adopted and used a mixed-methods design, combining questionnaires and interviews to understand services offered by savings and lending groups, the influence of CGSLs on agricultural development, the influence of lending mechanisms and the factors affecting decisions to invest in agriculture.

The study questions: how does agroecological heterogeneity affect credit demand, and what does this imply for CGSL product design? This question is important because rural agricultural development in South Sudan involves different pathways across the country. Some areas have stronger potential for crop production; others are more pastoral, agropastoral or flood prone. Some farmers require input finance for seeds and land preparation, while others require livestock-oriented finance, emergency liquidity, equipment hire, post-harvest storage or market transport. A single generic CGSL loan product cannot serve all these needs equally well. Product design must therefore become more differentiated if CGSLs are to support agricultural transformation rather than only immediate consumption smoothing. The study argues that agroecological zoning should be used as a product design tool. Rather than asking only whether a farmer has access to credit, CGSLs and their development partners should ask what type of credit is needed in each zone, at what time of the production cycle, against which risks, with which repayment schedule, and linked to which complementary services. This argument draws from financial inclusion theory, rural finance theory, social capital theory and institutional theory, but it is grounded in the state-level evidence from the South Sudan doctoral fieldwork. The study is not a soil survey, crop-cut experiment or GIS classification exercise. It is a rural finance piece that uses agroecological logic to interpret credit demand. The emphasis is on how production potential, risk, access and livelihood type shape demand for loan size, timing, tenor, collateral, insurance and repayment design. This approach is useful for South Sudan because rural finance is still constrained by insecurity, distance, weak formal banking penetration and high exposure to climate shocks. A product that works in one state or farming system may underperform in another if it ignores these ecological and institutional differences.

Study Objectives

This study narrows the wider arguments of Community Group Saving and Lending mechanisms into a product-design problem: how should CGSL loans and savings services be shaped when rural borrowers operate in different agroecological and livelihood settings? The argument is that a farmer in a relatively crop-oriented zone does not demand the same credit product as an agropastoral household that must manage livestock health, mobility, flood risk and market distance. Product design therefore must start with the production ecology of the borrower rather than with the convenience of the group fund.

The study has four specific objectives. First, it explains how agroecological zoning can be used as a practical lens for classifying credit demand in rural South Sudan. Second, it describes state-level heterogeneity in production systems, saving mechanisms, group membership and farming dependence across Eastern Equatoria, Jonglei and Lakes state. Third, it analyses

quantitative indicators on technology adoption, capital constraints and rural finance to show where demand for more differentiated CGSL products is strongest. Fourth, it proposes a zone-sensitive product menu that can help CGSLs move beyond generic short-term loans toward agricultural finance that is better matched to production calendars, risk profiles and market opportunities.

2. Literature Review and Theoretical Framing

2.1 Rural Finance, Seasonality and Product Fit

Rural finance has long been affected by high transaction costs, covariate risk and information asymmetry. Huppi and Feder (1990) showed that group lending can reduce some transaction costs by transferring screening and monitoring functions to borrowers themselves. Besley (1995) explained that informal finance institutions survive because they use local information and enforcement mechanisms that formal lenders cannot easily replicate. Armendariz and Morduch (2010) further argued that microfinance relies on innovations such as group liability, progressive lending and repayment discipline to reach borrowers excluded from conventional banking. These arguments are directly relevant to CGSLs because they function through member selection, trust, repeated meetings and peer accountability. However, a group mechanism does not automatically solve the problem of product fit. Agricultural income is seasonal, uncertain and highly dependent on weather, labor and market conditions. Carter (1988) and Binswanger and Rosenzweig (1986) observed that farmers in risky environments may avoid profitable investments when credit, insurance and land markets are incomplete. Barrett, Carter and Timmer (2010) argued that agricultural transformation depends on structural changes that allow households to invest, accumulate and participate in markets. For CGSLs, this means that a loan must do more than circulate money. It must finance the right activity at the right time and allow repayment from the income stream created by that activity.

Product fit is especially important in fragile contexts. In a stable commercial farming area, farmers may borrow from banks, purchase inputs, ensure crops and sell through predictable markets. In rural South Sudan, borrowers often operate with weak infrastructure, uncertain security, expensive transport and limited formal risk transfer. The product therefore must embed flexibility. A short weekly repayment design may be appropriate for petty trade but inappropriate for crop production where income arrives after harvest. Similarly, a small equal loan may be insufficient for high-potential crop zones but too risky for low-potential or shock-prone zones without insurance or savings buffers. The idea of product fit also relates to the distinction between access and use. Financial inclusion literature emphasizes that access to an account or credit facility is not enough if the product is not useful, affordable and reliable (Demirguc-Kunt, Klapper, Singer, Ansar, & Hess, 2018). In CGSLs, a member may formally access loans but still fail to invest in agriculture because the loan is too small, late, short in duration or not linked to inputs. Therefore, credit demand heterogeneity must be analyzed before scaling CGSL agricultural products.

2.2. Agroecological Zoning as a Financial Design Lens

Agroecological zoning has usually been applied to land suitability, crop planning and food security analysis. It classifies agricultural space according to climate, soil, growing period, elevation, water conditions and production potential. In the thesis abbreviations, AEZ is defined as agroecological zone, while terms such as length of growing period, cropland connectivity index and rural accessibility index indicate the kind of spatial variables that matter in agricultural planning. This study extends that logic to rural finance. If agroecological zones determine what farmers can

produce and when, they also determine the type and timing of finance that farmers demand. A crop-oriented zone with a reliable growing season may require input loans before planting, labor finance during weeding, and transport or storage finance after harvest. A flood-prone agropastoral zone may require more emergency liquidity, livestock movement finance, veterinary finance and flexible repayment. A mixed farming zone may require a portfolio product combining small crop loans, livestock loans and household consumption-smoothing savings. In all cases, the question is not only what amount of credit is needed, but what repayment structure makes repayment likely without forcing distress sales. Agroecological zone also helps prevent misdiagnosis. When farmers fail to repay or underuse loans, lenders may interpret this as lack of discipline or low demand. It may reflect a product that was mismatched to the zone. For example, a flood shock may destroy crops, while a drought may reduce pasture and increase livestock disease costs. In such contexts, a rigid product can convert an ecological shock into a financial default. A zone-sensitive product would instead combine loans with savings buffers, emergency windows, insurance or rescheduling rules triggered by community-verified shocks.

In the South Sudan CGSL context, agroecological zoning is therefore both a development planning tool and a financial risk-management tool. It helps groups identify what productive investments are feasible, which risks are most threatening, and how repayments can be aligned with income cycles. This is particularly important where CGSLs are expected to support the shift from subsistence production to market-oriented farming. Commercialization cannot occur through credit alone; it requires credit that matches production potential and market conditions.

2.3 Social Capital, Institutional Trust and Credit Demand

Social capital theory explains why CGSLs operate in environments where formal lenders are hesitant. Bourdieu (1986) conceptualized social capital as resources embedded in durable networks, while Coleman (1988) emphasized trust, obligations and norms as foundations of coordinated action. Putnam (1993) linked social capital to cooperation and institutional performance. In CGSLs, social capital reduces lender risk because members know one another, meet repeatedly and can use social pressure to encourage repayment. This is particularly relevant in rural South Sudan, where formal credit records, collateral titles and bank branches are often limited.

Yet, social capital also shapes credit demand. A group with high trust and strong record keeping may be willing to support larger agricultural loans or group-based equipment hire. A group with weak cohesion may prefer smaller loans and faster repayment. A pastoralist or agropastoral group may demand emergency loans not only because of production risk but because social obligations around livestock, illness and food security are intense. Thus, agroecological credit demand is mediated by social relations. Production conditions create needs, but group norms determine whether those needs become actual loan products. Institutional theory adds that CGSLs must gain legitimacy in local environments. Meyer and Rowan (1977) and DiMaggio and Powell (1983) argued that organizations adapt to institutional norms and expectations. In rural South Sudan, CGSLs must align with community norms, NGO procedures, government expectations and member livelihoods. If a product is perceived as unfair, too risky or disconnected from local production realities, it may not be accepted even if technically sound. Zone-sensitive design therefore needs participatory product development, not only top-down templates.

Literature suggests three implications. First, social collateral makes CGSL lending possible, but it is not a substitute for correct product design. Second, trust can support innovation, but only

when groups understand the purpose and risks of differentiated products. Third, zone-sensitive products require institutional support such as training, transparent rules, record systems and links to input suppliers or extension agents.

3. Methodology

The study uses a qualitative-quantitative reinterpretation of a doctoral mixed-methods study on CGSL mechanisms and rural agricultural development in South Sudan. The wider study was conducted in Eastern Equatoria, Jonglei and Lakes States between 2022 and 2025. It used questionnaires to generate descriptive and inferential statistics and interviews to contextualize the results. The survey reached 81 valid responses out of 85 administered questionnaires, producing a 95 percent response rate. Eastern Equatoria contributed 28 valid responses, Jonglei 29 and Lakes' state 24. The current study is not a new field survey. It is an analytical journal conversion that asks a new question of the thesis data. Instead of treating the three states only as geographical sites, the article treats them as evidence of production-system and credit-demand heterogeneity. The study covered 17 interviews which fitted into qualitative study. The sampled state contexts are interpreted as different rural finance environments: crop-oriented Eastern Equatoria, agropastoral Jonglei and pastoral/mixed farming in Lakes state. This classification is used carefully as a finance-design lens rather than as a full biophysical zoning exercise. Three categories of evidence are used. The first category is contextual evidence: field area, dominant production activity, saving mechanism and sample structure. The second category is descriptive and Likert-scale evidence: CGSL membership, farming share, service performance and mean scores on technology, working capital and rural finance. The third category is inferential evidence: chi-square tests linking CGSL participation with productivity indicators and logistic regression estimating the effect of credit access on technology investment.

The analysis proceeds in four stages. First, state-level sample and livelihood information are organized to identify likely credit demand profiles. Second, CGSL membership and farming dependence are compared to assessing potential market depth for agricultural credit products. Third, technology and finance indicators are examined to identify whether demand is likely to concern working capital, long-term capital, input finance, risk management or enterprise finance. Fourth, the statistical tests are interpreted as evidence for product design implications. This makes the article applied and policy-oriented while remaining grounded in the original study. The study uses equations as conceptual tools rather than econometric estimators beyond the reported thesis tests. The first equation defines credit demand as a function of agroecological and household factors. The second equation defines a product-fit index. The third equation presents the logistic regression form used to interpret the relationship between credit access and technology investment. These equations help translate qualitative and descriptive evidence into product-design logic.

3.1 Analytical Equations

The study conceptualizes agroecological credit demand as follows:

$$D_{ir} = f(AEZ_r, P_{ir}, R_{ir}, S_{ir}, M_{ir}, G_{ir})$$

where D_{ir} is the credit demand of household i in zone r ; AEZ_r is the agroecological-zone condition; P_{ir} is the production enterprise mix; R_{ir} is risk exposure; S_{ir} is seasonal cash-flow timing; M_{ir} is market access; and G_{ir} is group-level capacity and liquidity. This equation emphasises that credit

demand arises from the interaction of zone conditions, household livelihoods and group institutions.

The product-fit index is expressed as:

$$PF_{ir} = w1(LF_{ir}) + w2(TF_{ir}) + w3(RF_{ir}) + w4(AF_{ir}) + w5(IF_{ir})$$

where PF_{ir} is product fit; LF is loan-size fit; TF is timing fit; RF is repayment-fit; AF is affordability fit; IF is insurance or risk-buffer fit; and w represents weights determined by local priorities. A product with a high score matches the borrower production cycle; a product with a low score may increase access without increasing productive investment.

The thesis logistic model is interpreted as:

$$\text{logit}(\text{Pr}(TI_i = 1)) = \alpha + \beta_1(\text{CreditAccess}_i) + \epsilon_{\text{epsilon}_i}$$

where TI is the probability of investing in modern agricultural technology, and Credit Access indicates access to credit through CGSL mechanisms. The reported beta coefficient for access to credit was 1.9459 with $p = .026$, suggesting that credit access significantly increased the likelihood of technology investment. For product design, this result means that improved access should be accompanied by better product fit to avoid underinvestment caused by mismatch.

4. Results and Discussions

4.1 State Contexts and the Geography of Credit Demand

The state-level sample shows both sufficient response coverage and meaningful differences in rural livelihood contexts. Eastern Equatoria, represented by Magwi County, had 28 valid responses out of 30 targeted respondents. Jonglei, represented by

Bor County, had 29 valid responses out of 30. Lakes State, represented by Rumbek, Yirol Town and surrounding areas, had 24 valid responses out of 25. The high response rates support the use of state comparisons for product design discussions, although they do not replace a full national survey. The livelihood profiles point to different product needs. Eastern Equatoria is described in the thesis population table as oriented around crop production, including maize and ground nuts. This suggests a demand profile shaped by planting calendars, improved seed, land preparation, weeding labor, pest control, storage and transport. In such settings, product design should prioritize pre-planting disbursement, harvest repayment and input-supplier linkages.

Jonglei is described as agropastoral, involving cattle and sorghum. This profile creates a more complex demand structure. Crop-related loans remain relevant, but livestock health, mobility, flood exposure, market timing and emergency liquidity also matter. A single crop input loan may therefore be inadequate. The CGSL product menu should include both production loans and shock-response instruments, especially where floods or livestock disease can disrupt repayment capacity. Lakes' state is described as pastoral and mixed farming. Credit demand here is likely to involve livestock trade, veterinary needs, crop tools, small enterprise finance and food-security smoothing. The relevance of Pastoralist Field Schools in the thesis suggests that knowledge, training and animal-related services are also part of finance demand. Product design for such zones should be portfolio-based rather than focused only on crops.

Table 1

Study context, sample structure and agroecological credit-demand interpretation

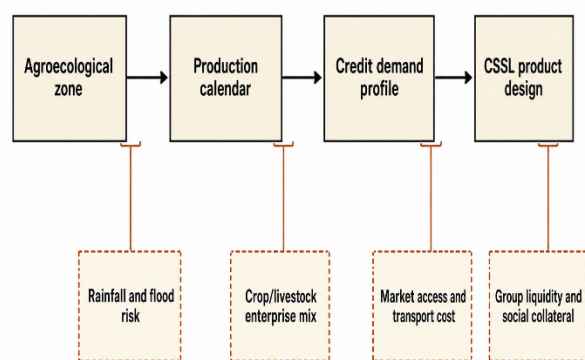
State	Field area	Target / valid responses	Dominant livelihood and saving mechanism	Credit-demand interpretation
Eastern Equatoria	Magwi County	30 / 28; 93% response rate	Crop production around maize and groundnuts; VSLAs and SILC groups	Demand is likely to centre on seasonal input loans, land preparation, seeds, tools and market-oriented crop finance.
Jonglei	Bor County	30 / 29; 97% response rate	Agro-pastoralism around cattle and sorghum; VSLAs and ROSCAs	Demand is likely to combine crop input finance, livestock health finance, flood recovery and emergency liquidity.
Lakes State	Rumbek and Yirol Town / East	25 / 24; 96% response rate	Pastoralism and mixed farming; VSLAs and Pastoralist Field Schools	Demand is likely to combine livestock trade, veterinary needs, mixed-crop tools and longer liquidity buffers.
Total	Three rural state contexts	85 / 81; 95% response rate	CGSLs and related community finance mechanisms	The combined sample allows comparison of finance needs across contrasting production and risk contexts.

Note. The table translates study geography into an agroecological credit-demand lens for article analysis.

Authors analysis based on field survey data on CGSL mechanisms in South Sudan (2022-2025).

The above table shows why CGSL product design should not be uniform across the three study settings. Eastern Equatoria has stronger crop-production framing, Jonglei combines agropastoral production with flood and livestock exposure, while Lakes' state

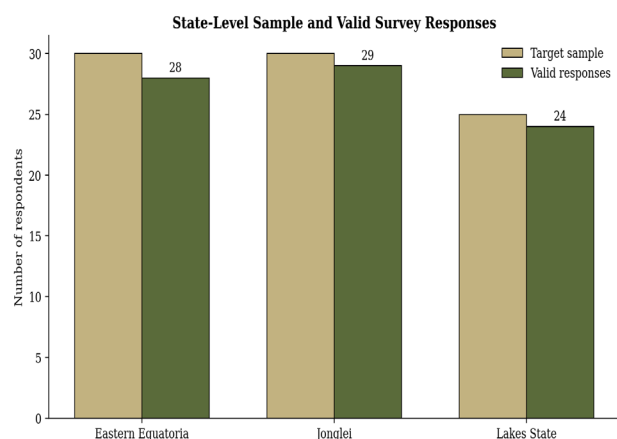
reflects pastoralism and mixed farming. These differences imply different loan purposes, repayment timing and risk-management needs even before individual household characteristics are considered

Figure 1*Agroecological credit-demand pathway for CGSL product design*

Product fit improves when loan size, timing, tenor, collateral and risk-sharing match the agroecological rhythm of production.

Authors' conceptualization developed from CGSL fieldwork and rural finance literature.

The above figure 1 presents the logic of this study. Agroecological zones shape the production calendar; the production calendar shapes the timing and size of credit demand; the credit-demand profile then determines the appropriate CGSL product. The lower boxes show that rainfall, flood risk, crop-livestock enterprise mix, market access, group liquidity and social collateral moderate the relationship. The implication is that product fit is highest when finance is designed around seasonal and ecological realities.

Figure 2*Sample structure and response strength across the three state contexts*

Authors analysis based on field survey data on CGSL mechanisms in South Sudan (2022-2025).

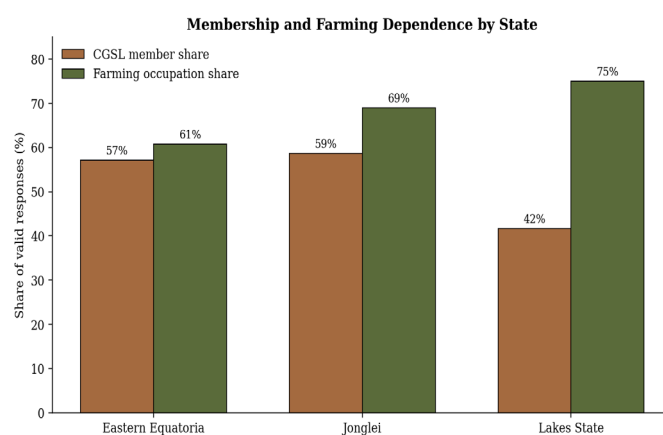
The above chart shows that each state had strong response coverage, with valid response rates above 90 percent. This matters because the article compares state contexts to discuss heterogeneity in credit demand. The high response rates indicate that the field evidence can support applied interpretation, while the relatively small sample size means that the conclusions are best treated as product-design guidance rather than definitive national estimates.

4.2. Membership, Farming Dependence and Potential Product Demand

CGSL membership was not uniform across the states. Eastern Equatoria recorded 16 CGSL members among 28 valid

respondents, while Jonglei recorded 17 among 29 and Lakes' state recorded 10 among 24. This means that membership shares were approximately 57 percent, 59 percent and 42 percent respectively. The product-design implication follows: the potential immediate market for CGSL-linked agricultural products is stronger in Eastern Equatoria and Jonglei than in Lakes' state, where non-member farmers may first require mobilization, trust building and group formation. Farming dependence was high in all three states. Farming was the occupation of 17 out of 28 Eastern Equatoria respondents, 20 out of 29 Jonglei respondents and 18 out of 24 Lakes state respondents. The corresponding shares were about 61 percent, 69 percent and 75 percent. This indicates that agricultural finance is not marginal to household livelihoods; it is central. Even where CGSL membership is lower, as in Lakes' state, demand for agriculture-related liquidity may remain high because livelihood dependence on farming and mixed production is substantial.

The combination of membership shares and farming dependence produces different product entry strategies. In Eastern Equatoria, where membership and crop production are relatively strong, CGSLs could pilot seasonal crop loans tied to inputs and harvest repayment. In Jonglei, where membership is also strong, but the livelihood profile is agropastoral, the product should include livestock and emergency components. In Lakes State, lower membership but high farming dependence suggests the need for product-linked group strengthening, financial literacy and savings mobilization before larger agricultural credit is scaled. This heterogeneity illustrates why a uniform CGSL product can miss local demand. A group with more farmers may need larger seasonal liquidity, while a group with more pastoral activity may need veterinary and market-timing finance. A group with fewer members may require a different scaling pathway from a well-established group. The design problem is therefore both agroecological and institutional.

Figure 3*CGSL membership and farming dependence by state*

Authors analysis-based field survey data on CGSL mechanisms in South Sudan (2022-2025).

The above chart compares the shares of respondents who were CGSL members with the share whose main occupation was farming. In all states, farming dependence was substantial, but membership varied. Lakes State had high farming dependence but a lower membership share, suggesting a product-design gap: demand for agricultural liquidity may exist even where group-based financial access is weaker. This supports a strategy of combining group formation with agriculture-linked products.

Table 3*State-level membership, farming dependence and product-design reading*

State	CGSL members / valid responses	Approx. member share	Farming respondents / valid responses	Product-design reading
Eastern Equatoria	16 / 28	57%	17 / 28 (61%)	Seasonal crop loans can be piloted through existing groups, with attention to loan size and input timing.
Jonglei	17 / 29	59%	20 / 29 (69%)	Agro-pastoral products should combine crop finance, livestock finance and emergency liquidity.
Lakes State	10 / 24	42%	18 / 24 (75%)	High farming dependence but lower membership suggests need for group strengthening before large loan scaling.
Overall	43 / 81	53%	55 / 81 (68%)	CGSLs reach a substantial share of rural respondents, but product design should follow state and livelihood differences.

Note. Percentages are computed from the valid response counts reported in the tables.

Authors analysis based on field survey data on CGSL mechanisms in South Sudan (2022-2025).

The above table shows that product demand cannot be read from membership alone. Lake's state has the lowest membership share but the highest farming share, indicating that agricultural liquidity needs may be underserved by existing group structures.

4.3 Technology, Working Capital and Product Differentiation

The technology and capital indicators show strong pressure for agricultural investment across all three states. Improved productivity through new technology scored 4.29 in Eastern Equatoria, 4.14 in Jonglei and 3.92 in Lakes' state. Credit as a prerequisite for technology scored 4.11, 4.03 and 3.92 respectively. Modern technology was perceived as capital intensive, with scores of 4.29, 4.34 and 4.25. Scarcity of working capital was the strongest indicator, scoring 4.75 in Eastern Equatoria, 4.72 in Jonglei and 4.54 in Lakes State.

These results show that farmers do not merely demand credit for smoothing consumption. They connect credit to technology adoption and investment. However, the high working-capital scarcity scores imply that the existing level of finance is inadequate for the investment requirements of modern agriculture. A CGSL product that offers only small short-term loans may help households cope with emergencies but may not finance improved seed, fertilizer, land preparation, tools, irrigation, veterinary services or transport.

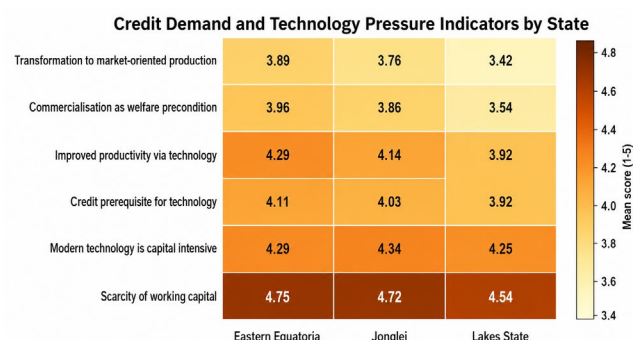
The state differences are modest but meaningful. Eastern Equatoria reports the highest score for improved productivity through technology, consistent with its crop production orientation. Jonglei reports the highest score for modern technology being capital intensive, which may reflect the combined cost of crop and livestock investments. Lakes State scores slightly lower on several transformation indicators but still shows strong recognition of capital intensity and working capital scarcity. This suggests that all states need better product fit, but the products should differ by enterprise mix and risk exposure. The data also show that the transition to market-oriented production is less strongly scored than working capital scarcity.

Eastern Equatoria and Jonglei have stronger membership bases, making them more ready for differentiated product pilots. Overall, 68 percent of respondents were primarily engaged in farming, confirming the relevance of agricultural credit design.

Transformation to market-oriented production had an overall mean of 3.70, while scarcity of working capital had an overall mean of 4.68. This gap is important. Farmers may know that capital is lacking, but market orientation also requires surplus, reliable production, storage, transport and buyers. CGSL products should therefore not stop at credit. They should connect loans to extension, input quality and market linkage services.

Figure 4

Technology and credit-demand pressure indicators by state



Authors analysis based on field survey data on CGSL mechanisms in South Sudan (2022-2025).

The heatmap highlights where product-design pressure is strongest. Working capital scarcity is high across all states, while modern technology is consistently perceived as capital intensive. Eastern Equatoria shows the strongest mean for improved productivity through technology, while Jonglei is particularly high on the capital intensity indicator. The pattern supports differentiated agricultural products rather than uniform short-term loans.

Table 4*Selected technology and capital indicators relevant to agroecological credit demand*

Indicator	Eastern Equatoria	Jonglei	Lakes State	Overall mean	Product-design implication
Transformation to market-oriented production	3.89	3.76	3.42	3.70	Credit should be linked to surplus production, storage and market access, not only loan disbursement.
Improved productivity via new technology	4.29	4.14	3.92	4.12	Agricultural loans should finance complete input packages and extension support.
Credit as prerequisite for technology	4.11	4.03	3.92	4.02	Technology adoption requires timely and sufficient seasonal credit.
Modern technology is capital intensive	4.29	4.34	4.25	4.30	Larger loan ceilings or external capital linkages are needed for productive investment.
Scarcity of working capital	4.75	4.72	4.54	4.68	Short-term micro-loans may need redesigning into seasonal working-capital products.
Importance of savings for poverty reduction	4.57	4.52	4.42	4.51	Savings should remain integrated with loan products to reduce vulnerability and default risk.

Note. Means are based on 1-5 Likert-scale responses in the survey. *Authors analysis based on field survey data on CGSL mechanisms in South Sudan (2022-2025).*

The above table summarizes the central product design evidence. Across all states, the highest pressure is working capital scarcity. This means that the binding constraint is not only willingness to invest but the capacity to finance investment. Since

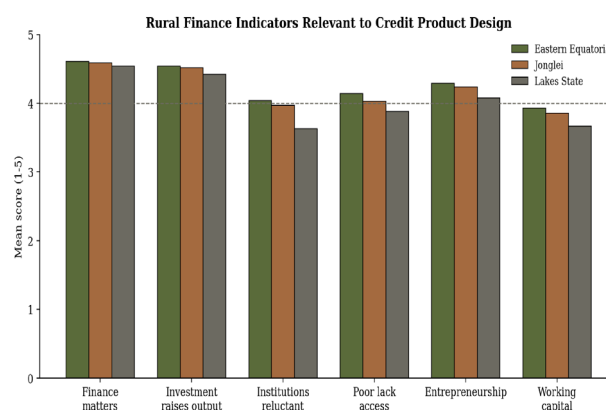
4.4 Rural Finance Indicators and Institutional Constraints

The rural finance indicators strengthen the argument for zone-sensitive CGSL design. Respondents strongly agreed that access to rural financial services can make a difference in agricultural productivity, with means of 4.61 in Eastern Equatoria, 4.59 in Jonglei and 4.54 in Lakes' state. They also agreed that productivity rises through investment in agriculture, with scores of 4.54, 4.52 and 4.42. These high means indicate a broad understanding that finance matters because it enables investment, not merely because it provides cash. At the same time, respondents recognized the institutional constraints facing rural finance. The statement that financial institutions are reluctant to serve rural areas scored 4.04 in Eastern Equatoria, 3.97 in Jonglei and 3.63 in Lakes State. Poor households being bereft of formal financial access scored 4.14, 4.03 and 3.88. This confirms the role of CGSLs as alternative financial institutions, but it also highlights the risk of overburdening them. If formal institutions are absent, CGSLs may face demand for products that exceed their internal savings capacity. Working capital as a driver of technology adoption scored 3.93 in Eastern Equatoria, 3.86 in Jonglei and 3.67 in Lakes' state. These means are positive but lower than the broader recognition that finance matters. This difference may indicate that respondents understand finance broadly but have trouble translating working capital into technology investment. Product design can close this gap by packaging finance with input suppliers, training and repayment terms that make the investment pathway visible and manageable.

The results also suggest that formal-informal linkages are needed. CGSLs can screen borrowers and mobilize savings, but external partners may provide wholesale capital, insurance design, input procurement or digital records. This is not a call to replace CGSLs with banks; it is a call to strengthen CGSLs so that they can handle differentiated demands. A zone-sensitive CGSL model

technology is also viewed as capital intensive, CGSLs need products that are larger, better timed and more closely connected to production calendars than generic small loans.

would retain the trust of community groups while adding technical support and product diversity.

Figure 5*Rural finance indicators shaping CGSL product design*

Authors analysis-based field survey data on CGSL mechanisms in South Sudan (2022-2025).

The figure shows that respondents across all states strongly recognized the productivity value of rural finance and investment. However, they also recognized institutional reluctance to serve rural areas and the exclusion of poor households from formal financial systems. These combined findings explain why CGSLs are important, but also why they must be strengthened with better capitalization, training, product variety and risk management.

4.5 Hypothesis Testing and Product Design Implications

The thesis hypothesis tests provide statistical support for the idea that CGSLs matter for agricultural transformation. Chi-square testing reported significant associations between CGSL

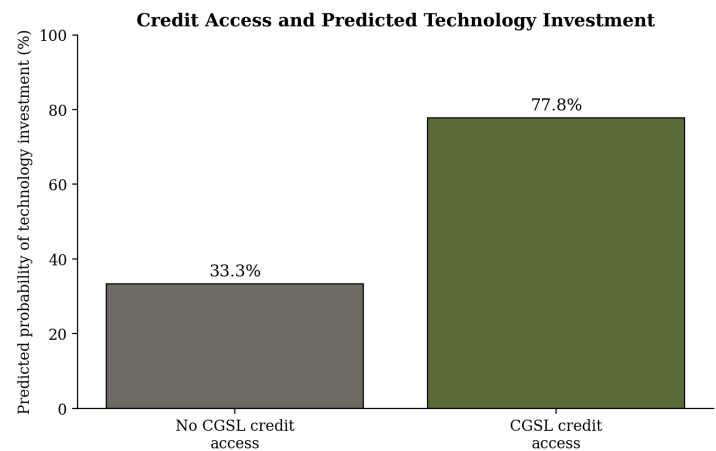
participation and three productivity indicators: transformation to market-oriented production, improved productivity through technology and access to credit for technology. Each indicator had a chi-square statistic of 15.92 with $p = .0001$ and 2 degrees of freedom. Although these tests do not specify the exact product design, they show that participation is meaningfully connected to outcomes that product design seeks to improve. The logistic regression result is also important. Access to credit had a coefficient of 1.9459, standard error of 0.875, z-value of 2.222 and p-value of .026. Interpreted as a logit coefficient, this means that access to credit significantly increased the likelihood of investing in modern agricultural technologies. Using the reported constant of -0.6932 and the credit coefficient, the predicted probability of technology investment rises from about 33.3 percent without credit access to about 77.8 percent with access. This result is useful for product design because it shows that credit access can change investment behavior.

However, the result should not be used to argue that any credit product is sufficient. The positive effect of credit access indicates potential, while the descriptive results on working capital scarcity and technology capital intensity indicate design constraints. If the credit product is too small, too late or too rigid, it may increase access without fully financing productive investment. The statistical result therefore supports the need for credit, while the agroecological framework explains what kind of credit should be provided. For a zone-sensitive CGSL system, the statistical findings imply that product designers should focus on the margin where credit access becomes investment. This margin is shaped by loan size, timing, tenor, collateral rules, group liquidity, risk buffers and complementary services. Different agroecological contexts will have different margins. In crop zones, the crucial margin may be pre-planting disbursement. In agropastoral zones,

it may be flooding recovery or livestock health. In mixed farming zones, it may be flexible portfolio lending.

Figure 6

Predicted probability of technology investment with and without CGSL credit access



Authors' analysis based on field survey data on CGSL mechanisms in South Sudan (2022-2025).

The above figure translates the reported logistic regression coefficients into an intuitive probability comparison. With the thesis constant and credit-access coefficient, predicted technology-investment probability is much higher when a respondent has credit access. The chart reinforces the importance of credit availability, while the wider article stresses that the credit must be designed to fit agroecological production cycles.

Table 5

Hypothesis tests and implications for zone-sensitive CGSL products

Statistical evidence	Reported value	Interpretation	Product-design implication
Chi-square: transformation to market-oriented production	chi-square = 15.92; $p = .0001$; $df = 2$	CGSL participation is significantly associated with market-orientation indicators.	CGSL products should support surplus production, storage and market linkage, not only household liquidity.
Chi-square: improved productivity through technology	chi-square = 15.92; $p = .0001$; $df = 2$	CGSL participation is significantly associated with technology-linked productivity.	Products should finance full technology packages and technical support.
Chi-square: access to credit for technology	chi-square = 15.92; $p = .0001$; $df = 2$	Credit and technology access are statistically linked.	Loan timing and size should match the agricultural calendar of the zone.
Logistic regression: access to credit	beta = 1.9459; SE = 0.875; $z = 2.222$; $p = .026$	Credit access significantly increases the likelihood of investing in modern technology.	Product fit determines whether credit access becomes actual productive investment.
Constant term	beta = -0.6932; $p = .304$	Baseline probability without credit access is lower and not statistically strong.	Credit products should target excluded borrowers but include risk safeguards.

Note. The table interprets the statistical outputs through a product-design lens.
Analysis based on field survey data on CGSL mechanisms in South Sudan (2022-2025).

The table connects statistical findings to practical decisions. Significant associations show that CGSLs are not peripheral institutions; they are linked to productivity and technology investment. The design implication is that CGSLs should develop

products that convert access into useful investment. This requires matching loan features to the ecological and seasonal conditions faced by borrowers.

Table 6

Agroecological-zone credit-demand typology for CGSL product design

AEZ code	Indicative zone logic	Likely borrower demand	Suggested CGSL product	Repayment and risk feature
HH	High production potential and high population density	Seasonal input finance, labour finance, storage, market transport	Larger seasonal crop loans and group marketing finance	Harvest-aligned repayment; input supplier linkage; storage-based repayment buffer
HL	High production potential and low population density	Mechanisation, land preparation, transport, aggregation	Equipment-hire finance and produce aggregation loans	Longer tenor; joint borrowing for assets; transport cost allowance
MH	Medium production potential and high population density	Mixed input finance, petty trade smoothing, food security savings	Split-purpose loans combining crop inputs and income smoothing	Staggered repayment; savings lockbox for food needs
ML	Medium production potential and low population density	Livestock, crop diversification, transport, tools	Livestock-crop portfolio loans and mobile banking partnerships	Flexible instalments; veterinary component; group verification of shocks
LH	Low production potential and high population density	Risk mitigation, drought/flood response, small enterprise diversification	Safety-first loans, emergency fund and insurance-linked savings	Small loan ceilings; shock-triggered rescheduling; strong training requirement
LL	Low production potential and low population density	Pastoral mobility, veterinary services, emergency liquidity, food reserve	Livestock health loans, revolving emergency loans and savings buffers	Flexible tenor; contingency reserve; repayment tied to livestock sale or seasonal market

Note. The typology uses AEZ abbreviations found in the glossary and adapts them for rural finance design.

Authors' adaptation of AEZ logic and CGSL product-design analysis.

The above table turns agroecological labels into practical finance options. High-potential zones require larger productive loans that can generate marketable surplus, while lower-potential or high-risk zones require safety-first products, savings buffers

5. Discussions

5.1 From Uniform Loans to Zone-Sensitive Financial Products

The findings support a shift from uniform CGSL lending to zone-sensitive product design. The current logic of many community finance groups is simple and accessible: members save, borrow from the accumulated fund and repay with interest. This structure is valuable because it builds discipline and local ownership. Yet agricultural transformation requires more than access to a revolving pot of money. It requires credit that is fitted to the production system. A standard loan product may be adequate for small trade but inadequate for crops, livestock or mixed farming.

In Eastern Equatoria, the product-design emphasis should be on seasonal crop finance. The evidence suggests strong recognition that technology can improve productivity and that credit is needed to access technology. A suitable product would provide pre-planting loans for seed, tools, land preparation, labor and pest management, with repayment after harvest. It should be complemented by input verification, extension advice and storage or market support. Without these links, farmers may borrow but still purchase incomplete or poor-quality input packages. In Jonglei, the product design should be more agropastoral. The same household may face crops and livestock cash needs. Floods, livestock disease, mobility and emergency food needs may interrupt repayment. A useful product would combine seasonal

and shock-responsive repayment. The central message is that the same loan size and repayment calendar should not be applied across all zones because the risks and cash-flow profiles differ sharply.

crop loans with livestock health loans and an emergency window. The repayment calendar should not assume that all income comes from one harvest. It should allow repayment from livestock sales, crop sales or staggered income sources. In Lakes state, where farming dependence is high, but CGSL membership share is lower, product design must combine inclusion and productive finance. Larger agricultural loans may be risky if group governance and savings mobilization are weak. Therefore, a gradual product ladder is appropriate: savings mobilization, financial literacy, small portfolio loans, livestock-related products, and then larger seasonal or equipment loans for groups that demonstrate repayment capacity. Product sequencing matters as much as product type.

5.2 Credit Demand Heterogeneity and the Limits of Access

Indicators

The study also challenges the common tendency to measure financial inclusion mainly through access. Access is important, but it can hide product mismatch. A farmer may be counted as having credit access even when the loan is too small to finance inputs or repayable before the crop produces income. Another farmer may be a member of a CGSL but avoid agricultural borrowing because the group loan rules are designed for short-cycle petty trade. In such cases, access exists on paper but not in the form that supports productive investment. Credit demand heterogeneity helps explain why this happens. Demand is not only

a desire for money; it is a structured need arising from production. A maize farmer has a different cash-flow profile from a cattle keeper. A flood-prone household needs different risk protection from a farmer in a relatively stable crop zone. A household with poor market access may need transport finance and longer repayment time, while one near a market may benefit more from input and storage finance. The product must therefore be evaluated by its fit with the borrowing context.

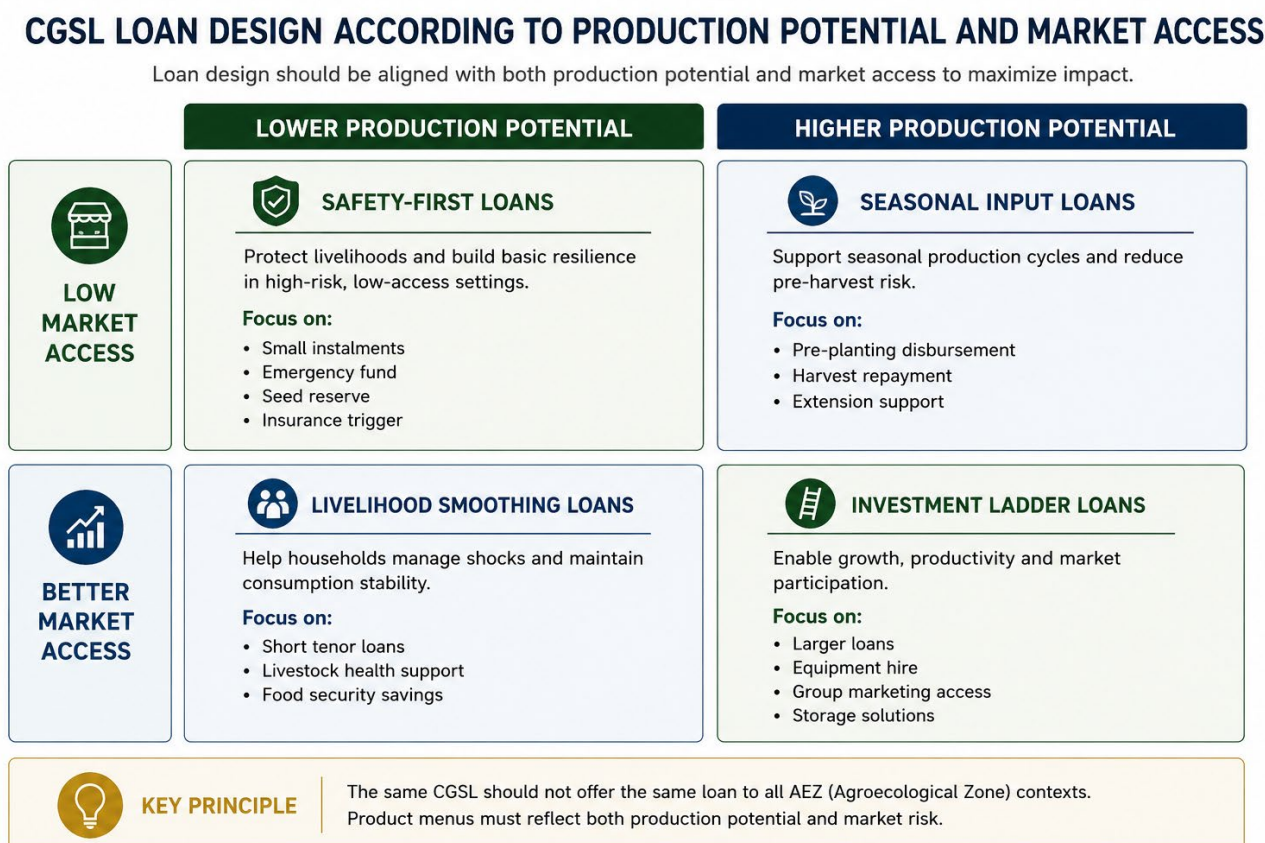
The high scores on working capital scarcity show that borrowers recognize the gap between available resources and agricultural investment needs. But working capital means different things across zones. In a crop zone, it may mean seed and

labor. In an agropastoral zone, it may mean veterinary drugs, feed, crop inputs and emergency food. In a mixed zone, it may mean small loans across several household enterprises. If CGSLs offer one product for all these needs, some borrowers will be underserved and others may be overexposed.

This discussion suggests that CGSL monitoring should add product-fit indicators. Groups should not only record how much was lent and repaid. They should record loan purpose, timing of disbursement, repayment source, production outcome, shocks faced and whether the loan size was enough for the planned investment. Such data can help groups learn which products fit which zones and which borrowers need adjustment.

Figure 7

Zone-sensitive CGSL product menu for contrasting production and market contexts



Source: Authors product-design synthesis based on findings.

The matrix converts the article argument into a practical product menu. High-potential zones with better market access can support investment-ladder products such as equipment hire and group marketing. High-potential zones with poorer access need aggregation and seasonal input finance. Lower-potential or high-risk zones need safety-first loans, emergency funds and insurance-linked savings. The figure cautions against applying one loan product across all agroecological settings.

5.3 Implications for CGSL Product Design

The first implication is that CGSLs should develop seasonal input loans where crop production potential is strong. These loans should be disbursed before planting, sized according to plot and input package, and repaid after harvest. They should not require frequent early repayment instalments that force farmers to divert cash before the investment matures. Such loans are particularly relevant to crop-oriented settings such as Eastern Equatoria.

The second implication is that agro-pastoral areas require mixed-purpose products. A household that combines cattle and crops may need veterinary finance and crop input finance in the same season. If the loan rules restrict borrowing to one narrow

purpose, the household may underinvest or borrow informally from expensive sources. A portfolio loan with clear sub-components can allow members to allocate finance across crop and livestock needs while maintaining accountability.

The third implication is that risk-management products are not optional. Floods, drought, disease, insecurity and market disruptions can convert a productive loan into a default. CGSLs should therefore include emergency savings funds, loan rescheduling rules, mutual insurance features or links to external insurance where possible. At minimum, groups should develop transparent shock-response rules so that members know how repayment will be handled when a verified covariate shock occurs.

The fourth implication is that loan ceilings should be differentiated. Equal loan ceilings appear fair but may be inefficient. A farmer cultivating a larger crop area or participating in group marketing may require a larger loan than a household borrowing for emergency food. However, differentiated ceilings must be governed carefully to prevent elite capture. Criteria should include repayment history, farm plan, group approval,

gender inclusion, risk exposure and whether the loan is tied to a productive package.

The fifth implication is that product design should include non-financial services. The thesis evidence highlights the role of NGOs, capacity building and government-donor collaboration. Agricultural loans perform better when linked to training, extension, input quality, record keeping and market information. This is consistent with microfinance debates showing that credit alone may have limited effects when complementary constraints

remain. CGSL products should therefore be embedded in a broader rural development support system.

The sixth implication is that product development should be participatory. Members understand local seasons, risks and social obligations. External actors may bring technical knowledge and capital, but local members should help design the loan purpose, repayment calendar and shock rules. Participatory design helps preserve trust and reduces the risk that a technically attractive product fails because it conflicts with local norms.

Table 7

Recommended CGSL product menu by agroecological credit-demand profile

Demand profile	Priority product	Key design features	Risk-control feature	Likely benefit
Crop-oriented seasonal demand	Seasonal input loan	Pre-planting disbursement; harvest repayment; package-based loan sizing	Input verification and group monitoring	Improved adoption of seeds, tools and productivity-enhancing inputs.
Agro-pastoral mixed demand	Crop-livestock portfolio loan	Sub-accounts for seed, livestock health and emergency liquidity	Flexible repayment from crop or livestock sale	Better fit for households with diversified income cycles.
Flood or drought exposure	Shock-responsive loan and savings fund	Emergency window; verified rescheduling; savings buffer	Group-level shock committee and reserve fund	Reduced distress borrowing and lower default pressure after shocks.
High-potential market-oriented production	Investment ladder loan	Progressive larger loans; storage, transport and group marketing support	Repayment history and business plan screening	Movement from subsistence to market surplus and enterprise growth.
Weak group or low membership context	Savings-first product ladder	Start with savings, literacy and small loans before larger agricultural credit	Graduated access based on governance and repayment performance	Builds institutional capacity before scaling high-risk loans.

Note. The menu should be adapted locally through member consultation and pilot testing before large-scale rollout.

Authors analysis based on field survey data on CGSL mechanisms in South Sudan (2022-2025).

The above table provides the practical output of the article. It shows how CGSL products can be differentiated by demand profile. Crop-oriented borrowers need seasonal input loans, agro-pastoral borrowers need portfolio loans, shock-prone borrowers

5.4 Policy and Institutional Implications

Government, NGOs and development partners should treat CGSLs as rural financial infrastructure. They are not banks, but they perform financial intermediation where banks are absent. Strengthening them requires more than training treasurers. It requires a system that helps groups understand agroecological demand, design differentiated products, keep records, manage risks and link borrowers to productive services. A national rural finance policy should therefore recognise CGSLs as local institutions that need support, supervision and integration.

One policy priority is the development of state-specific CGSL product guidelines. Such guidelines should not impose rigid templates; they should identify product options suitable for crop, agro-pastoral, pastoral and mixed-farming settings. The guidelines can include recommended loan tenors, repayment calendars, minimum savings buffers, shock-response procedures and criteria for larger productive loans. They should be simple enough for community use but detailed enough to prevent harmful lending practices.

A second policy priority is wholesale capital and guarantee support. The thesis results show high recognition of working capital scarcity. Internal savings alone may not meet agricultural investment demand, especially in high-potential zones. External capital can help, but it should not flood groups with funds before governance is ready. A staged approach is safer: groups that meet

need risk-responsive products, and weak groups need a savings-first ladder. This approach protects the group fund while improving the usefulness of credit for agricultural development.

record-keeping, savings and repayment standards can access larger capital lines for specific agricultural products. This prevents over-indebtedness and protects social trust.

A third policy priority is risk management. South Sudanese rural production is exposed to floods, droughts, insecurity, pests, disease and price fluctuations. If these risks are ignored, agricultural loans can damage both borrowers and groups. Development partners should help groups build contingency reserves, link to insurance where available, use community-verified shock triggers and create clear rescheduling procedures. Risk-sharing should be built into product design rather than addressed only after default occurs.

A fourth policy priority is data. CGSLs need simple tools for tracking zone, enterprise type, loan purpose, loan size, disbursement date, repayment date, shock occurrence and investment outcome. Such data would allow product refinement over time. It would also help policymakers understand rural credit demand more precisely. Without data, CGSL programmes may scale products that are popular but not transformative.

5.5 Ethical Considerations in Differentiated Lending

Differentiated products can improve fit, but they also create ethical risks. Larger or specialised loans may be captured by better-off members, men, local elites or those with stronger social influence. If CGSLs introduce zone-sensitive products without inclusion safeguards, they may widen inequality. Product criteria

should therefore include gender equity, youth access, poverty sensitivity and transparent decision-making. Groups should explain why loan sizes differ and how members can qualify for higher productive loans.

Another ethical issue is risk transfer. Development actors should not encourage poor farmers to take larger loans simply because agriculture has potential. A high-potential zone can still experience crop failure, conflict or market collapse. Borrowers should understand loan conditions, interest, penalties and shock rules before borrowing. Product design should prevent over-indebtedness by linking loan size to realistic farm plans and repayment sources.

Ethical design also requires preserving the social fabric of CGSLs. Group lending works because members trust one another. If a new product creates conflict, resentment or harsh enforcement, it can damage the institution. Piloting, member consultation, transparent records and grievance channels are therefore essential. Product innovation should strengthen social capital, not exploit it.

6. Conclusion

This study examines agroecological zoning and credit demand heterogeneity as foundations for CGSL product design in South Sudan. The analysis shows that rural borrowers do not face identical production systems, risks or cash-flow needs. Eastern Equatoria, Jonglei and Lakes state differ in crop orientation, agro-pastoral activities, pastoral and mixed farming systems, saving mechanisms, group membership and farming dependence. These differences matter for credit design because they shape loan purpose, size, timing, repayment and risk-management needs.

The study evidence supports the importance of CGSLs for agricultural development. Respondents strongly agreed that rural finance makes a difference to productivity, that productivity rises through investment, and that working capital scarcity constrains enterprise and technology adoption. Hypothesis testing found significant associations between CGSL participation and market-oriented transformation, technology-linked productivity and credit for technology. Logistic regression showed that access to credit significantly increased the likelihood of technology investment. These findings confirm that credit access matters. However, the study argues that access alone is not enough. Credit becomes transformative when it fits the agroecological and institutional context of the borrower. A generic loan product may help consumption smoothing but fail to finance productive investment. A zone-sensitive product menu can better support crop input finance, livestock health, flood recovery, equipment hire, group marketing, savings-linked insurance and shock-responsive repayment. This is the pathway through which CGSLs can move from informal emergency finance toward adaptive rural financial institutions.

The study take away recommendation is that CGSLs, NGOs, government agencies and rural finance partners should adopt agroecological product design. They should classify demand by production potential, livelihood system, risk exposure, market access and group capacity. They should then pilot products that match these demand profiles and monitor outcomes beyond repayment. Such an approach can strengthen the contribution of CGSLs to rural agricultural development in South Sudan and reduce the risk that farmers remain financially included but productively underserved.

7. Limitations and Suggestions for Further Research

The study is based on a reinterpretation of a doctoral study rather than a new agroecological mapping exercise. The state classifications used here are product-design proxies derived from the thesis context, production descriptions and survey results.

Future research should integrate GIS-based agroecological maps, rainfall data, market access measures and household finance data to produce a more precise credit-demand zoning model. The survey sample is useful for applied analysis but remains modest in size. Future studies should collect larger samples across more counties and across multiple seasons. Larger samples would make it possible to estimate how credit demand differs by crop, gender, income level, group maturity and exposure to flood or drought. Such evidence would help design better targeted products.

The study focuses on product design but does not test actual product pilots. Future research should compare repayment, yield, income and welfare outcomes across different CGSL products. For example, one group could use standard loans, another could use seasonal input loans and another could use seasonal input loans with insurance and extension support. Such designs would show which product combinations produce the strongest agricultural outcomes. Further studies should also investigate governance and inclusion. Differentiated lending can improve fit but may create inequality if better-off members receive most productive loans. Research should therefore examine how women, youth, poorer households and displaced communities participate in CGSL product innovation. Product design should be evaluated not only by profitability but by fairness, resilience and social cohesion.

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