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Evaluating the Impact of ICDP on India's Coffee Production, Yield, and Exports

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The coffee industry plays a pivotal role in India's agricultural sector, contributing significantly to the country's economy and livelihoods. However, the sector has faced challenges such as fluctuating yields, inconsistent production, and varying export quantities, largely due to biotic and abiotic stress factors. In response, the Ministry of Commerce and Industry launched the Integrated Coffee Development Project (ICDP) in 2014, aiming to enhance coffee production, productivity, and quality

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across both traditional and non-traditional growing regions in India. This research paper evaluates the impact of ICDP on coffee production, yield, and exports in India by analysing data from 2008 to 2022. The study adopts an interrupted time series analysis methodology to assess trends in the area under cultivation, production, yield, and export quantities before and after the ICDP intervention. The study period is divided into pre- and post-intervention phases to quantify the effects of the scheme. The results indicate a mixed impact of the ICDP. Traditional coffee-growing areas showed initial increases in production and yield, followed by declines, while non-traditional areas exhibited smaller but more consistent growth. Exports also experienced a temporary decline post-intervention but later rebounded, though at a slower growth rate. The analysis underscores the complexity of agricultural interventions, suggesting that while the ICDP had positive impacts in certain areas, challenges such as climate variability and pest infestations continue to affect the sector's overall growth. In conclusion, the ICDP has contributed to stabilizing and developing India's coffee sector, but ongoing efforts are needed to address the underlying challenges hindering sustained progress.

Keywords: Coffee; interrupted time series analysis; integrated coffee development project scheme.

1. INTRODUCTION

Coffee, a globally cherished beverage, holds significant economic importance as the second largest traded commodity after petroleum, with its origins tracing back to the highlands of Ethiopia and the Boma Plateau of Sudan [1]. The coffee plant, belonging to the Rubiaceae family and *Coffea* genus, thrives in tropical and subtropical highlands, with the earliest credible use as a beverage dating back to the 15th century in Yemen [2]. By the 16th century, coffee had spread across the Middle East, North Africa, and eventually Europe, becoming a staple beverage worldwide. The two primary species cultivated globally, *Coffea arabica and Coffea canephora* (commonly known as robusta), are grown in over 70 countries, particularly within the equatorial regions of America, Southeast Asia, the Indian subcontinent, and Africa. Brazil remains the leading producer, contributing a third of the world's coffee in 2018-19 [3]. In India, coffee occupies a significant position among plantation crops, primarily grown in the southern states of Karnataka, Kerala, and Tamil Nadu, with Karnataka alone accounting for over 53 percent of the total planted area [4]. India has maintained a consistent share of three to four percent in global coffee production over the past three decades, with exports playing a crucial role in the country's economy. Despite being the seventh largest coffee producer globally, India faces challenges related to market fluctuations, price instability, and competition from international players post-liberalization [5,6]. The Integrated Coffee Development Project (ICDP) Scheme was introduced to address these challenges, focusing on enhancing production, yield, and exports of Indian coffee, particularly in the face of competition and market dynamics shaped by global trade policies. Given the significance of coffee as a source of livelihood for millions and its contribution to the economy, evaluating the impact of the ICDP Scheme on coffee production, yield, and exports is crucial. This research paper aims to analyse the effectiveness of the ICDP in improving the overall productivity and export of Indian coffee. This evaluation is timely, as India's coffee sector is at a crossroads, facing both opportunities and threats in an increasingly competitive and volatile global market [7,1,4]. Understanding the role of government intervention through the ICDP Scheme will be instrumental in formulating future policies to sustain and enhance the growth of this vital sector.

2. METHODOLOGY

The data related to area, production, yield and exports were collected from sources such as the Coffee Board of India and International Coffee Organization statistics. (Source: https://coffeeboard.gov.in/coffee-statistics.html & https://icocoffee.org/what-we-do/world-coffee-statistics-database/).

2.1 Growth Rate

The compound growth rates for the area, production and export of coffee (quantity) were worked out for both sub-periods and the overall period using compound annual growth rate (CAGR). The compound growth function is specified in the following from.

$$Y_t = ab^t e^u \quad (1)$$

Where,

Y_t = export/production in the year t
t = Time period
a = Intercept value (value of y when t = 0)
b = (1+r), 'r' being the growth rate
u = Error term

Equation (1) was converted into the natural logarithmic form in order to facilitate the use of linear regression. Taking logarithms on both sides we obtain,

$$\text{Ln } Y_t = \text{Ln } a + t \text{ Ln } b + u \quad (2)$$

Ln a and Ln b are obtained by application of ordinary least squares (OLS) procedure to equation (2) and the growth rate r is computed as below:

r = (Anti Ln of Ln b – 1) X 100

2.2 Instability

The instability in area, production and export of coffee was analysed using Instability Index i.e. Cuddy-Della Valle Index, [8].

$$I = CV * (1-R^2)^{0.5}$$

Where, CV is the coefficient of variation and R^2 is the adjusted coefficient of determination of the log linear function.

2.3 Trade Competitiveness

Trade competitiveness of major coffee exporters was analysed for the period from 2014 to 2023, by using Revealed Comparative Advantage (RCA) index. The RCA Index developed by *Balassa* [9] is one of the popular methods of indicating competitiveness in international trade. It shows how much competitive is a product in a country's export compared to that product's share in global trade. A product with a high RCA value is competitive and can be exported to countries with low RCA value. The RCA index is computed by Equation (1):

$$RCA = \frac{\left(X_{ij}/X_{ik}\right)}{\left(X_{nj}/X_{nk}\right)} \quad (1)$$

Where,

X_{ij} = Exports by 'ith' country of 'jth'commodity, i.e. coffee
X_{ik} = Exports by 'ith' country of a set of 'commodities, i.e. agricultural commodities
X_{nj} = Exports by a set of 'n' countries of 'jth'commodity and
X_{nk} = Exports by a set of 'n' countries of a set of 'k' commodities

However, RCA suffers from the problem of asymmetry as 'pure' RCA is basically not comparable on both sides of unity. The index is made symmetric following the methodology suggested by *Dalum, et al.,* [10] and the new index is called Revealed Symmetric Comparative Advantage (RSCA) Index (Equation 2). This index ranges between -1 and +1 and is free from skewness problem.

Mathematically,

$$\text{RSCA} = \frac{(\text{RCA}-1)}{(\text{RCA}+1)} \quad (2)$$

2.4 Interrupted Time Series Analysis (ITSA)

Interrupted time series analysis (ITSA) was used to capture the impact of ICDP on area, production, yield and exports of coffee in different parts of India. In the present study, the approach of Bernal et al. [11], Crosbie [12] and Serumaga et al. [13] was used and the functional form is given as follows:

$$Y_{it} = \beta_0 + \beta_1 time_t + \beta_2 level_i + \beta_3 trend_{it} + \varepsilon_{it} \quad (3)$$

Where,

Y represents the wholesale or retail prices, the outcome variable;

β_0 is the level at t=0,
β_1 is the pre-intervention trend (*i.e.* before ICDP),
β_2 is the level change post-intervention and
β_3 is the change in slope post-intervention.

The STATA package 'itsa' has been used to estimate the coefficients of Eq. (3).

It uses OLS regression approach but produces Newey-West standard errors to account for autocorrelation and possible heteroskedasticity.

3. RESULTS AND DISCUSSION

Having outlined the research design and data collection methods, the following section presents the findings derived from the analysis, providing a detailed examination of the impact of the Integrated Coffee Development Project Scheme on coffee production, yield, and exports in India.

3.1 Global Coffee Production and Trade Overview

Table 1 provides a comprehensive overview of the major coffee-producing countries in 2022, highlighting their production volumes, the area under cultivation, and productivity. Brazil leads with the highest coffee production, contributing 29.13% of global output, with a productivity of 1.69 tons per hectare. Vietnam follows as the second-largest producer, with a notable productivity of 2.98 tons per hectare, the highest among the listed countries. Indonesia and Colombia also feature prominently, though their productivity is relatively lower at 0.62 and 0.79 tons per hectare, respectively. Ethiopia, Uganda, and India show moderate production levels, with Ethiopia and Uganda having a similar area under cultivation but differing productivity. The Central African Republic, despite having a relatively small production share, utilizes a larger area with low productivity. Overall, global coffee production is spread across 12.24 million hectares, with an average productivity of 0.89 tons per hectare, illustrating significant variations in production efficiency among different countries.

Table 1. Major coffee producers in the world in 2022. (Production in million tons and area in m ha)

Country	Production	%share	Area	% share	Productivity (tons/ha)
Brazil	3.17	29.13	1.87	15.30	1.69
Viet Nam	1.95	17.94	0.66	5.36	2.98
Indonesia	0.79	7.30	1.29	10.51	0.62
Colombia	0.67	6.11	0.84	6.88	0.79
Ethiopia	0.50	4.56	0.74	6.06	0.67
Uganda	0.39	3.62	0.73	5.94	0.54
Peru	0.35	3.24	0.42	3.46	0.83
India	0.34	3.11	0.44	3.58	0.77
Honduras	0.32	2.90	0.26	2.11	1.22
Central African Republic	0.31	2.82	0.76	6.22	0.40
World	10.89	100	12.24	100	0.89

Source: FAOSTAT Database (https://www.fao.org/faostat/en/#data)

Table 2. Major players in global coffee exports, 2023. (Value in million US$)

Sl No.	Exporters	Export value	% share in world trade
1	Brazil	7351	17.40
2	Switzerland	3644	8.63
3	Germany	3408	8.07
4	Viet Nam	3382	8.01
5	Colombia	2915	6.90
6	Italy	2586	6.12
7	Honduras	1488	3.52
8	Belgium	1310	3.10
9	France	1271	3.01
10	Ethiopia	1225	2.90
11	Netherlands	1200	2.84
12	USA	1193	2.83
13	Uganda	955	2.26
14	Guatemala	949	2.25
15	Indonesia	929	2.20
16	Peru	829	1.96
17	Canada	764	1.81
18	India	747	1.77
	World	42245	100

Source: ITC Trade map, 2024 (https://www.trademap.org/Index.aspx).

The table highlights the leading global coffee exporters in 2023, ranked by their export value in million US dollars and their share of world trade. Brazil tops the list, contributing a significant 17.40% of the global coffee trade with an export value of $7,351 million. Following Brazil, Switzerland and Germany hold second and third positions, with shares of 8.63% and 8.07%, respectively. Vietnam and Colombia round out the top five, each with around an 8% share. Notably, India ranks 18th with an export value of $747 million, accounting for 1.77% of global trade. The total global export value stands at $42,245 million. This data underscores the dominance of a few key players, particularly Brazil, while also reflecting the diverse contributions of other significant coffee-exporting nations across various continents.

3.2 Indian Scenario of Coffee Production and Trade

Fig. 1 illustrates a consistent increase in both the area under coffee cultivation and total production from 1990-91 to 2020-21. However, during this period, coffee yield has declined. This negative trend in yield is primarily due to biotic factors like the increased infestation of white stem borer and abiotic stress from erratic weather patterns affecting India's coffee-growing regions. These challenges have led to reduced yields despite the expansion in cultivation and production, emphasizing the importance of addressing these stressors to improve productivity.

The Table 3 outlines the status of coffee production in India, highlighting the distinction between traditional and non-traditional coffee-growing areas. Karnataka, Tamil Nadu, and Kerala are traditional areas of coffee production, collectively contributing a significant majority to India's coffee output. In the 2023-24 season, Karnataka alone produced 71.32% of the total coffee, with Kerala and Tamil Nadu adding another 24.39%, emphasizing their dominance. In contrast, states like Andhra Pradesh, Orissa, and the North Eastern Region are categorized as non-traditional coffee-producing areas. Their contributions are relatively minor, with Andhra Pradesh contributing 4.11% of the total production, while Orissa and the North Eastern Region together account for less than 0.2%. This stark contrast underscores the concentration of coffee cultivation in traditional areas, with non-traditional regions playing a very limited role in the industry.

The Table 4 highlights the compound growth rate (CAGR) analysis conducted to evaluate the growth in area, yield, production, and export quantity of coffee from 1991 to 2022. To study the growth rate CAGR was used. The study period was divided into three segments: Period I (1991-2005), Period II (2006-2022), and the overall period (1991-2022). The analysis revealed a significant and positive growth trend in the area under coffee cultivation during the overall period, with an annual growth rate of 2.3%. Production growth was most prominent in Period I, followed by the overall period and then Period II. The yield growth rate was highest and significant in Period I, but Period II saw a decline with a negative growth rate of -0.39% per annum. This decline in yield during Period II was attributed to unfavourable climatic conditions and inconsistent rainfall, which adversely affected coffee production. Regarding exports, the highest growth rate was observed in Period I, at 5.69% per annum. Despite a generally positive trend in export quantity, fluctuations were noted due to low coffee prices in both domestic and international markets. Overall, the study found positive and increasing growth trends in the area, production, and export quantity of coffee, but yield experienced a negative growth rate. These results are comparable with those of Namreen [14].

To analyse the instability in the area, yield, production, and export quantity of coffee during the study period, the coefficient of variation and Cuddy Della-Valle index were used, with the results presented in the Table 5. Period II showed the least variability in coffee cultivation area, at 0.96%, compared to 4.67% in Period I. However, the overall study period exhibited a higher instability of 5.22%, exceeding the individual periods. In terms of coffee production, variability was greater in Period I (9.48%) compared to Period II (5.70%), with the overall period showing a variation of 10.00%. Coffee yield variability was also higher in Period I (7.75%) than in Period II (5.68%), with an overall variability of 7.58%. Regarding export quantity, Period I saw more variability (13.03%) compared to Period II (12.87%), but the highest variability was recorded during the overall study period at 14.04%.

3.3 Impact of ICDP

Owing to the importance of the economic contribution of coffee production in India, The Integrated Coffee Development Project Scheme

(ICDP) was launched by the Ministry of Commerce and Industry in 2014 to encourage coffee development in traditional and non-traditional areas in India. The main objective of the Scheme is to develop improved varieties and technologies for increasing production, productivity and quality of coffee, to promote Indian coffee in overseas and domestic markets, and to encourage value addition to improve unit value realization. Hence the present study aims to study the impact of this scheme on area, production, productivity and export in traditional and non-traditional coffee growing areas by utilizing the data from 2008 to 2022. For this study we have divided the coffee growing area into traditional and non-traditional areas [4]. Traditional areas includes southern states like, Karnataka, Kerala and Tamil Nadu, while non-traditional areas are Andhra Pradesh, Orissa and North-Eastern states. The results are discussed as below.

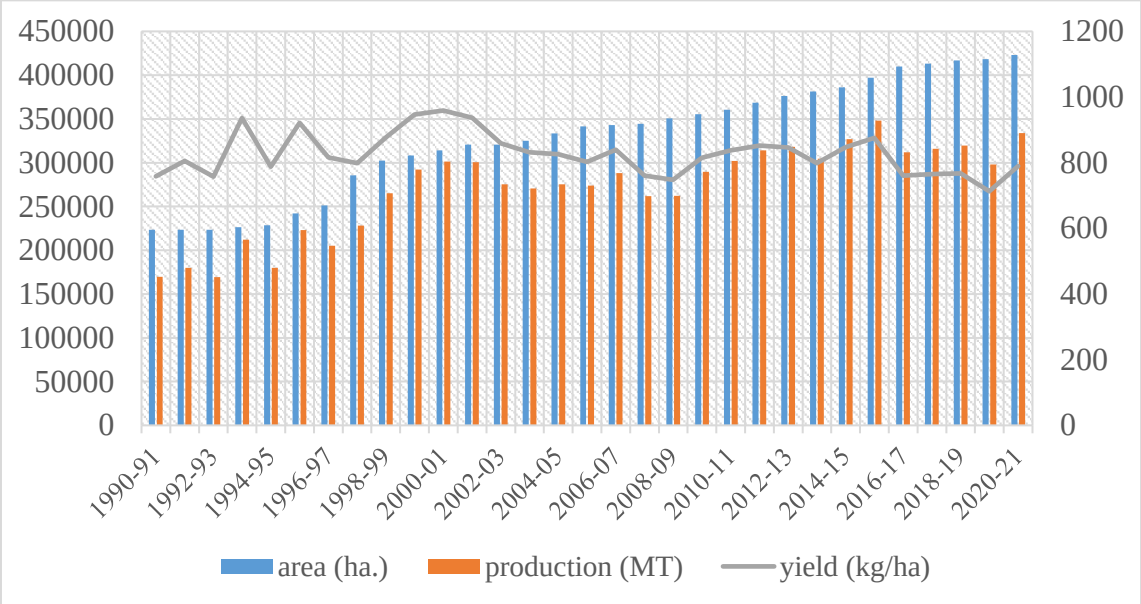

Fig. 1. Area, production and productivity of coffee in India from 1990-91 to 2020-21
Source; Coffee Board of India (https://coffeeboard.gov.in/coffee-statistics.html)

Table 3. Status of coffee production in India

States	2023-24			2022-23		
	Arabica	Robusta	Total	Arabica	Robusta	Total
Karnataka	81960 (72.53)	184925 (70.80)	266885 (71.32)	72020 (72.02)	176000 (69.84)	248020 (70.46)
Kerala	2075 (1.84)	70750 (27.09)	72825 (19.46)	1975 (1.98)	70450 (27.96)	72425 (20.58)
Tamil Nadu	13,045 (11.54)	5,390 (2.06)	18,435 (4.93)	13,250 (13.25)	5,450 (2.16)	18,700 (5.31)
Andhra Pradesh	15,340 (13.58)	40 (0.02)	15,380 (4.11)	12,225 (12.23)	40 (0.02)	12,265 (3.48)
Orissa	500 (0.44)	0 (0.00)	500 (0.13)	465 (0.47)	0 (0.00)	465 (0.13)
North Eastern Region	80 (0.07)	95 (0.04)	175 (0.05)	65 (0.07)	60 (0.02)	125 (0.04)
Grand Total (India)	1,13,000 (100)	2,61,200 (100)	3,74,200 (100)	1,00,000 (100)	2,52,000 (100)	3,52,000 (100)

Note: Figures in the parenthesis indicates percentages.
Source; Coffee Board of India (https://coffeeboard.gov.in/coffee-statistics.html).

Table 4. Trend in area, production, yield and export of coffee in India (1991-2022)

S.No	Source	Particulars	Period I (1991-2005)	Period II (2006-2022)	Overall period (1991-2022)
1	Area (ha)	R2	0.9225	0.9836	0.9306
		Coefficient	0.0352	0.0165	0.0228
		P value	0.0000	0.0000	0.0000
		Growth rate	3.58***	1.66***	2.3***
2	Production (Tonnes)	R2	0.8051	0.4883	0.7259
		Coefficient	0.0428	0.0126	0.0201
		P value	0.0000	0.0038	0.0000
		Growth rate	4.37***	1.26***	2.02***
3	Yield (kg/ha)	R2	0.1737	0.0878	0.0910
		Coefficient	0.0076	-0.0040	-0.0026
		P value	0.1223	0.2836	0.1052
		Growth rate	0.77	-0.39	-0.26
4	Export Quantity (Tonnes)	R2	0.7597	0.6061	0.8112
		Coefficient	0.0553	0.0373	0.0355
		P value	0.0000	0.0006	0.0000
		Growth rate	5.69***	3.8***	3.6***

Source: Author's computation

**** indicates significant at 1% level of significance*

Table 5. Instability of area, production, yield and exports of Indian coffee (1991-2022)

S.No	Source	Particulars	Period I (1991-2005)	Period II (2006-2022)	Overall period (1991-2022)
1	Area (ha)	C.V	16.15	7.22	19.48
		CDVI	4.67	0.96	5.22
2	Production (Tonnes)	C.V	20.69	7.67	18.76
		CDVI	9.48	5.70	10.00
3	Yield (kg/ha)	C.V	8.21	5.72	7.81
		CDVI	7.75	5.68	7.58
4	Export Quantity (Tonnes)	C.V	25.61	19.76	31.75
		CDVI	13.03	12.87	14.04

Source: Author's computation

3.4 Traditional Areas

3.4.1 Area

Traditional area - As shown in the regression table, the starting level of the bearing area was estimated at 318960.7 ha, and bearing area appeared to increase significantly every year prior to 2014 by 1972.2 ha (Table 6). In the first year of the intervention (2014), there appeared to be a significant increase in bearing area of 2541.633 ha, followed by a significant decrease in the annual trend bearing area (relative to the pre-intervention trend) of 681.0143 ha per year. We also see, from the lincom estimate produced by specifying post-trend, which after the introduction of scheme, bearing area increased annually at a rate of 2653.214 ha. Figure provides a visual display of these results (Fig. 2).

3.4.2 Production

For the traditional coffee-producing states, the regression analysis revealed that the initial production was estimated at 285,666.9 tons (Table 7). Prior to 2014, this production was expanding significantly, with an annual increase of 4,431.571 tons. However, in 2014, the year of intervention, there was a sharp rise in production by 8,384.381 tons. Following this, the annual growth trend reversed, with a notable decline of 7,469.429 tons per year compared to the pre-intervention pattern. According to the Lincom estimate, which accounts for post-intervention trends, the production continued to shrink annually by 3,037.857 hectares after the scheme was introduced. These trends are visually depicted in the accompanying figure (Fig. 3).

Table 6. Traditional states (Area)

Parameters	Co-efficient	P-value
Intercept	318960.7 (337.84)	0.000
Pre- intervention	1972.2 (174.59)	0.000
Post- intervention	2541.633 (3691.19)	0.508
Interaction term	681.0143 (991.77)	0.510
Lincom estimate	2653.214 (909.60)	

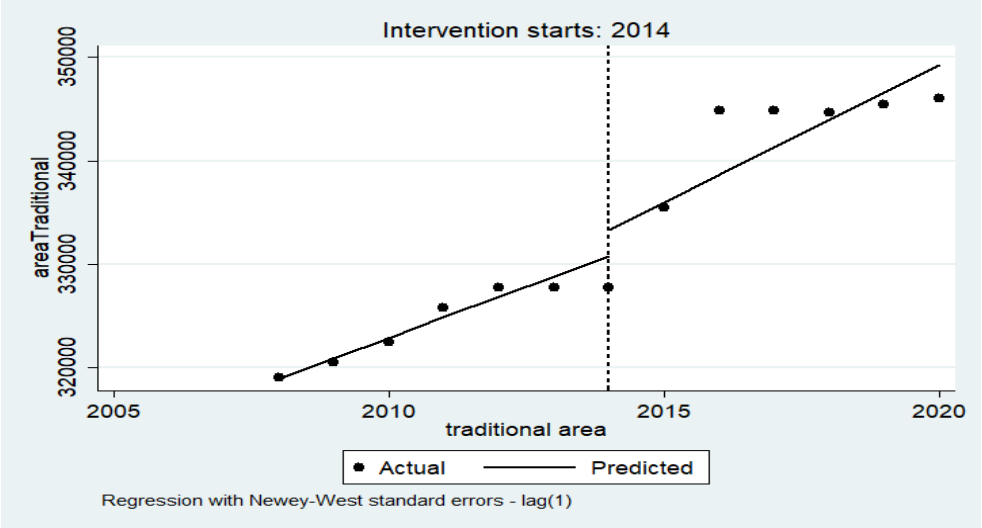

Fig. 2. Traditional states (Area)
Source: Author's computation

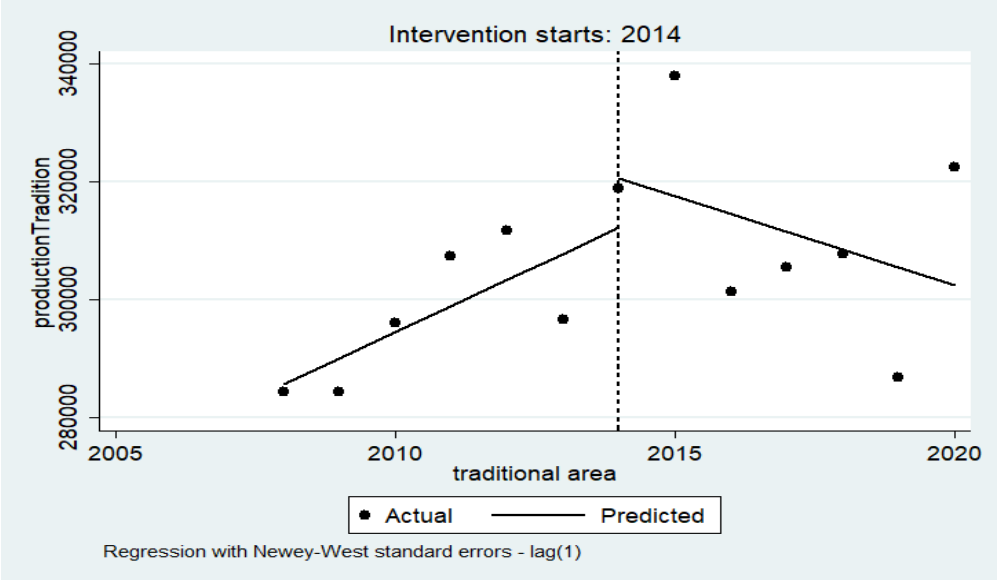

Fig. 3. Traditional states (production)

Table 7. Traditional states (production)

Parameters	Co-efficient	P-value
Intercept	285666.9 (3956.27)	0.000
Pre-intervention	4431.57 (1914.62)	0.046
Post- intervention	8384.38 (11990.04)	0.502
Interaction term	-7469.42 (-7469.43)	0.054
Lincom estimate	-3037.85 (2685.65)	

Table 8. Traditional states (Yield)

Parameters	Co-efficient	P-value
Intercept	895.4286 11.40939	0.000
Pre-intervention	8.228571 5.39488	0.162
Post- intervention	18.2 42.18527	0.676
Interaction term	-24.65714 10.44516	0.043
Lincom estimate	-16.42857 9.326131	

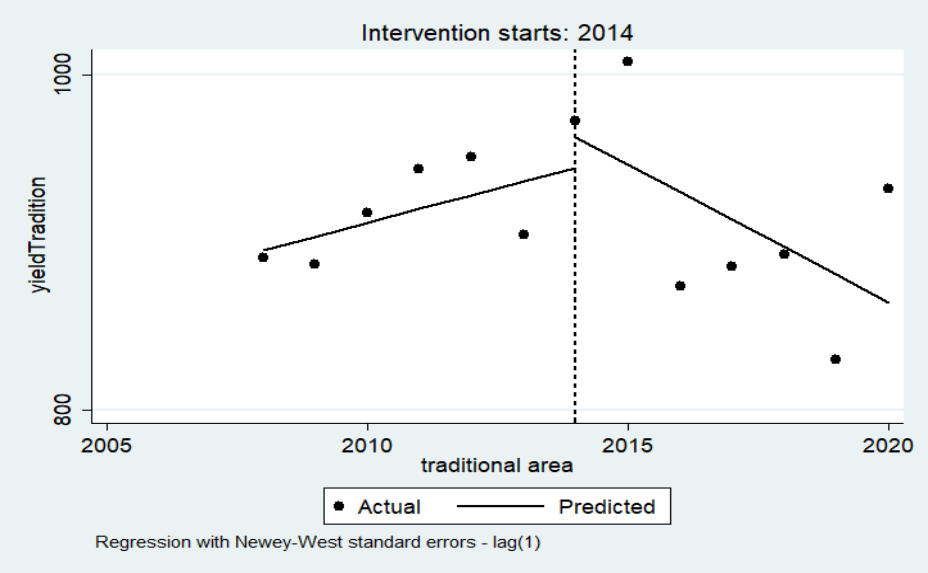

Fig. 4. Traditional states (Yield)

3.4.3 Yield

For traditional coffee-growing areas, the initial yield was estimated at 895 kilogram per hectares (kg/ha), with an annual increase of 8.2 kg/ha before 2014 (Table 8). In 2014, the bearing area rose significantly by 18.2 kg/ha, but this was followed by a sharp decline of 24.kg/ha per year compared to the pre-intervention trend. After the scheme's introduction, the yield continued to decrease annually by 16.42 kg/ha. These trends are visually represented in the accompanying figure (Fig. 4).

3.5 Non-traditional Areas

3.5.1 Area

For Andhra Pradesh and Odisha, the regression table indicates that the initial bearing area was estimated at 227,460.43 hectares, with an annual increase of 4,506.829 hectares prior to 2014 (Table 9). In 2014, the first year of intervention, there was a significant increase in the bearing area by 913.028 hectares. However, this was followed by a notable decrease in the annual trend, with the bearing area declining by 1,196.114 hectares per year compared to the pre-intervention trend. The Lincom estimate, which accounts for the post-intervention period, shows that after the introduction of the scheme, the bearing area continued to increase annually, but at a reduced rate of 3,310.714 hectares. The accompanying figure visually illustrates these trends (Fig. 5).

3.6 Northeast India (Area)

For the North Eastern Region (NER), the regression table indicates that the initial bearing area was estimated at 2,997.667 hectares. (Table 10) Before 2014, the bearing area decreased significantly each year by 61.00 hectares. However, in 2014, the first year of intervention, there was a substantial increase in the bearing area by 736.261 hectares. This was followed by a significant decline in the annual trend, with the bearing area decreasing by 222.785 hectares per year relative to the pre-intervention trend. According to the Lincom estimate, after the introduction of the scheme, the bearing area continued to decrease annually at a rate of 283.785 hectares. The accompanying figure visually represents these findings (Fig. 6).

3.6.1 Production

For Andhra Pradesh and Odisha, the initial production was estimated at 4,723.333 tons, with a significant annual increase of 519 tons before 2014 (Table 11). In 2014, production rose by 1,051.417 tons, but the growth trend then slowed by 28.10 tons annually. Post-intervention, the area increased by 490.89 hectares annually. This trend is visually depicted in the figure (Fig. 7).

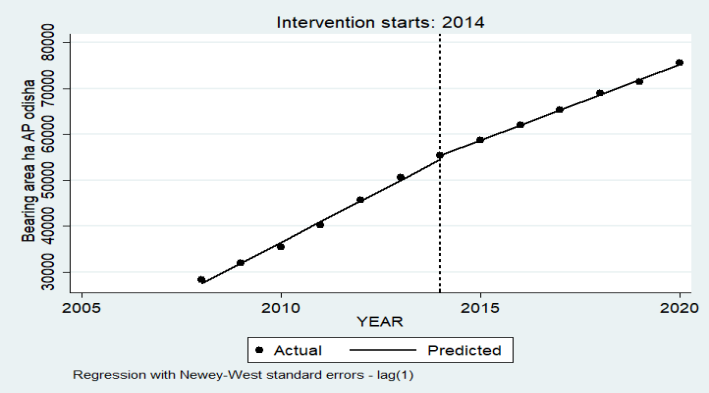

Fig. 5. AP and Odisha (Area)

Table 9. AP and Odisha (Area)

Parameters	Co-efficient	P-value
Intercept	227460.43 (690.44)	0.000***
Pre-intervention	4506.83 (204.63)	0.000***
Post- intervention	913.03 (747.80)	0.253
Interaction term	-1196.11 (210.34)	0.000***
Lincom estimate	3310.71 (36.40)	

Table 10. Northeast India (Area)

Parameters	Co-efficient	P-value
Intercept	2997.66 (120.86)	0.000***
Pre-intervention	-61 (35.099)	0.116
Post- intervention	736.26 (385.509)	0.087
Interaction term	-222.78 (97.072)	0.047**
Lincom estimate	-283.78 (97.521)	

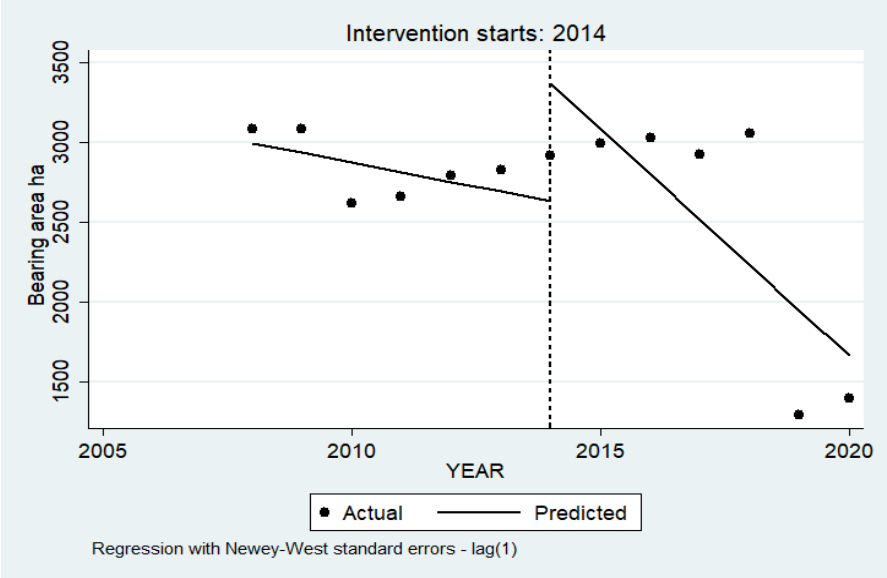

Fig. 6. Northeast India (Area)

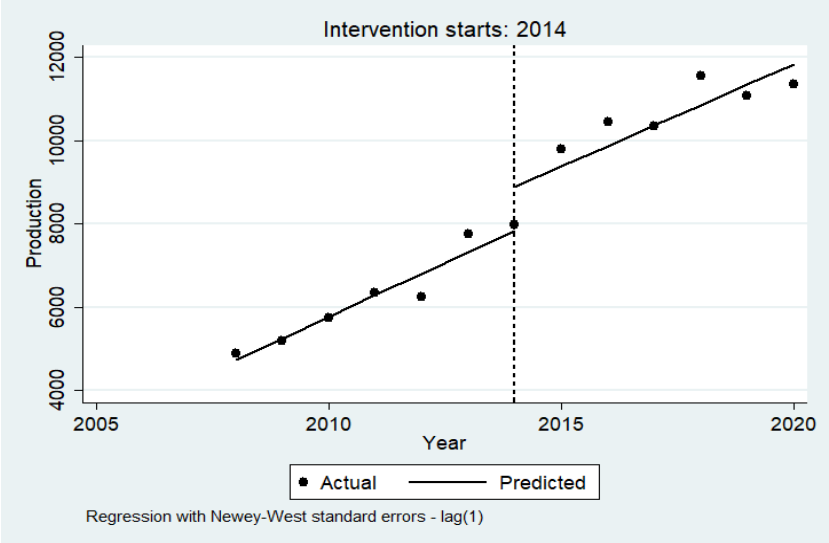

Fig. 7. AP and Odisha (production)

Table 11. AP and Odisha (production)

Parameters	Co-efficient	P-value
Intercept	4723.33 (122.78)	0.000
Pre-intervention	519 (71.89)	0.000
Post- intervention	1051.41 (755.05)	0.197
Interaction term	-28.10714 (122.12)	0.823
Lincom estimate	490.8929 136.63	

Table 12. Northeast India (production)

Parameters	Co-efficient	P-value
Intercept	120.95 14.71	0.000
Pre-intervention	17.28 4.85	0.006
Post- intervention	-21.98 29.17	0.470
Interaction term	-23.89 5.14	0.001
Lincom estimate	-6.60 3.10	

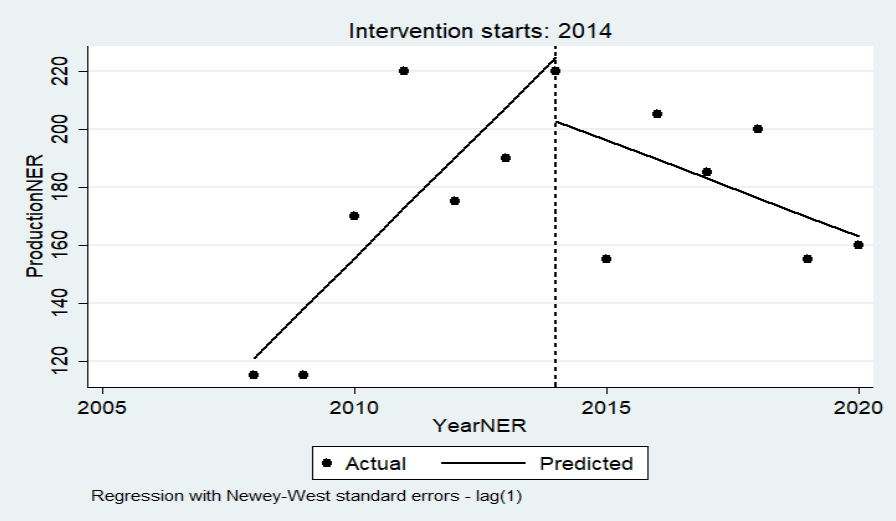

Fig. 8. Northeast India (production)

Similarly for NER, the initial production was 120.95 tons, with an annual increase of 17.28 tons before 2014 (Table 12). In 2014, there was a notable decrease of 21.99 tons, followed by an additional annual decline of 23.89 tons. Post-intervention, the area continued to decrease annually by 6.61 hectares. These trends are visually represented in the figure (Fig. 8).

3.6.2 Yield

For Andhra Pradesh and Odisha, the initial yield was 169.71 kg/ha, decreasing annually by 5.08 kg/ha before 2014 (Table 13). In 2014, the yield increased significantly by 19.98 kg/ha, followed by an annual growth of 4.83 kg/ha relative to the previous trend. However, post-intervention, the

yield saw a slight annual decline of 0.25 kg/ha. The figure visually represents these trends (Fig. 9).

Similarly for NER, the initial bearing area was 41.09 kg/ha, with an annual increase of 7.03 kg/ha before 2014 (Table 14). In 2014, the yield sharply decreased by 30.65 kg/ha, but this was followed by an annual increase of 2.01 kg/ha. After the intervention, the yield grew by 9.03 kg/ha annually. The accompanying figure illustrates these trends visually (Fig. 10).

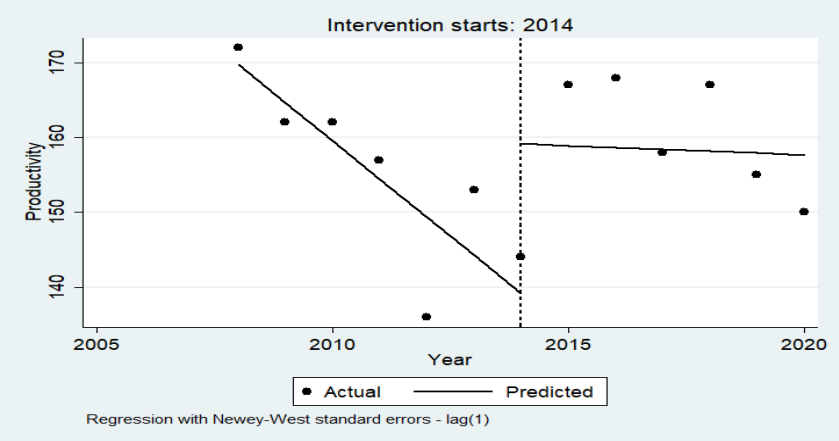

Fig. 9. AP and Odisha (Yield)

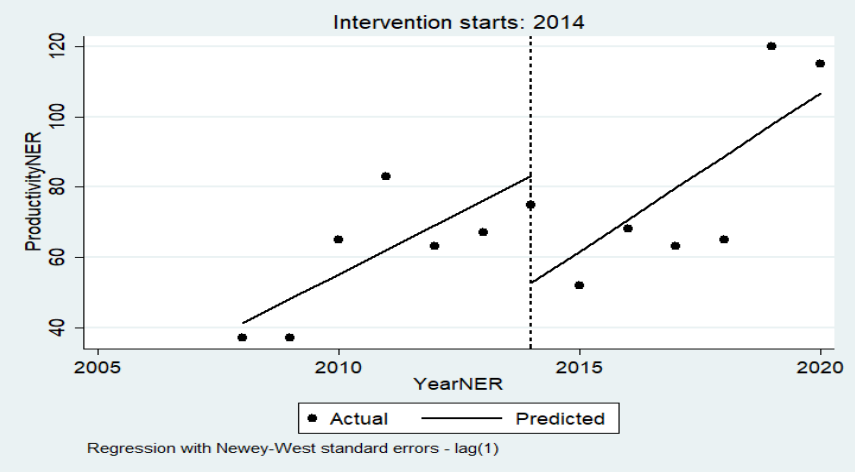

Fig. 10. Northeast India (Yield)

Table 13. AP and Odisha (Yield)

Parameters	Co-efficient	P-value
Intercept	169.7143 2.232968	0.000
Pre- intervention	-5.085714 1.435393	0.006
Post- intervention	19.97857 13.50473	0.173
Interaction term	4.835714 1.963921	0.036
Lincom estimate	-.25 2.172782	

Table 14. Northeast India (Yield)

Parameters	Co-efficient	P-value
Intercept	41.09524 7.608928	0.000
Pre-intervention	7.028571 2.468136	0.019
Post- intervention	-30.65952 19.35448	0.148
Interaction term	2.007143 3.753511	0.606
Lincom estimate	9.035714 3.545525	

Table 15. Overall India (Exports)

Parameters	Co-efficient	P-value
Intercept	205645.5 20708.89	0.000
Pre-intervention	24469.46 6334.253	0.004
Post- intervention	-35693.16 33668.84	0.317
Interaction term	-19302.64 10272.85	0.093
Lincom estimate	5166.821 7021.732	

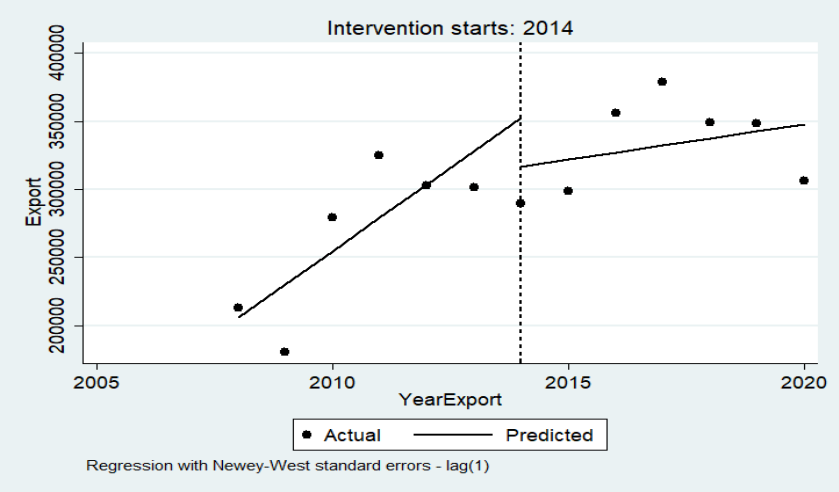

Fig. 11. Overall India (Exports)

3.6.3 Exports

The table presents data on coffee exports, showing that the initial export level was estimated at 205,645.5 tons, with an annual increase of 24,469.46 tons prior to 2014 (Table 15). However, in the first year of the intervention in 2014, there was a notable decline in coffee exports, dropping by 35,693.16 tons. This initial decline was followed by a further significant reduction in the annual export trend, decreasing by 19,302.64 tons per year compared to the pre-intervention period. Despite this initial setback, the Lincom estimate, which accounts for the post-intervention period, indicates that exports began to recover, increasing annually at a rate of 5,166.821 tons after the introduction of the scheme. This suggests that while the intervention

initially led to a sharp decline in exports, there was a positive shift in the export trend in the following years, albeit at a slower growth rate compared to the pre-intervention period. The accompanying figure visually depicts these trends, highlighting the fluctuations in coffee export levels before and after the intervention (Fig. 11). Overall, while the intervention initially disrupted the export trend, it eventually contributed to a moderate annual increase in coffee exports.

4. CONCLUSION

The study aimed to evaluate the impact of the Integrated Coffee Development Project (ICDP) on coffee production, yield, and exports in India, focusing on both traditional and non-traditional coffee-growing areas. The results indicate a mixed impact of the ICDP on coffee cultivation and production in India, with significant variations observed across different regions and time periods. In traditional coffee-producing areas such as Karnataka, Tamil Nadu, and Kerala, the ICDP led to an initial increase in the bearing area, production, and yield in the year of intervention (2014). However, this positive trend was followed by a decline in growth rates for these variables, suggesting that the initial benefits of the scheme were not sustained over time. For instance, while there was a significant increase in production and yield immediately after the scheme's introduction, the subsequent years saw a negative growth trend, indicating challenges in maintaining the momentum generated by the ICDP. This could be attributed to various factors, including unfavourable climatic conditions and inconsistencies in the implementation of the scheme [15]. In non-traditional coffee-producing areas such as Andhra Pradesh, Odisha, and the North Eastern Region (NER), the ICDP's impact was also varied. In Andhra Pradesh and Odisha, the scheme led to an increase in the bearing area and production, although the rate of growth slowed down post-intervention. The NER experienced an initial boost in the bearing area and production in 2014, but this was followed by a decline in both metrics, highlighting the difficulties in sustaining coffee cultivation in these regions. The study also analysed the impact of the ICDP on coffee exports, revealing a complex scenario. The initial year of the scheme saw a significant drop in export levels, which could be linked to disruptions in the supply chain or market dynamics. However, in the subsequent years, there was a moderate recovery in export growth, suggesting that the ICDP may have contributed to stabilizing exports after the initial shock. Nonetheless, the post-intervention growth rate of exports remained lower compared to the pre-intervention period, indicating that the scheme's impact on boosting India's coffee export competitiveness was limited.

In conclusion, the ICDP had a varied impact on coffee production, yield, and exports in India. While it generated short-term gains in traditional and non-traditional coffee-growing areas, the long-term sustainability of these benefits remains questionable. The study underscores the need for continuous support, improved implementation strategies, and addressing regional-specific challenges to enhance the effectiveness of the ICDP and ensure sustained growth in India's coffee sector.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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