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Bioresource Centres as Community-Owned Natural Farming Input Enterprises: An Economic Surplus Analysis and Scale-Up Framework in Chhattisgarh

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Abstract: Bioresource Centres (BRCs) are community-based enterprises that manufacture and distribute standardized biological inputs for natural farming-including Agniastra, Brahmastra, Neemastra, Ghan Jeevamrit, Multiseed Formulation, and Beejamrit/Handidava. This paper presents an economic surplus analysis of a five-year pilot BRC operated under the PRADAN programme in Chhattisgarh, and develops a scale-up framework for 80 BRCs across 10 aspirational districts. Pilot data demonstrates a five-year cumulative Benefit-Cost Ratio (BCR) of 1.79, net profit of ₹10.36 lakh per BRC, and profitability from Year 1 without subsidy dependency. Applying the economic surplus model, we estimate that the 80-BRC programme generates: (i) a producer surplus of ₹8.29 crore in direct enterprise profit; (ii) a consumer surplus of ₹194.40 crore through farmer input-cost savings of ₹9,000–₹13,500 per household per annum; and (iii) a total economic surplus of ₹202.69 crore against a government outlay of ₹5.72 crore — a programme-level BCR of 38.7×. The model further demonstrates that 64,000 farm households will benefit from a 40–60% reduction in cash input costs by Year 5. The paper concludes with institutional design recommendations, phased implementation pathways, and a monitoring framework for evidence-based programme management.

Keywords: Bioresource Centres; Natural Farming; Economic Surplus; ZBNF; Aspirational Districts; Community Enterprise; Biological Inputs; Chhattisgarh; Producer Surplus; Consumer Surplus

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1. Introduction

Indian agriculture's dependence on synthetic inputs -chemical fertilizers, pesticides, and herbicides - has generated a well-documented crisis of profitability, ecological degradation, and rural indebtedness (Pingali, 2012). In the aspirational districts of Chhattisgarh, this crisis is particularly acute: smallholder farmers spend ₹8,000–₹18,000 per acre annually on chemical inputs, representing 40–55% of total cultivation cost, while soil organic carbon levels have declined by 30–40% in key rice-growing belts over the past two decades (NABARD, 2022).

Natural farming systems- including Zero Budget Natural Farming (ZBNF), Rishi Kheti, and allied approaches -offer a structurally different pathway. Multiple field trials across Andhra Pradesh, Himachal Pradesh, and Chhattisgarh demonstrate input cost reductions of 40–70% within two cropping seasons, with yields returning to parity with chemical agriculture in the third to fifth year of transition (Bharucha, et al., 2020). However, the transition consistently founders on one supply-side bottleneck: farmers cannot independently produce biological preparations at the consistency, quantity, and quality required for reliable crop protection and soil health management.

Bioresource Centres (BRCs) are designed to resolve precisely this bottleneck. A BRC is a community-based small enterprise that manufactures standardized biological inputs — Agniastra (botanical pest repellent), Brahmastra (broad-spectrum bio-pesticide), Neemastra (neem-based insecticide), Ghan Jeevamrit (solid microbial culture), Multiseed Formulation, and Beejamrit/Handidava (seed priming preparation) — and distributes them to farmers within a 5–8 km service radius at prices 40–60% below chemical equivalents.

Specifically, this paper makes four contributions. First, it presents a five-year cost-benefit analysis of an operational pilot BRC under the PRADAN programme in Chhattisgarh. Second, it develops a formal economic surplus model — decomposing producer surplus, consumer surplus, and total welfare effects — for a proposed 80-BRC scale-up across aspirational and operational districts. Third, it provides an institutional and financial framework for implementation. Fourth, it proposes a monitoring and evaluation architecture for programme management and replication.

1.1. Study Area and Context

Chhattisgarh's aspirational and operational districts — Bastar, Kanker, Narayanpur, Bijapur, Sukma, Dantewada, Kondagaon, Mahasamund, Raigarh, Korba,

Rajnadgaon, and Surguja — were identified under the NITI Aayogs Aspirational Districts Programme (ADP) for their compounded development deficits: low agricultural productivity, high tribal population share (40–70%), limited financial inclusion, and poor human development outcomes (NITI Aayog, 2023). These districts are predominantly rain-fed, with paddy (Oryza sativa) as the primary kharif crop, supplemented by millets, pulses, and horticultural crops. Their agro-ecological profile makes them inherently suited to natural farming: diverse farming systems, abundant biomass, and limited reliance on irrigation infrastructure that embeds chemical input systems.

PRADAN (a civil society organisation operating in Chhattisgarh) has piloted the BRC model in select tribal villages intially as NPM shops since 2019. The pilot BRC data used in this paper is drawn from PRADAN's programme records and field assessments.

2. Review of Literature

2.1. Economics of Natural Farming Transition

The economic literature on natural farming systems has converged on a consistent finding: the primary barrier to adoption is not output price uncertainty but input supply disruption and transition-period income loss (Reganold & Wachter, 2016; Eyhorn et al., 2019). Surveys in Andhra Pradesh's ZBNF programme found that 73% of transitioning farmers cited input availability - particularly biological preparations — as the binding constraint, ahead of market access or credit (Bharucha, et al., 2020). This finding directly motivates the BRC infrastructure model.

Welfare analysis of input delivery systems in smallholder agriculture has largely focused on fertilizer subsidy reforms (Druilhe & Barreiro-Hurlé, 2019) and seed market liberalization (Spielman et al., 2011), with relatively limited attention to the emerging class of biological input enterprises. Gulati et al. (2021) provide a partial equilibrium framework for bio-input pricing that is extended in this paper to estimate consumer surplus effects.

2.2. Economic Surplus Analysis in Agricultural Programmes

Economic surplus analysis — decomposing welfare effects into producer surplus (enterprise profit) and consumer surplus (buyer price savings) — has been a standard evaluation methodology since Harberger (1995) and Alston et al. (1995). In the agricultural development context, it has been applied to extension services

(Alston et al., 2000), irrigation infrastructure (Fan et al., 2008), and input subsidy programmes (Jayne & Rashid, 2013).

The surplus framework is particularly appropriate for BRC analysis because BRCs operate in a market characterized by: (i) large price differentials between biological and chemical input equivalents; (ii) inelastic short-run demand from transitioning farmers; and (iii) significant supply-side market failures that prevent competitive entry. In this context, the BRC simultaneously generates producer surplus through enterprise profit and consumer surplus through below-market-rate input supply — a double welfare gain rarely captured in conventional cost-benefit analysis.

2.3. Community Enterprise in Rural Input Markets

The community enterprise model for rural input supply has precedent in fertilizer cooperatives (Jayne et al., 2019), seed systems (McGuire & Sperling, 2016), and integrated pest management service centres (Heong & Hardy, 2009). What distinguishes BRCs is their integration of manufacturing, quality assurance, extension, and last-mile distribution within a single community-owned entity — reducing the coordination failures that have afflicted multi-party input delivery models (Dorward et al., 2004).

Narrod et al. (2009) and Shiferaw et al. (2011) have documented the market access and price-premium benefits of farmer collective action in output markets; this paper extends the analysis to input markets, where the collective action logic operates differently — emphasizing supply reliability and price suppression rather than price enhancement.

3. Materials and Methods

3.1. Data Sources

Primary data for the pilot BRC cost-benefit analysis was obtained from PRADAN programme financial records covering five operational years (2019–20 to 2023–24). Data includes: (i) capital expenditure on durable assets; (ii) variable costs — labour and biological input procurement; (iii) production quantities by product line; (iv) sale prices and gross revenue; and (v) net profit after all costs. Financial records were cross-validated with quarterly production logs and farmer sales receipts.

Secondary data on chemical input costs, farmer household economics, and aspirational district agronomic profiles was sourced from: NABARD All-India Rural Financial Inclusion Survey (2021–22); Directorate of Economics and Statistics,

Government of Chhattisgarh (2023); NITI Aayog Aspirational Districts data portal; and published literature on ZBNF programme economics.

3.2. Cost-Benefit Analysis Framework

The single-BRC cost-benefit analysis follows standard agricultural project appraisal methodology (Gittinger, 1972; Lagman-Martin, 2004). Total costs comprise: (i) capital costs (durable assets — processing equipment, storage vessels, weighing instruments); (ii) recurrent variable costs (raw biological inputs — cow dung, cow urine, neem, jaggery, plant materials); and (iii) labour costs (preparation, quality control, packaging, distribution). Interest costs were excluded in the primary analysis; a sensitivity analysis at 12% opportunity cost of capital is reported.

Gross sales are computed as the product of quantity sold and the prevailing market price for each biological preparation. The Benefit-Cost Ratio (BCR) is computed as:

BCR = Gross Sales (Benefits) ÷ Total Costs

Net Present Value (NPV) is calculated at a social discount rate of 10%, consistent with Government of India infrastructure appraisal norms. Internal Rate of Return (IRR) is computed iteratively.

3.3. Economic Surplus Model

The economic surplus model follows the partial equilibrium framework of Alston et al. (1995), adapted for the biological input market context. We define:

- Producer Surplus (PS): The net profit earned by BRC enterprises above minimum viable production cost. In this analysis, PS ⊠ Net Profit (the margin above total recorded costs, including labour and materials).
- Consumer Surplus (CS): The welfare gain to farmer-buyers arising from the difference between the willingness-to-pay price (proxied by the market price of chemical equivalents providing equivalent crop protection) and the actual BRC product price.
- Total Economic Surplus (TES): TES = PS + CS. This represents the aggregate welfare gain from BRC operation compared to the counterfactual of continued exclusive reliance on chemical inputs.

Consumer surplus estimation follows the price-differential method. For each BRC product, the chemical equivalent price is established from market surveys and secondary sources. The CS per farmer per unit area is:

CS per farmer = (P_chem − P_BRC) × Q_BRC × Area

Where P_chem = weighted average price of chemical input equivalents (₹/litre or ₹/kg); P_BRC = BRC product price; Q_BRC = quantity of BRC products consumed per acre; Area = average operational holding size in hectares.

Aggregate CS is computed across the cumulative farmer beneficiary base (4,000 in Year 1 rising to 64,000 by Year 5). A conservative estimate of ₹9,000 per acre saving (chemical equivalent cost ₹14,000 minus BRC cost ₹5,000) and average operational holding of 1.5 acres is applied.

3.4. Scale-Up Projections

Scale-up projections for 80 BRCs are derived by linear aggregation of single-BRC pilot data, with the following conservative adjustments: (i) a 10% management cost loading applied to aggregate costs to reflect district coordination and quality oversight; (ii) no price premium assumed for the aggregate — BRCs sell at pilot prices; (iii) phased commissioning (20 BRCs in Year 1, full 80 by Year 2) is reflected in employment and farmer-coverage projections but not in per-BRC financial projections, which assume the full 80-BRC base throughout for conservative BCR computation.

4. Results

4.1. Five-Year Financial Performance of Pilot BRC

Table 1 presents the complete cost-benefit profile of the pilot BRC over five operational years (2019–20 to 2023–24).

Table 1: Five-Year Financial Performance of Pilot BRC under PRADAN, Chhattisgarh (₹)

Cost/Revenue Head	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*5-Yr Total*
Durable Assets (₹)	10,000	10,000	0	10,000	0	30,000
Labour Cost (₹)	20,000	25,000	30,000	40,000	50,000	1,65,000
Input Cost (₹)	1,00,000	1,49,100	2,09,000	2,80,500	3,72,100	11,10,700
Total Cost (₹)	1,30,000	1,84,100	2,39,000	3,30,500	4,22,100	13,05,700
Gross Sales (₹)	1,80,000	3,12,500	4,28,000	5,80,000	8,41,000	23,41,500
Net Profit (₹)	50,000	1,28,400	1,89,000	2,49,500	4,18,900	10,35,800
BCR	1.38	1.70	1.79	1.75	1.99	1.79

Note: BCR = Gross Sales ÷ Total Cost. All costs include durable asset replacement at actuals. No interest on working capital imputed in primary analysis. Source: PRADAN programme records (2019–20 to 2023–24).

The pilot BRC achieved profitability in its first year of operation, with a BCR of 1.38, rising to 1.99 in Year 5. Cumulative five-year revenue of ₹23.42 lakh against total costs of ₹13.06 lakh yielded a net profit of ₹10.36 lakh. Revenue growth was driven primarily by volume expansion (Year 1 to Year 5 quantity CAGR: ~15%) and modest price appreciation (Year 1 to Year 5 weighted price CAGR: ~10%), yielding a compound annual revenue growth rate of 47%.

Labour cost growth (from ₹20,000 in Year 1 to ₹50,000 in Year 5) reflects both scale-up of operations and a deliberate programme decision to increase worker remuneration - a feature that enhances programme sustainability by reducing staff turnover risk. Input costs (raw biological materials) grew at 39% CAGR, tracking production expansion.

4.2. Product-wise Revenue Analysis

Table 2 presents the product-wise revenue profile, showing the evolution from a two-product BRC in Year 1 (Agniastra and Multiseed Formulation) to a six-product enterprise by Year 2 onwards.

Table 2: Product-wise Revenue Profile — Pilot BRC (Quantity in litres/kg; Price in ₹)

Product	*Yr1 Qty*	*Yr1 Price*	*Yr5 Qty*	*Yr5 Price*	*Yr1 Sales (₹)*	*Yr5 Sales (₹)*	*Growth (%)*
Agniastra	1,400	60	2,500	90	84,000	2,25,000	168%
Multiseed Formulation	1,600	60	2,500	90	96,000	2,25,000	134%
Ghan Jeevamrit	—	—	1,200	60	—	72,000	—
Beejamrit (Handidava)	—	—	1,000	55	—	55,000	—
Neemastra	—	—	1,200	70	—	84,000	—
Brahmastra	—	—	2,000	90	—	1,80,000	—
Total Revenue	—	—	—	—	1,80,000	8,41,000	367%

Note: Indicates product not in production in Year 1. Year 5 data from pilot records. Growth % for total revenue (Year 1 to Year 5). Source: Field date of PRADAN.

The product diversification strategy -deliberately sequencing product introduction to match farmer adoption curves and raw material availability -proved important to both revenue growth and enterprise resilience. Brahmastra, introduced in Year 2, became the highest-revenue single product by Year 5 (₹1.80 lakh), while Agniastra remained the foundational product with the longest established farmer relationship.

4.3. Key Financial Ratios -Pilot BRC

Table 3 summarises the key financial performance indicators derived from the five-year pilot data.

Table 3: Financial Performance Indicators — Pilot BRC

Financial Indicator	*Value/Result*
5-Year Cumulative Revenue	₹23,41,500
5-Year Cumulative Total Cost	₹13,05,700
5-Year Net Profit	₹10,35,800
Average Annual Net Profit	₹2,07,160
Benefit-Cost Ratio (5-year cumulative)	1.79
Net Present Value @ 10% SDR	₹6.54 lakh
Internal Rate of Return (IRR)	58%
Payback Period	< 12 months
Revenue CAGR (Year 1 – Year 5)	47%
Profit CAGR (Year 1 – Year 5)	70%
Average Annual Return on Working Capital	~79%

Note: NPV calculated at 10% social discount rate (GoI infrastructure appraisal norm). IRR computed iteratively. Working capital proxied by annual input + labour costs. Source: Authors' calculations from field data.

5. Economic Surplus Analysis

5.1. Conceptual Framework

The economic surplus framework used in this analysis distinguishes three layers of welfare effect generated by BRC operation, depicted in Figure 1 (conceptual):

PRODUCER SURPLUS	CONSUMER SURPLUS	ECOLOGICAL SURPLUS
Net profit of BRC enterprise above total production cost	Farmer savings from BRC price vs. chemical equivalent price	Soil health, water quality, biodiversity — not monetised here
₹8.29 Crore (80 BRCs, 5 years)	₹194.40 Crore (cumulative, 5 yrs)	Substantial — indicative only

Figure 1: Three-Layer Economic Surplus Framework for BRC Analysis.

5.2. Producer Surplus Estimation

Producer surplus is defined as the excess of revenue over total costs — equivalent to net profit at the enterprise level. For the pilot BRC:

- Annual producer surplus ranges from ₹50,000 (Year 1) to ₹4,18,900 (Year 5).
- Cumulative 5-year producer surplus = ₹10,35,800 per BRC.
- At 80 BRCs: total producer surplus = ₹8.29 crore.
- Producer surplus as share of gross revenue: 27% (Year 1) rising to 50% (Year 5).

The rising producer surplus share reflects improving operational efficiency as BRCs mature: raw input sourcing networks consolidate, labour productivity improves, and product diversification spreads fixed overheads across a larger revenue base. This trend is consistent with learning-curve effects documented in community enterprise literature (Shiferaw et al., 2011).

Table 4 presents the producer surplus profile over the programme period for the 80-BRC aggregate.

Table 4: Producer Surplus — 80-BRC Programme Scale-Up Projections (₹ Crore)

Metric	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*5-Yr Total*
No. of BRCs	80	80	80	80	80	80
Total Cost (₹ Cr)	1.04	1.47	1.91	2.64	3.38	10.44
Total Gross Sales (₹ Cr)	1.44	2.50	3.42	4.64	6.73	18.73
Producer Surplus / Net Profit (₹ Cr)	0.40	1.03	1.51	2.00	3.35	8.29
PS as % of Gross Sales	28%	41%	44%	43%	50%	44%
Surplus per BRC (₹ lakh)	0.50	1.28	1.89	2.50	4.19	10.36

Note: Producer surplus ≡ net profit (gross sales minus total costs). 80-BRC aggregate scaled from single-BRC pilot data. Source: Authors' calculations.

5.3. Consumer Surplus Estimation

Consumer surplus is estimated as the welfare gain to farmer-buyers from purchasing biological inputs at BRC prices rather than the chemical equivalent price (Table 5). The estimation parameters are:

Table 5: Consumer Surplus Estimation

Parameter	*Value / Source*
Chemical equivalent input cost (₹/acre/season)	₹14,000 (NABARD AIFRINS 2022; field surveys)
BRC biological input cost (₹/acre/season)	₹5,000 (BRC price list; PRADAN'S field records)
Net saving per acre per season	₹9,000
Average operational holding — aspirational districts	1.5 acres (Census of Agriculture 2015–16)
Consumer surplus per farm household per year	₹13,500
Farmer beneficiary base (Year 1 → Year 5)	4,000 → 64,000 (cumulative)

Note: Chemical equivalent cost reflects aggregate spend on pesticides, fertilisers, and herbicides per acre. BRC cost = actual recorded price for complete biological input package.

Applying these parameters, annual consumer surplus is computed for each year by multiplying the per-farmer surplus (₹13,500) by the cumulative farmer beneficiary count:

Table 5: Consumer Surplus Estimation — Annual and Cumulative (₹ Crore)

Parameter	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*Year 5*	*Cumulative*
Farmers Served (cumulative)	4,000	12,000	24,000	40,000	64,000	—
CS per Farmer (₹/yr)	13,500	13,500	13,500	13,500	13,500	—
Annual CS (₹ Cr)	5.40	16.20	32.40	54.00	86.40	—
Cumulative CS (₹ Cr)	5.40	21.60	54.00	108.00	194.40	194.40

Note: CS = (Chemical Input Cost – BRC Input Cost) × Average Holding Size × Farmers Served. Conservative estimate. Does not include yield improvements post-transition.

The cumulative 5-year consumer surplus of ₹194.40 crore substantially exceeds the producer surplus of ₹8.29 crore — a finding consistent with competitive input market theory, where consumer welfare gains dominate in markets characterised by large price differentials and inelastic demand (Alston et al., 1995). The ratio of CS to PS (~23:1) underscores that the BRC model's primary welfare contribution is overwhelmingly to farmer households rather than enterprise operators — a strongly pro-poor equity outcome.

5.4. Total Economic Surplus and Programme Efficiency

Table 6 presents the consolidated economic surplus analysis and programme-level return on government investment.

Table 6: Consolidated Economic Surplus Analysis — 80-BRC Programme

Surplus Component / Metric	*Value (₹ Crore)*
(A) Producer Surplus — BRC Net Profit (5-year, 80 BRCs)	8.29
(B) Consumer Surplus — Farmer Input Savings (5-year cumulative)	194.40
(C) Total Economic Surplus (A + B)	202.69
(D) Total Gross Sales (market value of BRC outputs)	18.73
(E) Government Outlay (5-year programme cost)	5.72
(F) Programme BCR on Govt Outlay [(C+D) / E]	38.7×
(G) Surplus BCR [C / E]	35.4×
(H) Employment Generated (person-days)	1,32,000
(I) Cost per Person-Day of Employment (₹)	433
(J) Farmers Served by Year 5	64,000+
(K) Cost per Farm Household Benefitted (₹)	894

Note: Programme BCR = (Total Economic Surplus + Gross Sales) ÷ Government Outlay. Surplus BCR = Total Economic Surplus ÷ Government Outlay. Cost per employment = Government Outlay ÷ Total Person-Days. Source: Authors' calculations.

The total economic surplus of ₹202.69 crore, against a government outlay of ₹5.72 crore, yields a Surplus BCR of 35.4× — meaning that every rupee of public investment generates ₹35.40 in aggregate social welfare gain. When gross market output value is included in the numerator, the Programme BCR reaches 38.7×. The cost per farm household benefitted of ₹894 is among the lowest reported for agricultural development programmes of comparable scope (Fan et al., 2008; Gulati et al., 2021).

5.5. Sensitivity Analysis

Table 7 presents a sensitivity analysis of the key economic surplus outcomes under alternative assumptions.

Table 7: Sensitivity Analysis — Key Economic Surplus Outcomes

Scenario / Parameter	*5-Yr Producer Surplus (₹ Cr)*	*5-Yr Consumer Surplus (₹ Cr)*	*Total Economic Surplus (₹ Cr)*	*Surplus BCR*
Base Case (pilot data, 80 BRCs)	8.29	194.40	202.69	35.4×
Pessimistic: 20% lower revenue	6.63	194.40	201.03	35.1×
Pessimistic: 20% higher costs	5.54	194.40	199.94	35.0×
Optimistic: 20% higher revenue	9.95	194.40	204.35	35.7×
Interest on WC @ 12% p.a.	6.24	194.40	200.64	35.1×

Scenario / Parameter	*5-Yr Producer Surplus (₹ Cr)*	*5-Yr Consumer Surplus (₹ Cr)*	*Total Economic Surplus (₹ Cr)*	*Surplus BCR*
Conservative CS (₹6,000/acre)	8.29	129.60	137.89	24.1×
Partial adoption (50% of farmers BRC-buying)	8.29	97.20	105.49	18.4×

Note: Scenarios applied individually to the base case. WC = Working Capital. CS = Consumer Surplus.

The sensitivity analysis demonstrates robustness: even under the most conservative combined scenario (50% farmer adoption rate, ₹6,000/acre saving), the programme delivers a Surplus BCR of 3.1× and total economic surplus exceeding ₹18 crore. The inclusion of working capital interest at 12% reduces producer surplus by approximately 25% but leaves consumer surplus unaffected, indicating that the programme's primary welfare delivery channel is farmer savings rather than enterprise profit — a socially desirable feature.

6. Scale-UP Framework: 80 BRCs in Aspirational and operational Districts

6.1. District-wise Implementation

The proposed scale-up covers 10 aspirational and operational districts of Chhattisgarh, each hosting 8 BRCs in two geographic sub-clusters (4+4), enabling shared logistics, quality monitoring, and peer learning. Table 8 maps districts to their agro-ecological profiles and product priorities.

Table 8: District-wise BRC Implementation Mapping

District	*Lead Crop(s)*	*Priority BRC Products*	*Tribal Share (%)*	*BRC Cluster*
Bastar	Paddy / Millets	Agniastra, Brahmastra	66%	4+4
Kanker	Vegetables / Paddy	Neemastra, Multiseed	52%	4+4
Narayanpur	Paddy / Kodo-Kutki	Beejamrit, Jeevamrit	71%	4+4
Bijapur	Paddy / Pulses	Agniastra, Ghan Jeevamrit	70%	4+4
Sukma	Paddy / Oil Seeds	Brahmastra, Beejamrit	58%	4+4
Dantewada	Vegetables / Spices	Neemastra, Multiseed	54%	4+4
Kondagaon	Maize / Paddy	Agniastra, Brahmastra	51%	4+4
Gariaband	Paddy / Horticulture	Ghan Jeevamrit, Neemastra	48%	4+4
Jashpur	Tea / Paddy	Multiseed, Beejamrit	42%	4+4
Surguja	Paddy / Millets	Brahmastra, Ghan Jeevamrit	45%	4+4

Note: Tribal share from Census 2011. Product priorities reflect district crop calendar and dominant pest-disease complex. Source: Authors; NITI Aayog ADP data.

6.2. Institutional Architecture

The programme operates through a three-tier institutional structure aligned with the PRADAN implementation model. At state level, a dedicated BRC monitoring unit (within PRADAN'S state office in Raipur, Chhattisgarh) oversees policy, standards, MIS, and certification. At district level, technical team — constituted within district's PRADAN'S field office — provide technical backstopping, quality testing, and procurement aggregation. At village level, BRC Community Enterprises (constituted as FPOs under the Companies Act, 2013) own and operate individual BRCs with elected management committees.

This architecture deliberately separates public-good functions (standards, MIS, training — state and district tier) from private-good functions (production, sales, profit distribution — village tier), minimising moral hazard and maximising enterprise incentive while ensuring quality accountability.

6.3. Employment and Gender Dimensions

The 80 BRC programme will generate 240–400 direct jobs (Technical Operator, Field Extension Worker per BRC), with a target of 60–65% women participation by Year 3. In aspirational districts characterised by high male out-migration, this represents a significant women's economic empowerment opportunity. Indirect employment through expanded farmer adoption of natural farming and associated reduction in purchased-input expenditure (releasing cash for other productive investments) is estimated at 3–5 times the direct employment effect.

Employment cost-efficiency of ₹433 per person-day of direct employment created (government outlay basis) compares favourably with VBGRAMG effective cost of ₹550–₹700 per person-day in Chhattisgarh (MoRD, 2023), with the additional advantage that BRC employment is skilled, year-round, and enterprise-based rather than contingent on government works allocation.

7. Discussion

7.1. BRC as a Market Correction Instrument

The economic surplus analysis reveals that BRCs function primarily as a market correction mechanism in imperfect input markets. The large price differential between biological and chemical input equivalents (₹9,000/acre, or 64% savings) is not principally a subsidy effect -BRC products are sold at cost-plus-margin prices that

sustain profitable enterprise operations. Rather, it reflects the systematic market failure in biological input supply: high product complexity and knowledge requirements, fragmented rural markets with thin demand density, and absence of commercial intermediaries willing to service low-income tribal farming communities.

This interpretation aligns with the finding that consumer surplus (₹194.40 crore) substantially exceeds producer surplus (₹8.29 crore). In a well-functioning market, competition would erode both price differentials and producer margins. The persistence of this surplus gap over five years of BRC operation indicates genuine market failure rather than temporary arbitrage -and validates public investment in BRC infrastructure as a welfare-improving intervention.

7.2. Comparison with Conventional Input Subsidy Approaches

The dominant policy response to high input costs in Indian agriculture has been chemical input subsidies — fertilizer, pesticide, and electricity subsidies totalling approximately ₹3.5 lakh crore annually at the national level (GoI, 2023). These subsidies have been extensively critiqued for fiscal unsustainability, market distortion, and regressive incidence. The BRC model offers a structurally different response: rather than subsidising the chemical inputs that cause ecological harm, it creates competitive market alternatives that are financially self-sustaining.

The programme BCR of 38.7× compares favourably with estimated BCRs for fertilizer subsidy programmes in India (0.8–1.2×; Fan et al., 2008) and with watershed development programmes (2.5–4×) and rural road investment (3.8×; Fan et al., 2008). The cost per beneficiary household of ₹894 is an order of magnitude below most rural livelihood programme benchmarks.

7.3. Limitations

This analysis carries four principal limitations. First, the producer surplus estimates are based on data from a single pilot BRC; performance heterogeneity across 80 BRCs operating in diverse agro-ecological and institutional contexts may be significant. Second, consumer surplus is estimated using the price-differential method with a fixed savings figure — actual farmer savings depend on input substitution behaviour, adoption extent, and agronomic response, all of which were not directly measured. Third, ecological surplus (soil health, biodiversity, water quality) is not monetised - its inclusion would substantially increase total economic surplus estimates but requires long-term field studies not yet available for Chhattisgarh's aspirational

districts. Fourth, the analysis does not model competitive response from chemical input suppliers, which could affect the sustainability of consumer surplus estimates if chemical input prices are reduced competitively.

8. Conclusions and Policy Implications

This paper has demonstrated, through a combined cost-benefit and economic surplus analysis, that Bioresource Centres represent a financially robust, welfare-enhancing, and institutionally scalable model for biological input supply in India's natural farming transition. The key findings are:

- The pilot BRC achieved a five-year BCR of 1.79, with profitability from Year 1, net profit CAGR of 70%, and IRR of 58% — performance metrics that justify replication without subsidy dependency.
- At 80-BRC programme scale, total producer surplus (₹8.29 crore) and consumer surplus (₹194.40 crore) yield a total economic surplus of ₹202.69 crore against a government outlay of ₹5.72 crore — a Surplus BCR of 35.4×.
- 64,000 farm households will access biological inputs at ₹9,000/acre below chemical equivalents by Year 5, representing an aggregate annual welfare transfer of ₹8.64 crore to tribal farming households.
- Employment is generated at ₹433 per person-day — more cost-efficient than VBGRAMG and generating skilled, enterprise-based livelihoods.
- Sensitivity analysis confirms robustness: the Surplus BCR exceeds 3.0× even under worst-case parameter combinations.

The policy implications are direct. Governments and development organisations investing in natural farming transitions should prioritise biological input supply infrastructure over farmer-level subsidy programmes. BRCs represent the most capital-efficient modality identified in this analysis. Specifically, we recommend: (i) programme notification and budget release by the Government of Chhattisgarh for the BRCs in aspirational and needed district programme; (ii) establishment of a NABARD revolving working capital fund to the BRCs; (iii) integration of BRC-served villages with PGS or NPOP organic certification clusters to capture output market premiums; and (iv) formalization of research partnerships with IGKV and other agricultural universities to generate the long-term ecological evidence base for next-generation programme design.

The BRC model's combination of enterprise self-sufficiency, community ownership, and dual welfare delivery (producer and consumer surplus) makes it a

candidate for national replication in states pursuing natural farming transitions. This analysis provides the evidence base and analytical framework for that expansion.

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