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Original Research Article

Impact of Productive Safety Net Program on Household Food Security in Kenna District, Konso Zone, Southern Ethiopia

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Abstract: Chronic food insecurity is one of the problems that has plagued millions of Ethiopians for centuries. To solve this problem, in 2005 the Ethiopian government, in collaboration with development partners, launched a social protection program called the Productive Safety Net Program. This study evaluated the impact of the Productive Safety Net program on household food security in the Konso Zone, Kenna District, Southern Ethiopia. Data were collected from a total of 264 selected households using a multistage sampling procedure. Propensity score matching (PSM) was used to assess program impact on household food security. A logit model was used to analyze potential covariate variables that influence household participation in the Productive Safety Net program. The study found that having livestock, credit, and a large amount of cultivated land had a negative impact on people's willingness to participate in the productive safety net program. Conversely, positively influenced by shock experience and agricultural extension. The Propensity Score Matching (PSM) resulted in matching 125 control households with 130 treated households. In other words, matching comparisons based on outcome variables were performed on these households that shared similar pre-intervention characteristics except for participation in the program. According to the PSM results, the program intervention raised the beneficiary families' total income and calorie intake by 277.31 kcal per capita/AE/Day) and 1789.42 ETB, respectively, as compared to non-beneficiaries. This study demonstrated how the program had a considerable impact on household calorie consumption and income. As a result, the focus of the development intervention should be on linking PSNP support with income-generating activities, vocational training, and credit access; designing labor-intensive public works that build sustainable community assets; regularly assessing PSNP's impact on food security and making timely adjustments.

Keywords: Food Security; Household; Kenna District Productive Safety Net Program; Logit regression; Propensity Score Matching

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1. Introduction

Food security, employment, and global economic growth all depend on the agricultural sector (Alliance for Green Revolution in Africa) (AGRA, 2014). It also serves as the foundation for economic expansion, particularly in the majority of African nations, where it accounts for around 25% of the region's Gross Domestic Product (GDP) (Schaffnit-Chatterjee, 2014). The agricultural industry makes up the lion's share of Ethiopia's overall economic growth. It generates an average of 34.9% of the country's GDP and provides 80 percent of the inhabitants with a living (NBE, 2018).

Despite this, small-scale farmers have historically predominated the sector for generations, and their performance has long been negatively impacted by rain deficit and water scarcity, leaving many of them with food insecurity and relying on humanitarian aid (Abebaw *et al.*, 2015).

The Ethiopian government has implemented many food security measures in response to the issue of food insecurity (FSP) in the last decade and half years. The productive safety net program (PSNP), one of these initiatives, was started in 2005 with the goals of reducing home vulnerability, enhancing community resilience to shock and stress, and ending the cycle of dependence on food aid (MoARD, 2015). While humanitarian aid focuses on individuals experiencing temporary food insecurity, this program has been focusing on those who experience chronic food insecurity.

Public work and direct support clients make up the program's two client categories. A limited percentage (up to 15%) of PSNP participants are direct assistance clients and do not provide labor for public projects. Nonetheless, the majority of the program's clients are engaged in public service projects that help their communities adapt to the effects of climate change and the hazards posed by food poverty. The household's "able bodied" laborers are the main cause of their ongoing food insecurity. It has been in place since 2005, according to the Kenna District Agricultural Office (KWoA, 2019). There are currently 3,769 households in the district who are PSNP clients. The program's projected impact on beneficiary households' daily calorie consumption and total income, which are considered in this analysis as indicators or outcomes of the PSNP, is not well supported by empirical data. Similar to this, research examined the PSNP's effects across the country (for instance, Tadele, 2011; Kassa, 2018; and Gizachew *et al.*, 2017). Yet, the majority of these studies assessed how PSNP affected asset accumulation.

So, the main objective of this study is to evaluate the impact of the Productive Safety Net Program on household food security in Kenna Woreda, Southern Ethiopia.

Specifically, it aims to:

1. To identify factors affecting participation in Productive Safety Net Program; and
2. To evaluate the impact of the Productive Safety Net Program on beneficiary households' food security in the study area.

2. Methodology

2.1. Description of the Study Area

The administrative unit of the study area is located in the Southern Nations, Nationalities, and Peoples Region (SNNPR) of Ethiopia. Kenna Woreda/ District is one of the four Woredas in Konso Zone. The administrative center of the Woreda is Fasha. It is located about 615 km south of Addis Ababa at 5°10'–5°40' N latitude and 37°00'–37°40'E longitude. Geographically, Kenna Woreda is located in the southwest part of the country and within the circle of rift valley. The total land area of the Woreda is 400 square km. The Woreda shares a common boundary with Borena Zone of Oromia Region in the South, Alle Woreda and Weyito River in the West which separates it from the Debub Omo Zone, the Dirashe Woreda in the North, Amaro Woreda in the Northeast, and Burji Woreda in the East (Kenna Woreda office of finance and economic development (KWoFED, 2019).

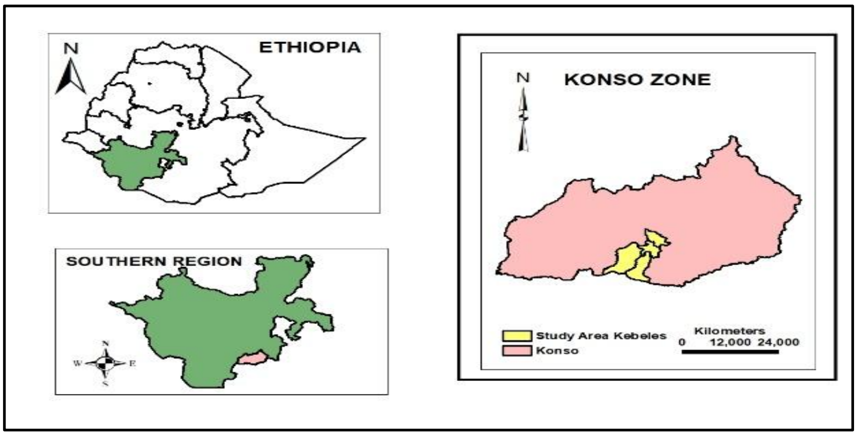

Figure 1. Map of the study area

2.2. Data Collection and Sampling Frame

Multi-stage sampling procedure was employed to collect primary data. In the first stage, out of 10 *kebeles*, four *kebeles* are selected randomly. In the second stage, households from each of the selected *kebeles* categorized into two strata. Stratum 1 represents households that are participating in the PSNP and represents beneficiary groups. Stratum 2 refers to those households who are not selected in the program during community-based selection process and represents the controlled or non-beneficiary groups. Finally, from the four *kebeles*, 264 representative households (132 beneficiary and 132 non-beneficiary) were selected using simple random sampling with probability proportional to size.

To determine the sample size the formula given by Kothari (2004) was used as follows;

$$n = \frac{Z^2 pqN}{e^2(N-1) + Z^2 pq} \quad (1)$$

Where Z is the 95% confidence level under the normal curve (1.96), e is the acceptable error term (0.05), but for these study error term adjusted to six percent to collect cost effective representative sample size. N is the total population and p and q are the proportion of the population participating in PSNP and non-PSNP respectively with 50 percent probability each.

$$n=\frac{(1.96)^2*0.5*0.5*32271}{(0.06)^2(32271-1)((1.96)^2*0.5*0.5)}=264 \quad (2)$$

2.3. Econometric Model Specification

Propensity score matching (PSM) addresses selection bias in Productive Safety Net Program (PSNP) impact evaluations, where program participation is based on vulnerability. PSM, a robust method for impact evaluation, answers the counterfactual question of what would have happened to PSNP participants without the program, effectively mitigating selection bias and contamination issues (White *et al.*, 1999).

The first step in PSM is estimating the propensity score, which can be derived from any binary choice model; this study utilized a logit model. The model used a composite of pre-intervention characteristics of the sample households (Rosenbaum & Rubin, 1983), with participation in PSNP as the dependent variable, valued at 1 for participants and 0 for non-participants. The second step involves selecting an appropriate matching estimator. This study employed commonly used methods such as nearest neighbor matching (NNM), caliper matching (CM), and kernel matching. The choice of the optimal matching algorithm was based on criteria including a high number of insignificant variables after matching, a large matched sample size, a low pseudo-R^2, and low mean standard bias.

The third step in PSM is imposing common support conditions, ensuring that any characteristic combination in the treatment group is also present in the control group (Bryson *et al.*, 2002; Cameron & Trivedi, 2005). Once a common support condition is met, the next step is to perform a balancing test on the propensity score and covariates using the selected matching algorithm. Finally, sensitivity analysis was conducted to assess the impact of unobserved variables.

3. Results and Discussion

3.1. Econometric Model Results

3.1.1. Factors affecting participation in the Productive safety net program

The first step in the PSM is to run the logit/Probit model. This study utilized a binary logistic regression model to identify factors influencing participation in the PSNP. Table 1 displays the logit estimation results regarding factors affecting PSNP participation. The likelihood ratio chi-square of 43.48 with a p-value of 0.000 indicates that the model is statistically significant. The logit regression coefficients represent the change in the Z-score or logit index for a one-unit change in each predictor.

Logit model results indicate that livestock ownership, access to credit, and cultivated land size negatively affect household participation in the PSNP, suggesting that wealthier households are less likely to qualify. Specifically, an additional TLU decreases participation likelihood by 3.61%, access to credit by 13.95%, and each additional hectare of land by 12.26%, consistent with previous research. Conversely, access to agricultural extension services increases participation probability by 28.15%, possibly due to increased awareness. Experiencing shocks also raises participation likelihood by 14.26%, as affected households are more vulnerable and require greater support.

Table 1. Logit model result of household program participation

Covariates	coefficients	Std. Err	ME (dy/dx)	Z-value
Sex of HH head	-0.0317	0 .3804	-0.0079	-0.08
Marital status of HH	0.0437	0.2894	0.0109	0.15
Family size	0.0203	0.0573	0.0050	0.35
Education status	0.0418	0.0250	0.0104	1.67
TLU	-0.1446***	0.0619	-0.0361	-2.34

Covariates	coefficients	Std. Err	ME (dy/dx)	Z-value
Education status	-0.3010	0.2968	-0.0751	-1.01
Non-farm income	-0.0002	0.0001	-0.0000	-1.12
Agricultural extension	1.1592***	0.2851	0.2815	4.07
Credit service	-0.5620**	0.2783	-0.1395	-2.02
Cultivated land size	-0.4906**	0.2138	-0.1226	-2.29
Irrigation access	-0.3148	0.2931	-0.0785	-1.07
Distance to the market	-0.0419	0.0422	-0.0104	-0.99
Shock experience	.05748**	0.2754	0.1426	2.09
Constant	-0.857	1.2041		-0.71
Logistic regression	Sample size	= 264	Prob > chi2	= 0.000
	LR chi2(13)	= 43.48	Pseudo R^2	= 0.1188
Log likelihood =	-161.2490			

Source: Own computation results (2023)

3.1.2. Imposing the common support region

The next step in propensity score matching is to verify the common support condition. Only observations within the common support region can be matched with the other group; those outside this region should be excluded. Once defined, individuals outside the common support cannot be included in the treatment effect estimation.

As shown in Table 2, the estimated propensity scores range from 0.1604 to 0.8799, with a mean of 0.5761 for treatment households, and from 0.0821 to 0.8496, with a mean of 0.4239 for control households. Indicating sufficient overlap in the distribution of propensity scores between treatment and control group that crucial for ensuring comparability and for the validity of the propensity score matching (PSM) technique. Therefore, the common support interval lies between 0.1604 and 0.8496. Due to this restriction, 12 households (10 control and 2 treatment) are removed from the analysis.

Table 2. Estimated propensity score distribution

Household	Observation	Mean	Std. dev	Minimum	Maximum
Total household	264	0.5	0.1968	0.0821	0.8799
Treatment households	132	0.5761	0.1684	0.1604	0.8799
Control households	132	0.4239	0.1942	0.0821	0.8496

Note that Std. dev stands for standard deviation

Source: own computation results (2023)

Afterward, common support was assessed by plotting a histogram of the propensity scores. Figure 2 displays the frequency distribution of propensity scores for the treatment and control groups of PSNP, indicating a substantial overlap and suggesting that a serious common support problem is absent.

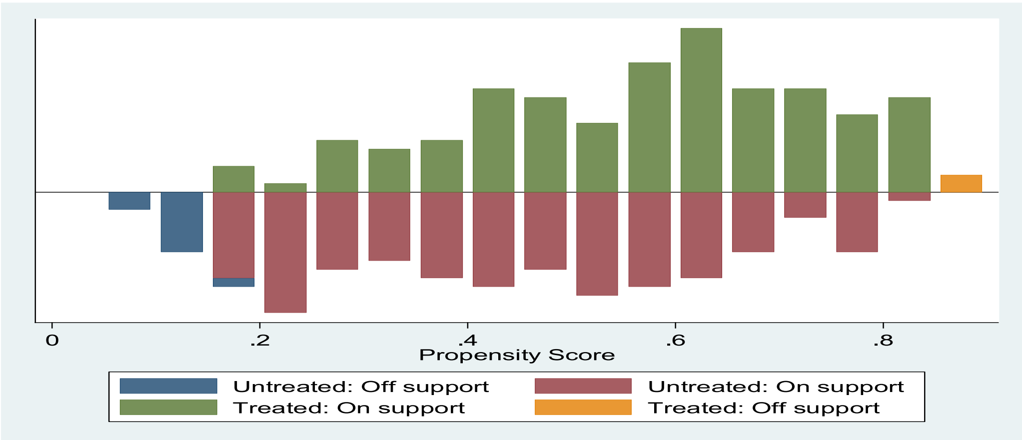

Figure 2. Histogram of the propensity score estimation distribution for the treatment and control groups of PSNP.

3.1.3. Choosing a matching estimator

Different alternatives of matching estimators were conducted to match the beneficiary and non-beneficiary households fall in the common support region. In this study, the best matching algorithm chosen is the one with large-matched sample size, large number of insignificant variables after matching, small pseudo-R2 after matching and small mean standardized bias. Results presented in Table 3 indicate that kernel matching estimator with bandwidth of 0.1 is the best matching estimator satisfying all the four criteria listed above Kernel matching has an advantage of lower variance because more information is used (Heckman *et al.,* 1998).

Table 3. Comparison of the four matching estimators by performance criteria

	Performance criteria			
Matching Estimators	balancing test*	Pseudo R^2	matched sample size	Mean SB
Matching Nearest Neighbor				
With replacement	9	0.048	252	12.6
Without replacement	12	0.067	244	14.7

Matching Estimators	balancing test*	Pseudo R^2	matched sample size	Mean SB
Caliper matching				
0.1	9	0.048	252	12.6
0.25	9	0.048	252	12.6
0.5	9	0.048	252	12.6
0.8	9	0.048	252	12.6
Kernel matching				
Bandwidth 0.1	13	0.006	252	3.5
Bandwidth 0.25	13	0.017	252	5.9
Bandwidth 0.5	11	0.044	252	11.7
Bandwidth 0.8	11	0.072	252	15.6

Source: own computation result (2023)

* Note: Number of covariate variables with no statistically significant mean differences between of beneficiary and non-beneficiary households.

3.1.4. Balance test for propensity score and covariates

After choosing the best performing matching algorithm, the next mission is to check the balancing of propensity score and covariates using various steps by applying the selected matching algorithm.

Accordingly, the output of the balancing test (Table 4) shows two rows for each covariate variables unmatched represented by "U" and matched represented by "M", that is before matching and after matching mean for covariate, "% bias", % reduction in bias, and t-test for treatment and control group. The fifth and sixth columns of (Table 4) show the mean standardized bias before and after matching and total bias reduction obtained by the matching procedures, respectively. The standardized difference in covariates before matching is in the range of 3.7 percent and 45.2 percent in absolute value. After matching, the remaining standardized difference of covariate for all covariates lies between 0.2 percent and 1.2 percent, which by far below critical level of 20 percent suggested by Rosenbaum and Rubin (1985). In all cases, it is evident that sample differences in the unmatched data significantly exceed those of matched cases. Therefore, the process of matching thus creates a high degree of covariate balance between the treatment and control samples that are ready to use in the estimation procedure.

Moreover, t-value obtained in (Table 4) shows that before matching five covariates from the thirteen-exhibited statistically significant difference, whereas all of the covariates balanced after matching.

Table 4. Results of the Balancing Test of Covariates and Pscore Using the Kernel Matching Estimator

		Mean		Standardized bias		T-value	
Covariates	Sample	Treated	Control	%bias	%Reduction	T	P>|t|
Propensity	U	.57611	.42389	83.7		6.80	0.000
Score	M	.5714	.56386	4.2	95.0	0.3	0.707
Sex of HH head	U	.73485	.75758	-5.2		-0.42	0.673
	M	.74615	.7729	-6.1	-17.9	-0.50	0.615
Marital status of	U	1.2197	1.1894	5.4		0.44	0.662
HH	M	1.2077	1.2172	-1.7	68.6	-0.13	0.896
Family size	U	7.8106	7.7197	3.7		0.30	0.765
	M	7.8538	7.7767	3.1	15.1	0.25	0.801
Age of HH head	U	39.394	38.394	17.1		1.39	0.165
	M	39.392	38.978	7.1	58.6	0.57	0.572
TLU	U	2.3671	2.8967	-23.8		-1.93*	0.054
	M	2.3938	2.2683	5.6	76.3	0.47	0.637
Education status	U	.53788	.62879	-18.4		-1.50	0.135
	M	.54615	.55778	-2.4	87.2	-0.19	0.851
Non-farm -	U	946.8	1084.2	-14.3		-1.16	0.245
Income	M	956.75	998.43	-4.3	69.7	-0.38	0.704
Agricultural-	U	.66667	.44697	45.2		3.67***	0.000
Extension	M	.66154	.65062	2.2	95.0	0.18	0.854
Credit service	U	.47727	.61364	-27.5		-2.24**	0.026
	M	.48462	.52811	-8.8	68.1	-0.70	0.485
Cultivated land	U	.84848	1.0492	-28.5		-2.34***	0.020
Size	M	.85192	.85192	1.2	95.9	-0.11	0.915
Irrigation access	U	.37879	.44697	-13.8		-1.12	0.262
	M	.38462	.37764	1.4	89.8	0.12	0.908

	Mean			Standardized bias		T-value	
Covariates	Sample	Treated	Control	%bias	%Reduction	T	P>|t|
Distance to the-	U	6.6061	7.1288	-16.0		-1.30	0.196
Market	M	6.5923	6.5923	-0.2	99.0	-0.01	0.990
Shock-	U	.58333	.4697	22.8		1.85*	0.065
Experience	M	.57692	.58339	-1.3	94.3	-0.11	0.916

Source: own computation result (2023)

Note: ***, ** and* means significant at 1%, 5% and 10% probability level, respectively; U-Unmatched, M-Matched, HH, TLU, stand for Household Head And tropical livestock unit.

Table 5. Chi-square test for the joint significance test of covariates

Sample	Pseudo R^2	LR chi^2	P>chi^2
Unmatched	0.125	45.85	0.000
Matched	0.006	2.27	1.000

Source: own computation result (2023)

All of the above tests suggest that the matching algorithm, which has chosen, is relatively the best estimator for the data we have at hand. Thus, we can proceed to estimate ATT for households.

3.1.5. Estimating treatment effect on treated

The results in Table 6 indicate a statistically significant impact of the program on calorie intake and total household income. After adjusting for pre-intervention differences between PSNP beneficiaries (treatment) and non-beneficiaries (control), the analysis revealed that PSNP participation increased average calorie intake by 277.31 kcal/AE/Day and total household income by 1789.42 ETB. Similar findings were reported by Hermela (2015), Abduselam (2017), Melkamu and Mesfin (2015), Nesreddin (2014), and Yitagesu (2014). However, Tadele (2011) and Habtamu (2011) found a negative effect of PSNP on the calorie intake of beneficiary households. Additionally, Waleign *et al.* (2019) noted an insignificant, yet positive effect of PSNP on the food security of beneficiary households.

Table 6. The result of average treatment effect on treated (ATT)

Outcome variables	Treated	Control	Difference	Std.err	T-value
Per capital Daily Calorie intake	2225.80	1948.49	277.31	121.59	2.28**
Household total income in birr	7076.15	5286.72	1789.42	666.38	2.69***

Note: ***and** means significant at 1% and 5% probability level.

Source: Own computation result (2023)

3.1.6. Sensitivity analysis

Table 7 and 8 below provide the result of the sensitivity analysis of the significant outcome variable per capital daily calorie intake and total household income. The result showed that the PSNP estimators ATT are insensitive to the unobserved election bias and the pure effect of the PSNP participation on the outcomes variables.

Table 7. Sensitivity analysis of outcome variable (calorie intake) after matching by Rosenbaum bound (rbound)

P-critical (the upper bound of wilcoxon significant level (Sig^+) at different critical value of Gamma(e^y)									
Outcome	ey=1	ey=1.25	Ey=1.5	Ey=1.75	Ey=2	Ey=2.25	E*y=2.5*	E*y=2.75*	E*y=3*
Kcal/AE	P<0.00	0	0	0	0	0	0	2.2e-	16

Table 8. Sensitivity analysis of outcome variable (Total household income) after matching by Rosenbaum bound (rbound)

P-critical (the upper bound of wilcoxon significant level (Sig^+) at different critical value of Gamma(e^y)									
Outcome	ey=1	ey=1.25	Ey=1.5	Ey=1.75	Ey=2	Ey=2.25	E*y=2.5*	E*y=2.75*	E*y=3*
Kcal/AE	P<0.00	0	0	0	0	0	0	2.2e-	16

4. Conclusion and Recommendation

This study has used cross-sectional data from the Kenna District of Konso Zone to examine the impact of the productive safety net on households' food security. The logit model results show that household participation in PSNP was positively influenced by agricultural extension and shock experiences while negatively influenced by livestock holding, credit service, and cultivated land.

The Average Treatment Effect (ATT) is calculated based on the selected matching algorithm. The results indicate that participation in program increased *beneficiary households' calorie intake and total income by 277.31 kcal per capital /AE/Day and 1789.42 ETB, respectively* Consequently, development interventions should focus on: improving beneficiary identification accuracy to reach the most food-insecure households; linking PSNP support with income-generating activities, vocational training, and credit access; designing labor-intensive public works that build sustainable community assets; regularly assessing PSNP's impact on food security and making timely adjustments; and engaging local communities in program design, planning, and implementation to enhance participant benefits. Given the program's broad reach and substantial resource allocation, this study's conclusions about its national impact are unreliable. Further research with larger, geographically diverse samples is needed to produce credible findings on the program's effects on food security, representing a key area for future investigation.

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