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# Beyond the Blend: Linking Indonesia's E20 Bioethanol Transition to Sugarcane Smallholder Welfare, Inclusive Value Chains and Equitable Rural Development—A Review

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A R T I C L E I N F O

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A B S T R A C T

Indonesia's ambition to expand E20 gasoline production presents an opportunity to connect domestic renewable-fuel development with improvement in sugarcane smallholder livelihoods. Yet additional industrial demand does not automatically translate into higher real farm income, stronger bargaining power, or improved household wellbeing. This article develops a qualitative literature review of peer-reviewed research published from 2020 to 2026, complemented by primary Indonesian policy announcements. It synthesises evidence on farm productivity, contract farming, sugarcane pricing, cooperative organisation, agribusiness finance, industrial coproducts, food–fuel trade-offs, and environmental safeguards. The synthesis identifies nine interdependent themes and proposes an E20–Sugarcane Farmer Welfare and Inclusive Value Creation Framework. It distinguishes creation of ethanol-related economic value from the contractual and institutional mechanisms through which smallholders may capture that value. Indonesia-specific evidence reveals heterogeneity in contract participation, persistent information asymmetries, and opportunities for technological upgrading. International research indicates that contract design and land governance condition livelihood outcomes

## INTRODUCTION

Indonesia's E20 policy ambition, announced in September 2026, creates opportunities to expand bioethanol production through sugarcane development and agro-industrial investment. However, increased ethanol demand does not automatically translate into improved smallholder welfare. The distribution of economic benefits depends on procurement prices, contract arrangements, production costs, market access, and payment security. Therefore, the central issue is not merely the expansion of bioethanol production but also how the additional value generated along the sugarcane value chain can be fairly captured by farmers (Sekretariat Kabinet Republik Indonesia, 2026; Wirawan et al., 2025a; Boly and Sanou, 2022).

Sugarcane smallholders in Indonesia have diverse characteristics in terms of land ownership, farm size, access to credit, irrigation, technology, and institutional support. These differences influence productivity, profitability, and participation in contract farming. Consequently, increased yields or agricultural demand do not necessarily improve household income when production, labour, transportation, and financing costs also increase. Assessing farmer welfare therefore requires considering net profitability, payment security, household income, and resilience rather than relying solely on production growth (Hakim, Suprehatin and Rifin, 2024; Rokhani et al., 2020; Astuti, Prasmatiwi and Murniati, 2021).

This paper examines the economic and institutional gap between potential bioethanol value creation and smallholder value capture. It explores how E20 demand may influence sugarcane prices and profitability, what production and organizational capabilities farmers require, and which procurement, cooperative, and benefit-sharing mechanisms can promote inclusive development. It also considers food security, land rights, and environmental sustainability. To address these issues, the paper proposes the E20–Sugarcane Farmer Welfare and Inclusive Value Creation Framework (E20-SFW-ICVF) as a research and policy framework for evaluating the conditions under which bioethanol development can generate sustainable and equitable benefits for sugarcane smallholders. The framework represents a structured policy proposition rather than an empirically validated causal model (Ayodele, Alsaffar and Mustapa, 2020; Chireshe, Petersen and Görgens, 2025; Maryono et al., 2024).

## LITERATURE REVIEW

### 1. Welfare, Livelihood Assets and Inclusive Development

A welfare assessment requires a wider lens than tonnes of cane supplied or annual farm receipts. Sustainable livelihoods include financial resources, productive equipment, land and water, practical skills, social organizations, and the capacity to manage shocks without permanently losing assets. Income is central, but welfare also concerns stability and the ability to finance education, food, health, and future production (Ndlela and Worth, 2021; Ruml, Ragasa and Qaim, 2022; Maryono et al., 2024).

The proposed analytical chain separates four categories: market opportunity, economic transmission, distributional mediation and final household outcomes. Outcomes encompass risk-adjusted real profit, income

stability, access to essential consumption and accumulation of productive assets. This approach avoids assuming a linear relationship between industrial expansion and wellbeing (Hoang, 2021; Ray, Clarke and Waley, 2021; Ruml, Ragasa and Qaim, 2022).

**2. Value-Chain Governance, Contracts and Bargaining Power**

Cane growers may supply mills through formal contracts, informal buying arrangements, marketing groups or intermediary networks. Each configuration allocates measurement authority, price risk, delivery responsibilities, working-capital obligations and dispute resolution differently. The central question is therefore not whether contracts are intrinsically desirable but which contractual features generate a fairer and more efficient distribution of risks and rewards (Rokhani et al., 2020; Machimu, 2024; Harwoto et al., 2022).

Contract design has implications that extend to land rights and household labor. Such evidence shows why a commercial expansion strategy should examine unequal negotiating positions before recommending long-term exclusivity or intensive specialization. Distributional legitimacy thus requires informed consent, clear termination rights and accessible grievance mechanisms (Bahati, Martiniello and Abebe, 2022; Fedi, Asefa and Waktole, 2022; Machimu, 2024; Adam and Agegnehu, 2023).

**3. Productivity, Technology Adoption and Farmer Services**

Farm-level efficiency is an important component of the welfare transmission process. Yield gains, however, should be measured jointly with costs, particularly where new planting materials, irrigation and mechanization require up-front expenditures. Extension programmes can provide advice on varietal selection, pest management and crop scheduling, but must be adapted to growers' capabilities and actual field conditions (Suwandari et al., 2020; Rokhani et al., 2021; Hanani AR, Asmara and Fahriyah, 2023; Riajaya et al., 2022).

Production risk is also inseparable from climate adaptation and access to natural resources. The appropriate objective is therefore improved, climate-resilient net earnings per household or hectare rather than maximization of cane tonnage at any environmental cost (Hasibuan et al., 2023; Yang et al., 2022; Pandey et al., 2020; Cherubin et al., 2021).

**4. Sugar–Ethanol Biorefineries and Industrial Value**

Sugarcane provides several industrially valuable material streams. Juice and fermentable sugars can enter sugar or ethanol production, molasses can serve as a fermentation substrate, and bagasse can supply heat, electricity, advanced bioethanol or other products. Integrated biorefineries may improve industrial resource efficiency and diversify revenue, but doing so requires equipment, energy, finance and access to product markets (Ayodele, Alsaffar and Mustapa, 2020; Chireshe, Petersen and Görgens, 2025; Elias et al., 2024; Meghana and Shastri, 2020). A transparent calculation would first establish incremental, audited net distributable proceeds rather than a percentage of gross ethanol sales. Studies of bagasse processing in Indonesia and wider biorefinery research

illustrate the project-specific economics and risks that any proposed benefit-sharing model needs to respect (Bahar et al., 2025; Gomes, Vaz Júnior and Gurgel, 2024; Zambello et al., 2026; Priadi et al., 2024).

**5. Cooperative Organization, Finance and Governance**

Farmer cooperatives can reduce transaction costs through pooled procurement, shared equipment, centralized transport, market-information services and collective contract negotiation. Such advantages are conditional on governance: executives must be accountable to members, financial records must be accessible, and contracts must represent smaller producers as well as influential members (Maryono et al., 2024; Machimu, 2024; Sahara et al., 2025; Ndlela and Worth, 2021). Credit is equally important in cane systems, where agricultural expenses typically occur before harvesting and mill payment. Public programmes should prioritize transparent interest charges, suitability for harvest cycles, choice of suppliers and protections against over-indebtedness (Gelata and Han, 2024; Ruml, Ragasa and Qaim, 2022; Akalu et al., 2025).

**6. Environmental Constraints and Food–Fuel Interactions**

The environmental case for sugarcane ethanol cannot be inferred simply from biomass renewability. Lifecycle emissions depend on agricultural inputs, processing energy and land conversion, while water pressure and soil management influence sustainability at the farm and watershed scales (Hiloidhari et al., 2021; Liu, Kwon and Wang, 2023; Duden et al., 2021; Carpanez et al., 2022). Food–fuel interactions are particularly important where cane competes for land, irrigation, labor or investment with food crops. E20 planning requires local land-tenure analysis, sugar-market safeguards, food-price monitoring and explicit protection of ecosystems with high carbon or biodiversity value (Jha et al., 2026; Gurgel et al., 2026; Justus et al., 2025; Boly and Sanou, 2022; Guarenghi et al., 2023).

## METHODOLOGY

**1. Research Design and Interpretive Scope**

This article uses a qualitative literature review (QLR), not a systematic literature review, quantitative meta-analysis or impact evaluation. The objective is to synthesize how different research traditions explain the relationship between agricultural commercialization and farm household welfare, and then to apply those insights cautiously to Indonesia's prospective E20 programme. The review is interdisciplinary because no single empirical field covers all relevant questions: agricultural efficiency studies explain farm performance; contract-farming research explains buyer–seller institutions; energy and biorefinery research explains industrial value formation; and environmental studies clarify resource constraints. The analytical contribution is the integration of these perspectives into a welfare-transmission framework rather than an estimated national causal effect. Literature considered for the article consists principally of peer-reviewed studies published between 2020 and October 2026. Priority is given to Indonesian sugarcane research and to international evidence on sugarcane outgrowers, agricultural contracts, inclusive agribusiness

partnerships, bioethanol and food–fuel interactions. Public policy announcements provide temporal context for the E20 ambition but are not used to assert actual programme effectiveness. The literature was assembled purposefully for conceptual and empirical relevance, with attention to methodological differences and the risk that successful industrial case studies attract disproportionate attention. The approach does not claim exhaustive database coverage or report fictional screening counts, and it does not use PRISMA procedures.

**2. Coding, Comparison and Evidence Appraisal**

The synthesis follows six linked interpretive steps. First, sources are classified by setting, farmer population, industrial or agricultural activity, research method, and reported outcome. Second, findings are organized into the themes of market opportunity, farm productivity, procurement governance, benefit distribution, financial inclusion, household welfare, environmental sustainability, and institutional capacity. Third, empirical associations are distinguished from proposed policy mechanisms, while numerical findings are retained only in their original geographic and methodological context. Fourth, contradictory evidence is compared, particularly where contracts raise average revenue yet distribute benefits unevenly. Fifth, themes are connected in an explicit welfare-transmission architecture. Finally, the framework is translated into proposed indicators and a conditional roadmap for Indonesian policymaking. Evidence strength is evaluated qualitatively rather than with an arbitrary scoring system. Indonesia-specific farm surveys offer direct contextual relevance but can predate E20 and cannot demonstrate its impacts. Observational contract comparisons may be influenced by self-selection because better-connected farmers are more likely to participate in schemes; those limitations must be acknowledged even when statistical controls are used. Techno-economic studies provide conditional estimates rather than observed factory profits, while lifecycle models depend on boundary and land-use assumptions. Reviews of partnerships are useful for identifying recurring patterns but do not replace primary observation of the contemplated Indonesian contracts. Triangulation across these types of evidence supports more defensible conditional conclusions (Hakim, Suprehatin and Rifin, 2024; Ray, Clarke and Waley, 2021; Maryono et al., 2024; Bahar et al., 2025).

**3. Scope of Claims and Limitations**

No household survey, mill accounting audit, farmer census, land assessment or counterfactual E20 welfare estimate was conducted for this article. Accordingly, the review cannot establish the number of farmers who will benefit, the precise farm-gate price response, the profitability of a specific future distillery, or the causal magnitude of household welfare change. The E20-SFW-ICVF should be treated as a conceptual framework to structure future empirical work. The recommended indicators and contract mechanisms are propositions requiring legal, economic and political assessment before adoption. Maintaining this distinction is especially important because the relevant September 2026

policy statements describe a programme under preparation rather than completed outcomes.

## RESULTS

### 1. Theme One: Higher Demand is an Opportunity, Not a Welfare Result

The first cross-cutting finding is that additional cane demand can create a stronger market opportunity but does not prescribe the price or bargaining relationship facing individual farmers. New ethanol capacity might increase competing bids for cane in some districts, stabilize purchases through long-term arrangements, or be supplied largely from existing mill-side molasses without proportionate additional farm purchases. Alternatively, if new fuel capacity secures exclusive arrangements with a few processors, local buyer concentration could persist. The final effect depends on the chosen feedstock route, mill allocation decisions, procurement geography and the contractual link between processors and growers. Biofuel-policy studies support this systems interpretation and caution that price effects vary across market structures (Lundberg, Cintas Sanchez and Zetterholm, 2023; Boly and Sanou, 2022; Wirawan et al., 2025a; Jabbarzadeh and Shamsi, 2025). The distinction between sugarcane juice, molasses and agricultural residues is therefore distributively important. Expanding direct cane-juice ethanol may increase demand for primary cane, but using surplus molasses or bagasse can add industrial value without requiring equal increments in farm output. A farmer may benefit indirectly through a stronger mill, more reliable buying, or better services; such benefits must be demonstrated rather than assumed. By separating physical feedstock flows from contractual cash flows, the proposed analysis prevents misleading claims that each additional litre of ethanol generates a fixed additional payment to sugarcane growers. The same logic applies to processing residues that may already have energy or other uses (Ayodele, Alsaffar and Mustapa, 2020; Chireshe, Petersen and Görgens, 2025; Elias et al., 2024; Meghana and Shastri, 2020). The proposed channels of transmission are illustrated in Figure 1. The diagram distinguishes the emergence of an ethanol market from the contractual, productive and institutional pathways that may affect cane-growing households. It also marks sustainability safeguards as conditions for interpreting final welfare outcomes rather than as secondary benefits.




**Figure 1. Proposed Causal Channels Linking E20 Industrial Development to Smallholder Welfare. Original Conceptual Synthesis**

Figure 1 separates policy-driven ethanol demand from four intervening mechanisms: agricultural market terms, productive capability, institutions and household resilience. This ordering identifies the points where additional economic value can fail to reach farmers. A new downstream market may remain remote from disadvantaged producers if they lack adequate contract access or if quality deductions and delayed settlement erode gross receipts. The figure consequently represents conditional channels, not a claim that every connection has already produced a measurable causal effect in Indonesia.

**2. Theme Two: Productivity and Net Farm Profitability**

The literature provides a substantial Indonesia-specific foundation for improving cane productivity and the efficiency of agricultural inputs. Research on certified planting material finds productivity and efficiency implications, while analyses of PTPN X partner farmers, East Java farms and other regional production systems demonstrate measurable differences in technical and managerial efficiency. Those findings support targeted extension, soil and variety matching, water management, and timely harvesting. They do not justify promising uniform financial returns from every innovation. The appropriate E20-related agricultural investment should be assessed by changes in net income after accounting for all variable inputs, unpaid family labor where relevant, depreciation, credit charges and transport rather than by output tonnage alone (Suwandari et al., 2020; Rosidah et al., 2023; Santosa et al., 2024; Hanani AR, Asmara and Fahriyah, 2023). Heterogeneity is central to designing such support. Some growers could increase profitability through better ratoon management and certified seed, while others face more fundamental constraints involving irrigation, fragmented plots, mechanization services or market access. Farmers without sufficient collateral may be unable to finance improvements even when expected benefits are attractive. Digital information and mechanization should therefore be delivered through viable service arrangements instead of assuming each farmer can purchase complex equipment. Research on agricultural technologies and small farm constraints reinforces the need for proportional, locally adapted solutions. The welfare evaluation must also record who could not participate in the intervention and why (Dhillon and Moncur, 2023; Riajaya et al., 2022; Astuti, Prasmatiwi and Murniati, 2021; Anggrainingrum, Prasetyo and Roessali, 2022). Risk-adjusted profitability requires attention to weather and market disruption. Climate adaptation research on Indonesian sugarcane indicates that agricultural support and integrated crop systems influence farmers' responses to climate risk. Comparative analysis of productivity and eco-efficiency elsewhere similarly identifies possible tension between maximum yields and efficient resource use. The implication for E20 policy is to integrate crop-risk support, water security and conservation into profitability programmes. A project may report higher average yield but deliver worse livelihood security if growers take on concentrated debt or lose alternative earning opportunities. Assessments should include sensitivity to poor harvests, input-price shocks and interruptions in mill crushing schedules (Hasibuan et al., 2023; Yang et al., 2022; Pandey et al., 2020).

**3. Theme Three: Contract Access and Information Asymmetry**

Findings from Indonesia's contracting systems reveal material differences in participation and market access. These studies collectively imply that expanding E20 procurement through existing contractual channels could reproduce pre-existing selection patterns. An inclusive policy should therefore report participation by farm size, tenure and location, and require alternatives for qualified growers excluded from dominant purchasing arrangements (Hakim, Suprehatin and Rifin, 2024; Rokhani et al., 2020; Umaiya, Irham and Perwitasari, 2024). Information asymmetry is a particularly direct obstacle to equitable returns. A 2025 study of the cane supply chain in Jember documents farmer dependence on information originating from mills and identifies challenges surrounding transaction and production costs. Nevertheless, they justify independent quality testing, timely publication of price formulas, itemized weight and quality statements, and appeal routes for disputed deductions (Suwandari et al., 2025; Harwoto et al., 2022; Fredella, Soedarto and Atasa, 2025). International evidence supports a similarly conditional position. Sugarcane outgrower arrangements can provide services and market access, but studies also report conflicts involving farmers' choices, land rights, labor and the distribution of gains. The policy lesson is not that any single international model should be copied; it is that Indonesian agreements need transparent rights and obligations, workable grievance procedures, and comparable monitoring of contracted and non-contracted farmers (Machimu, 2024; Bahati, Martiniello and Abebe, 2022; Fedi, Asefa and Waktole, 2022; Ruml, Ragasa and Qaim, 2022; Ray, Clarke and Waley, 2021).

Table 1. Comparative Farmer–Mill Procurement and Partnership Options (Analytical Proposals)

| Arrangement | Potential farmer benefit | Principal risk or safeguard |
|---|---|---|
| Direct cane purchase | Clarity of quantity and pricing | Independent sampling; prompt and enforceable payment |
| Sugar revenue sharing | Potential participation in specified sugar returns | Transparent recovery and permitted deductions |
| Collective cooperative supply | Negotiation, transport and input economies | Member accountability and fair service access |
| Resource-providing contract | Input finance and agronomic support | Avoid tied-input debt and unilateral price adjustments |
| Ethanol-linked incentive or equity | Conditional downstream participation | Explicit legal right; audit; voluntary risk disclosure |

Table 1 compares broad procurement and institutional options according to who bears price, production, settlement and management risks. It deliberately avoids classifying any model as universally best because the preferred arrangement depends on local competition, the reliability of quality testing, the cost of capital and the capacity of farmer organizations. A fair contract can be a simple and transparent purchase agreement rather than an elaborate benefit-

sharing scheme; conversely, sophisticated agreements may fail when records cannot be independently verified. Evaluating the model against realized farmer returns is more meaningful than evaluating it by contractual label alone. Figure 2 will compare direct cane purchases, revenue-sharing arrangements, cooperative purchasing and negotiated ethanol-linked benefits. It introduces the discussion of industrial value distribution by showing that each model depends on different forms of information and governance. The schematic is an evaluation aid, not a claim that any model is officially included in the September 2026 E20 initiative. Figure 2 brings the four proposed procurement and partnership models into a common decision framework. It links each arrangement to practical acceptance tests, including transparent prices, enforceable contracts, farmer choice, and independent grievances. The figure should be interpreted as a comparison of possible institutional designs rather than a description of E20 rules already in force.




**Figure 2. Alternative Cane Procurement and Benefit-Sharing Arrangements. Proposed Options, Not Existing E20 Rules**

**4. Theme Four: Ethanol Coproducts and Distributive Entitlement**

Research on integrated sugarcane processing identifies opportunities for ethanol, electricity, fertilizers and other coproducts, but project profitability varies with plant configuration and local input costs. Analyses of sugarcane bagasse conversion in Indonesia provide concrete techno-economic scenarios, while international biorefinery work illustrates the importance of processing energy and competing residue uses. For farmers, the practical issue is whether contracts provide participation in any incremental verified surplus after additional costs. Such participation could take the form of cane-quality premiums, procurement bonuses, improved extension services, cooperative dividends or equity returns, but none is automatic merely because molasses or bagasse originates from cane previously produced by farmers (Bahar et al., 2025; Elias et al., 2024; Gomes, Vaz Júnior and Gurgel, 2024; Zambello et al., 2026). Proposed benefit-sharing mechanisms must be grounded in transparent accounting and lawful ownership. A bonus based on gross ethanol revenues could become unsustainable in years of weak refining margins or high energy costs; an agreement referencing net margin must specify allowable deductions and independent audit access. Farmer equity could provide upside but also expose households to business losses and illiquid investments. Guaranteed procurement and prompt payment may in some circumstances generate greater

welfare benefits than a small uncertain downstream dividend. These alternatives require participatory appraisal using projected cash flows and farmers' risk preferences. The literature on agricultural contracts and multi-stakeholder partnerships supports conditional, negotiated arrangements over rhetoric of automatic trickle-down benefits (Maryono et al., 2024; Ruml, Ragasa and Qaim, 2022; Adam and Agegnehu, 2023; Akalu et al., 2025). The separation of physical production and contractual benefit entitlement is visualized in Figure 3. The diagram traces cane from growers through the mill into sugar, ethanol and residue markets, while showing farmer receipts as a distinct payment stream. This distinction matters because downstream revenues do not automatically establish a legal entitlement for growers.




**Figure 3. Physical Outputs and Potential Financial Entitlements in an Integrated Sugar–Ethanol Value Chain. Conceptual Illustration**

Figure 3 shows where the physical cane, sugar, ethanol and residue flows diverge from the financial streams available to farmers. Its principal contribution is to differentiate a processing company's creation of value from a farmer's contractual claim over that value. The diagram also identifies the points at which transaction records, grading systems and industrial accounts should become accessible to independent verification. It offers a visual template for negotiation and due diligence rather than establishing the legal allocation of coproduct ownership.

**5. Theme Five: Cooperatives, Finance and Practical Empowerment**

Collective farmer organizations can improve the efficiency of production and marketing by negotiating contracts, purchasing inputs jointly, organizing harvesting and transport, and commissioning independent quality assessments. Partnerships in Indonesia demonstrate a diversity of organizational arrangements, and international research emphasizes that intermediary institutions can help small-scale cane farmers overcome power imbalances. However, cooperative structure alone does not guarantee inclusion. Transparent elections, audited accounts, accessible complaint channels and publication of member-level payments are needed to reduce elite capture and ensure that smallholders receive the promised services. The performance of an organization should be assessed against members' net outcomes rather than its number of registered participants (Machimu, 2024; Maryono et al., 2024; Sahara et al., 2025; Khairani et al., 2023). Affordable finance can strengthen growers' position when it enables timely purchase of planting materials, fertiliser, machinery services

and transport without dependence on expensive traders. Yet debt tied to a single buyer can reduce autonomy when grading and settlement remain opaque. Cross-country research on rural credit and contract farming suggests that these arrangements are closely linked, and Indonesian farm research points to the importance of extension and support. An inclusive E20 programme should provide flexible financial products linked to actual cane cycles, disclose effective borrowing costs, and separate credit recovery from disputed procurement deductions. Cooperative finance must also be supervised to protect members from unmanageable enterprise or investment risk (Gelata and Han, 2024; Rokhani et al., 2021; Harwoto et al., 2022).

**6. Theme Six: Distributional Exclusion and Social Safeguards**

The synthesis indicates that aggregate farmer participation cannot substitute for distribution-sensitive monitoring. Contract schemes may preferentially recruit growers with larger plots, better infrastructure and more secure titles because these attributes lower transaction costs for buyers. Land-poor households and wage workers may experience the expansion indirectly through prices, jobs or land markets rather than through cane sales. Large agricultural investments elsewhere have produced mixed local welfare impacts, illustrating why programmes should evaluate the fortunes of non-participants and affected communities alongside enrolled suppliers. E20-related project appraisals should therefore report not only tons procured from smallholders but also the proportional representation and economic position of disadvantaged groups (Hakim, Suprehatin and Rifin, 2024; Akalu et al., 2025; Bahati, Martiniello and Abebe, 2022). A gender- and generation-sensitive approach is also required because formal cane ownership may not correspond to the allocation of household labor or control over earnings. Women, young adults, tenants and seasonal workers may have weak representation in contractual negotiations despite contributing materially to production and family livelihoods. Research on younger partner farmers and smallholder sustainable livelihoods supports the importance of accessible services, recognition and long-term participation. Where mechanization reduces the need for particular tasks, policymakers must consider changes in rural wage opportunities as well as potential savings for cane producers. Social inclusion is therefore a set of measurable distributional results rather than a generic statement attached to an industrial investment proposal (Umaiya, Irham and Perwitasari, 2024; Ndlela and Worth, 2021; Dhillon and Moncur, 2023).

**7. Theme Seven: Resource Security and Environmental Credibility**

The scientific evidence shows that environmental constraints can directly affect the durability of farmer-welfare gains. Water-intensive expansion may increase competition among agriculture, settlements and ecosystems, while fertilizer misuse can create health and environmental burdens. Lifecycle research highlights the importance of carbon and water accounting for sugarcane systems, and land-use studies demonstrate variation in the consequences of expansion. Agricultural producers ultimately depend on the productivity of local soil and

water resources; payments today are not sufficient compensation for undermining future production capacity or for exposing households to land conflict. Environmental safeguards therefore belong inside the welfare framework rather than as an unrelated section of energy policy (Hiloidhari et al., 2021; Duden et al., 2021; Cherubin et al., 2021; Guarenghi et al., 2023). Food-market impacts are likewise conditional. Expansion that improves yield on existing agricultural land may affect resource competition differently from conversion of land previously used for food or local livelihoods. Models of Brazilian sugarcane bioenergy expansion identify scenarios with compatible development and food-security goals, while research concerning other blending strategies identifies land, nutrient and food-price pressures. Neither literature establishes a universal prediction for Indonesia. Safeguards should include participatory land mapping, protection of protected ecosystems, transparent sugar-market monitoring and independent assessment of competing water demands. In welfare monitoring, household food-consumption adequacy and security of land access should sit alongside net agricultural income (Gurgel et al., 2026; Justus et al., 2025; Jha et al., 2026; Boly and Sanou, 2022).

**8.. Theme Eight: Learning From International and Indonesian Institutions**

Experience from Brazil suggests that integrated sugar–ethanol systems can generate multiple industrial outputs and offer broader economic benefits under favorable production and policy conditions. Yet results from national and economy-wide models cannot be transposed mechanically to Indonesian mills or household groups. The national structure of landholdings, sugar markets, energy prices and public finance differs, and the relevant baseline for smallholder welfare is the household's realistic alternative use of resources. International experience is most valuable as a source of institutional options: verifiable contract standards, efficiency improvements, crop-risk safeguards and lifecycle accountability. It is not a ready-made estimate of the gains Indonesia's farmers will receive (Gurgel et al., 2026; Justus et al., 2025; Liu, Kwon and Wang, 2023; López-Ortega et al., 2021). Indonesia's own body of research provides a more immediate starting point. Evidence on farm efficiency, certified seed, extension access, climate adaptation, contract selection, direct payments and information asymmetry can guide programme design before dedicated E20 household-impact data become available. The strongest immediate recommendation is to establish reliable baselines and differentiated intervention groups rather than to promise an undifferentiated increase in farmer prosperity. Existing sugarcane farmer associations and mill partnerships can be assessed through pilot changes in procurement, information access and technical services, with outcomes evaluated across multiple harvest seasons. Such a design would allow policy learning while protecting farmers from untested nationwide contractual arrangements (Rosidah et al., 2023; Suwandari et al., 2020; Hasibuan et al., 2023; Suwandari et al., 2025).

## DISCUSSION

### 1. Reframing E20 Success Around Household Welfare

E20 success should be measured through verified improvements in farmers' welfare, not merely ethanol production, planted hectares or industrial investment. Key indicators include net farm profit, income stability, household consumption, resilience and access to productive opportunities. Evaluation should establish baseline conditions and monitor outcomes across several harvest seasons, using comparison groups where feasible. Although this literature review cannot provide direct impact estimates, it identifies the evidence needed to assess whether E20 delivers meaningful benefits to sugarcane households (Machimu, 2024; Maryono et al., 2024; Hakim, Suprehatin and Rifin, 2024).

### 2. Transparent Cane Pricing and Dispute Resolution

Transparent cane pricing is essential to ensure that increased industrial demand translates into fair farmer income. Purchasing agreements should clearly disclose accepted weights, quality measurements, benchmark prices, deductions, transportation costs and payment schedules. Independent sampling, digital receipts, accessible arbitration and farmer representation can reduce information asymmetry and payment disputes. However, transparency must be supported by enforceable mechanisms protecting farmers against unfair deductions, delayed payments and discriminatory processing access (Suwandari et al., 2025; Harwoto et al., 2022; Yu, 2023).

### 3. Conditional Mechanisms for Sharing Ethanol-Related Value

Ethanol-related benefit-sharing mechanisms should only be introduced after industrial revenues, costs and ownership arrangements are independently verified. Possible mechanisms include quality premiums, performance bonuses, extension support, cooperative investment and farmer equity participation. Each option involves different financial risks and distributional consequences. Therefore, economic simulations should assess production costs, ethanol prices, mill utilization and alternative uses of bagasse and molasses before establishing payment arrangements. Farm profit and distributable industrial surplus must be calculated separately to prevent unsupported promises based on gross ethanol revenue. Any benefit-sharing arrangement should include transparent accounting, independent audits and enforceable contractual provisions (Elias et al., 2024; Bahar et al., 2025; Ruml, Ragasa and Qaim, 2022). The central recommendation is that E20 implementation should prioritize measurable household welfare, transparent procurement and accountable benefit-sharing rather than relying solely on industrial production targets.

$$\Pi_f = R_c + B_e - C_f$$

$$S_{net} = R_e - C_e - O_a$$

Here, Π denotes farm profit, R_c represents cane receipts, B_e denotes an enforceable ethanol-related transfer, and C_f represents production, marketing and financing costs borne by the farm. The symbol S_net denotes net incremental industrial surplus, R_e represents incremental industrial revenue, C_e denotes

incremental industrial costs, and O_a is the opportunity cost of alternative uses of outputs. Actual benefit distribution would require independently verified accounts, a defined accounting period and enforceable provisions specifying eligible costs and any farmer share.

Table 2. Illustrative Ethanol-Related Value-Sharing Mechanisms and Their Conditions.

| Mechanism | What farmers receive | Qualification and risk |
|---|---|---|
| Quality premium | Higher payment for objectively tested cane quality | Published formula and independent measurement |
| Reliability premium | On-time supply bonus under accepted agreements | Transparent scheduling and feasible obligations |
| Net-surplus sharing | Agreed share of audited incremental proceeds | Common cost definitions and dispute process |
| Cooperative equity | Dividends when genuinely earned | Voluntary membership, full risk disclosure, governance |
| Service-based transfer | Subsidized extension, machinery or working capital | Measure real service value and avoid capture |

Table 2 proposes a comparison of alternative ways farmers might participate in E20-related value creation. The table's practical purpose is to evaluate the requirements and exposure associated with each option, rather than designate one universal solution. It highlights why a reliable cane payment may sometimes be preferable to uncertain downstream equity, and why cooperative investment should be voluntary and informed. Future pilot negotiations should incorporate independent financial advice and consultation with tenants and smaller growers who may be underrepresented in formal organizations.

**4. Cooperative governance, finance and capability development**

Farmer organizations can act as collective service providers and credible bargaining counterparts when they are sufficiently representative and professionally managed. Their activities might include coordinated planting schedules, bulk fertilizer procurement, shared harvesting machinery, independent cane-quality sampling and collective transport. Such services can reduce unit costs and improve access, but the benefits should be documented at member level. A larger cooperative turnover is not equivalent to improved member welfare if administrative expenses, elite capture or unequal service access absorb the gains. Performance contracts for cooperative managers, transparent financial reports and independent member complaint channels would strengthen both agricultural efficiency and accountability (Maryono et al., 2024; Sahara et al., 2025; Machimu, 2024; Ndlela and Worth, 2021). Empirical research from Indonesian rice farmer organizations reinforces the importance of governance processes within collective action. Ahmad, Shadbolt and Reid (2024) identify member voice, leadership and information exchange as relevant to collective participation and value-chain upgrading in Yogyakarta. The

commodity differs from sugarcane, so the transferable insight concerns the conditions for effective organization rather than an assumed size of financial gain from cooperative membership. A complementary finance architecture should match cash flows to the biological and processing cycle of sugarcane. Input loans, equipment leasing, harvest advances and weather-related insurance could be designed jointly with farmer groups and regulated lenders. Borrowers need transparent interest rates and the freedom to challenge disputed deductions; lenders need realistic risk assessment instead of collateral requirements that exclude tenants by design. Technical assistance should accompany finance so that debt supports productive changes rather than merely financing higher input intensity. Where E20 contracts create new supply opportunities, programme operators should monitor loan repayment alongside net household income, because a lower default rate achieved through excessive deductions would not itself demonstrate welfare improvement (Gelata and Han, 2024; Hasibuan et al., 2023; Rokhani et al., 2021). Cooperative influence on pricing also depends on the particular market and contract structure. Han and Sun (2024) investigate cooperative participation in agricultural supply-chain pricing and show why changes in bargaining arrangements can alter the division of returns between market actors. This theoretical result supports considering different procurement and fee structures in E20 pilots, alongside empirical checks that smaller growers actually receive the negotiated benefits.

**5. E20–Sugarcane Farmer Welfare and Inclusive Value Creation Framework**

The proposed E20-SFW-ICVF integrates policy opportunity, agricultural and processing interfaces, economic transmission, distributional governance and observable household outcomes. In the model, E20-related demand enters an existing supply network characterized by unequal farm resources and institutional access. Its effects are mediated through farm-gate pricing and payment, agricultural efficiency, cooperative participation, finance and risk exposure. Environmental protection, food security and land rights act as constraints that must be satisfied rather than welfare gains assumed from higher agricultural output. The framework deliberately separates physical cane movement from cash-flow entitlement and measures success at the household level. This structure reflects the methodological limits of current literature and the need for evidence on the specific arrangements ultimately adopted in Indonesia (Hakim, Suprehatin and Rifin, 2024; Suwandari et al., 2025; Bahati, Martiniello and Abebe, 2022; Maryono et al., 2024).

Figure 4 presents the proposed E20-SFW-ICVF as an integrated sequence of policy opportunity, household capabilities, institutional mediation and measured welfare outcomes. The four intermediate channels help identify where benefits may be delayed, excluded or distributed unevenly. Environmental and social safeguards are treated as explicit conditions rather than presumed consequences of higher bioethanol demand.




**Figure 4. E20–Sugarcane Farmer Welfare and Inclusive Value Creation Framework (E20-SFW-ICVF). Original Conceptual Model.**

Figure 4 depicts the integrated framework as a sequence of opportunity, mediation and outcome stages surrounded by sustainability conditions. The arrows represent possible economic and institutional pathways rather than estimated causal effects. The figure is particularly useful for policy analysis because it shows how a programme can encounter different blockages: growers may lack productive assets, receive uncertain procurement prices, remain outside contracts, face unaffordable finance, or bear ecological damage. Intervention and monitoring can then be directed to the failing mechanism rather than assuming that construction of additional ethanol plants resolves every welfare constraint.

**6. Measuring Welfare Fairly and Consistently**

A measurement system should combine economic, social, institutional and environmental indicators. The economic core consists of real net cane profit per hectare and per participating household, supplemented by payment punctuality, debt-service burden, income variability and non-cane earnings. Farm productivity should be assessed by yield and unit cost, while inclusion indicators should capture participation and realized gains among smaller growers, tenants, women, younger farmers and hired workers. Social measures should examine food security, schooling expenditure and household coping strategies. Such a multidimensional approach is needed because average procurement revenues can rise even when vulnerable households face worsening conditions or are excluded from the new market (Ndlela and Worth, 2021; Yang et al., 2022; Hoang, 2021; Akalu et al., 2025). Table 3 operationalizes farmer welfare through economic, institutional, social and environmental indicators. Each proposed indicator is paired with an interpretive requirement so that increased output or contract enrollment is not misreported as a welfare gain. Implementation would require farm-level baseline observations and comparison information to support reliable attribution.

Table 3. Proposed Indicators for Evaluating E20-Related Sugarcane Smallholder Welfare

| Dimension | Proposed indicator | Interpretive requirement |
|---|---|---|
| Profitability | Real net cane profit per hectare / household | Include labor, finance, marketing and depreciation |
| Payment security | Days between accepted delivery and payment | Disaggregate by mill, contract and farmer group |
| Productivity | Cane yield and unit production cost | Track input intensity and local climate conditions |
| Bargaining power | Access to grading, price and contract information | Verify appeal access and independent sampling |
| Financial resilience | Debt-service burden and liquidity gaps | Monitor seasonal cash flow and default risks |
| Household welfare | Food security, schooling, health, asset changes | Baseline and comparison observations |
| Inclusion | Tenant, small-farm, women and youth participation | Measure realized benefits, not enrollment alone |
| Environmental security | Water/soil condition, tenure and complaints | Independent spatial and household monitoring |

Table 3 specifies candidate indicators and the underlying evidence required to interpret them. An annual average is useful for programme management, but distributional statistics should accompany it: medians, variation across farm-size groups, the share of payments delivered on time, and the position of non-participants. Where claims concern welfare improvements caused by E20, indicators also need pre-policy and comparison-group observations. The monitoring framework should openly distinguish outputs directly controlled by programme institutions from broader changes that may reflect climate or commodity markets. No unsupported welfare percentages are assigned in this conceptual review.

## 7. Integrating Social and Environmental Safeguards

Farmer prosperity depends on preserving natural and institutional assets over time. Expansion into ecologically sensitive areas or contested land could generate short-term procurement volume while undermining local livelihoods and social legitimacy. Similarly, inefficient irrigation or excessive fertilizer use can raise production costs and erode future agricultural productivity. Therefore, land-use due diligence, watershed assessments, transparent tenure procedures and monitoring of food markets should precede large-scale planting commitments. International studies show that sugarcane bioenergy can have different development and environmental consequences according to land-use change, productivity and system design. Indonesia needs safeguards adapted to actual local conditions rather than assuming either guaranteed sustainability or

inevitable food insecurity (Duden et al., 2021; Hiloidhari et al., 2021; Jha et al., 2026; Gurgel et al., 2026). A socially credible transition should also consider rural workers who are not cane owners. Mechanized harvesting may improve farm profitability while reducing seasonal employment, depending on local labor markets and alternative opportunities. Large investments may affect rental prices, access to land and the availability of common resources. The welfare programme should therefore provide meaningful consultation with affected residents and make grievance procedures available beyond formal supply contracts. Indicators for employees and nearby households should be evaluated separately from those for participating farms. This approach recognizes that the benefits and costs of an agricultural energy transition may accrue to different people and that an aggregate benefit–cost calculation cannot settle questions of distributive fairness (Bahati, Martiniello and Abebe, 2022; Akalu et al., 2025; Adam and Agegnehu, 2023).

**8. Stage-Gated Policy Implementation and Institutional Accountability**

A welfare-centered implementation roadmap should begin with diagnostic work rather than a universal promise of increased farmer earnings. The initial stage would verify existing partnership arrangements, net farm costs, payment delays, farmer organization capacity, land rights and baseline household welfare. A second stage could pilot several transparent procurement and advisory arrangements in selected regions with documented farmer participation and independent measurement. A third stage would expand only approaches that demonstrate improvements in real net returns or meaningful risk reduction without unacceptable food, land or water impacts. The longer-term stage would support productivity, diversified rural livelihoods and optional cooperative investment where management capability and financial viability are demonstrated. This sequence makes measured farmer welfare a condition for scaling rather than a retrospective public-relations indicator (Wirawan et al., 2025a; Hakim, Suprehatin and Rifin, 2024; Maryono et al., 2024). The implementation sequence proposed in Figure 5 converts the conceptual framework into conditional decisions. Each transition requires evidence on contract quality, observed household outcomes and sustainability before subsequent scaling. The indicated periods constitute a research-based roadmap rather than an official government timetable.




**Figure 5. Proposed Stage-Gated Farmer-Welfare Implementation Roadmap, 2026–2035. Indicative Analysis Rather than an Official Schedule**

Figure 5 translates the proposed strategy into four phases separated by verifiable decision gates. The first gate concerns baseline and contractual evidence; the second concerns trial results in pricing, payment, farm economics and social safeguards; the third concerns demonstrated regional welfare benefits and sustainability. If a gate fails, project design or investment sequencing should be revised rather than automatically accelerated to meet an announcement date. The dates are indicative recommendations prepared for the review; they are not presented as an officially adopted government programme. Institutional responsibility should be divided yet coordinated. Agricultural authorities and extension services can support farm productivity and independent agronomic data; mills and ethanol producers are responsible for procurement and processing records; financial authorities regulate lending and public incentives; environmental and land institutions assess safeguards; and farmer organizations represent suppliers in negotiated arrangements. An independent assessment function should publish aggregate results and describe the limitations of causal attribution. Such division of responsibility reduces the likelihood that one industrial actor both benefits from and exclusively evaluates a welfare programme. Transparent budget and data governance are especially important if public funds support crop development or guaranteed procurement (Maryono et al., 2024; Afandi, 2024; Khairani et al., 2023).

**9. Research Implications and a Realistic Impact-Evaluation Agenda**

The framework contributes to the literature by emphasizing that biofuel policy is simultaneously a demand intervention, an industrial investment process and a distributive institutional choice. Empirical testing would require matched farm and mill records, seasonal household panels, price and quality statements, production-cost accounting, and mapping of contract participation. Where a policy is introduced progressively, differences across participating and comparison areas could support more credible estimates, subject to parallel-trend and spillover limitations. Qualitative interviews would remain important to explain why farmers decline contracts, perceive grading as unfair, or experience benefits differently despite similar cane yields. This mixed future agenda follows from the observed heterogeneity and information asymmetries documented in Indonesian studies (Hakim, Suprehatin and Rifin, 2024; Suwandari et al., 2025; Harwoto et al., 2022). A second research priority concerns the measurement of industrial surplus and its allocation. Future studies should compare pricing and benefit-sharing models using audited process balances and cash flows, including foregone sugar revenue, energy use, depreciation, financial risk and actual farmer entitlements. A third priority is land and water opportunity-cost analysis under regionally differentiated ethanol-feedstock pathways. Combining these perspectives will allow policymakers to assess whether a given expansion strategy is not merely feasible and low-carbon, but distributively legitimate and resilient under unfavorable harvest and energy-price scenarios. Until those observations are available, the review's central proposition remains conditional: E20 can support farmer prosperity if institutions deliberately convert industrial

opportunity into sustained household welfare (Bahar et al., 2025; Chireshe, Petersen and Görgens, 2025; Yang et al., 2022; Boly and Sanou, 2022).

## CONCLUSIONS AND RECOMMENDATIONS

Indonesia's E20 ambition offers a potentially valuable opportunity to connect energy diversification with agricultural development, but the creation of new industrial ethanol demand does not guarantee improvements in smallholder welfare. Farm incomes depend on productivity, procurement prices, input costs, contract participation, payment reliability, credit conditions and household exposure to risk. Existing Indonesian research establishes the relevance of heterogeneous farm capabilities, asymmetrical information and varying partnership arrangements, while comparative international evidence demonstrates that contract farming can produce different livelihood outcomes under different institutional settings. E20 policy should therefore specify farmer welfare as an independently measured objective rather than treat it as an automatic consequence of increased ethanol production.

The article recommends transparent cane-quality and purchasing arrangements, independently verifiable settlement records, accessible dispute resolution, extension and finance tailored to smaller farms, and accountable cooperative organizations. Any ethanol-related benefit-sharing scheme should rest on legal entitlements, audited incremental net value and voluntary, informed participation, rather than unsupported assumptions that growers automatically own downstream processing revenues. Procurement stability and lower production costs may sometimes yield greater welfare benefits than a complex profit-sharing formula. Policy design should compare alternatives against actual changes in risk-adjusted real household income and bargaining power.

A comprehensive implementation strategy should incorporate land-tenure protection, food-market surveillance, watershed safeguards and attention to tenants, women, young farmers, seasonal workers and non-participating households. Its rollout should be phased through baseline diagnosis, independently reviewed trials, conditional regional scaling and long-term institutional upgrading. The principal contribution of the proposed E20-SFW-ICVF is to connect energy-market objectives to the economic and institutional pathways through which farmer welfare can improve or deteriorate. Future research should validate those pathways using longitudinal household surveys, farm–mill transaction records, independent industrial accounts and credible comparison designs. A successful transition will be one in which verified renewable-fuel development is accompanied by sustained, equitable and ecologically secure gains in rural wellbeing.

## FURTHER STUDY

This study still has some limitations, so more research on the topic Beyond the Blend: Linking Indonesia's E20 Bioethanol Transition to Sugarcane Smallholder Welfare, Inclusive Value Chains and Equitable Rural Development—A Review is needed to refine this study and give the author and readers more insights.

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