Examining Human Capital Dynamics and Determinants among Rural Ethiopian Crop Producers and Pastoralists: A Comparative Analysis

Ketema Bekele[1*], Kedir Jemal[1]

[1]School of Agricultural Economics and Agribusiness, Haramaya University, P.O. Box 138, Dire Dawa, Ethiopia

ORCID

Ketema Bekele http://orcid.org/0000-0002-8107-4807

*Corresponding author

Contents

ABSTRACT

This study explores human capital dynamics in Ethiopia by comparing crop producers and pastoralists, using data from the Living Standards Measurement Study (LSMS) for 2015 and 2017. The analysis reveals that crop producers average 3.82 years of education versus 3.27 years for pastoralists. Although pastoralists spend more on education per capita (0.41 thousand Birr vs. 0.30 thousand Birr), this difference is not statistically significant, possibly due to higher education costs and limited access in pastoralist regions. Health metrics show improvements linked to income increases: crop producers' absenteeism due to health issues dropped from 9.75 to 3.38 days, while pastoralists' decreased from 10.43 to 5.06 days. Income analysis reveals that pastoralists earn more from livestock (7.07 thousand Birr) compared to crop producers (0.97 thousand Birr), but crop producers have higher income from crops (12.01 thousand Birr vs. 7.23 thousand Birr), resulting in a higher total income per capita for crop producers (4.36 thousand Birr) compared to pastoralists (3.30 thousand Birr). This disparity is attributed to technological advancements and better market access for crop producers. Nutritional indicators also show significant disparities: pastoralist children have poorer outcomes, with higher rates of stunting and underweight compared to crop producers. Despite improvements, high levels of malnutrition persist in pastoralist communities. The fixed effects model highlights that human capital (coefficient of 0.0945) and age (coefficient of 0.307) positively impact rural income. Household size has a moderate positive effect (coefficient of 0.0551), and livestock unit is strongly associated with rural income (coefficient of 0.0466). However, the interaction term shows a significant negative effect, suggesting combined variable influences can diminish rural income. The random effects model indicates a significant negative impact of household size (coefficient of -0.0616) and a positive effect of the log of income (coefficient of 0.037) on human capital. The study concludes that targeted interventions are needed to address these disparities. For pastoralists, improving educational access, integrating traditional and modern education, and investing in healthcare and infrastructure are essential. For crop producers, continued investment in agricultural education and technology is crucial. A comprehensive strategy to enhance healthcare, education, infrastructure, and economic stability is vital for equitable and sustainable development across Ethiopia's rural communities.

Keywords: Human capital, agricultural income, educational investment, health metrics, livelihood disparities, pastoralism

1. INTRODUCTION

Human capital development is a fundamental driver of socio-economic progress, particularly in rural settings of developing countries like Ethiopia (Šlaus and Jacobs, 2011; Hippe, 2014; Ali et al., 2018). The concept, which includes education, skills, and health, is crucial for enhancing agricultural productivity and ensuring economic stability (Schultz, 2003; Abraham and Mallatt, 2022; Barrett and Beegle, 2023; Mrabet, 2023). Recent literature indicates substantial variations in human capital dynamics across different livelihood systems, such as crop production and pastoralism, which influence agricultural outcomes and income levels in distinct ways (Wu et al., 2017; Smith and Subandoro, 2022). In Ethiopia, where agriculture is a predominant economic activity, understanding how human capital dynamics differ between crop producers and pastoralists is essential for crafting effective policies and promoting equitable growth.

Human capital theory suggests that investments in education and health create a more skilled and healthier workforce, which in turn enhances productivity and fosters economic growth (Becker, 2009; Schultz, 2003; Hannum and Buchmann, 2005; Hippe, 2014). Research indicates that higher levels of education contribute to increased GDP per capita by improving the workforce's ability to adopt and implement new technologies (Mankiw et al., 1992; Hannum and Buchmann, 2005). Nonetheless, the relationship between human capital and economic growth is context specific, complex and can be influenced by various factors such as institutional quality and economic policies (Rodrik et al., 2004; Ali et al., 2018). Additionally, the quality of education is often considered more critical than mere educational attainment for driving economic growth (Hanushek and Wößmann, 2007).

In Ethiopia, disparities in human capital development between crop producers and pastoralists reflect broader socio-economic inequalities. Pastoralists frequently encounter lower educational attainment, limited access to healthcare, and insufficient vocational training, which adversely affect their productivity and economic stability (Gemedo-Dalle et al., 2006; Catley and Aklilu, 2013; Tofu et al., 2023). In contrast, crop producers, who benefit from more stable living conditions, generally have better access to educational and health resources, contributing to higher productivity and economic stability (Tesema and Berhanu, 2018; Fentie et al., 2023).

Despite Ethiopia's impressive economic growth, averaging 9.8% annually from 2008/09 to 2018/19 (Mengesha and Singh, 2023), the benefits have not been evenly distributed. Limited public investment in education and health has constrained human capital development, particularly affecting the labor sector and exacerbating economic disparities (Becker, 2009; Bareke et al., 2023). The Ethiopian Ten-Year National Strategic Plan (2020-2030) highlights the importance of enhancing technological adoption and human capital development in achieving sustainable development goals and boosting agricultural productivity (Satriawan and Swinton, 2005; Tesema and Berhanu, 2018; Fentie et al., 2023).

Given the critical role of human capital in economic growth and the observed disparities between livelihood systems, this study aims to investigate the dynamics of human capital among rural Ethiopian crop producers and pastoralists through a comparative analysis. It seeks to understand how human capital is developed and utilized within these two distinct livelihood systems by examining its evolution, its relationship with agricultural income, and the key determinants influencing its development. The study is guided by several key hypotheses. First, it is hypothesized that household human capital development differs significantly between crop producers and pastoralists in rural Ethiopia, reflecting distinct livelihood strategies and access to resources (Catley and Aklilu, 2013; Tesema and Berhanu, 2018). Second, there is an expectation of a positive correlation between human capital investment and agricultural income, suggesting that enhanced human capital leads to better economic outcomes (Mankiw et al., 1992; Schultz, 2003; Barrett et al., 2019). Lastly, the study hypothesizes that the determinants of household human capital development vary between crop producers and pastoralists, indicating that different factors influence human capital development in each livelihood base, necessitating tailored policy interventions (Gemedo-Dalle et al., 2006; Attanasio et al., 2020). By addressing these hypotheses, the research aims to provide insights into effective strategies for promoting balanced rural development and enhancing human capital across Ethiopia’s diverse livelihood systems (Šlaus and Jacobs, 2011).

2. METHODOLOGY

2.1. Data Source

This study utilized data from the Living Standards Measurement Study (LSMS), a comprehensive survey series conducted by the World Bank in collaboration with the Central Statistical Agency, covering two datasets from 2015 and 2017 (World Bank, 2020).

2.2. Data Description

The LSMS provides detailed insights into living standards, including household characteristics, community infrastructure, agricultural practices, and livestock management (Jolliffe and Banerjee, 2015). The survey comprises five modules: Household Characteristics, Community Information, Post-Planting, Post-Harvesting, and Livestock, which together offer a comprehensive view of socio-economic conditions at both household and community levels (CSA, 2019).

2.3. Data Collection and Study Areas

Data collection encompassed both rural and urban areas across all regional states of Ethiopia, including the Addis Ababa City Administration (World Bank, 2020). For this study, the focus was on rural areas with crop producing and pastoralist households. Pastoralist regions included the Afar and Somali regions, where approximately 80-90% and 60-70% of the populations, respectively, engage in pastoralism due to arid and harsh climatic conditions (World Bank, 2020; Jolliffe and Banerjee, 2014). Conversely, crop producing areas included the Amhara and Oromia regions. In Amhara, about 70-80% of the population is involved in crop production, benefiting from fertile highland soils (CSA, 2019). Oromia, with diverse agro-ecological zones, supports around 60-70% of its population in crop production agriculture (World Bank, 2020).

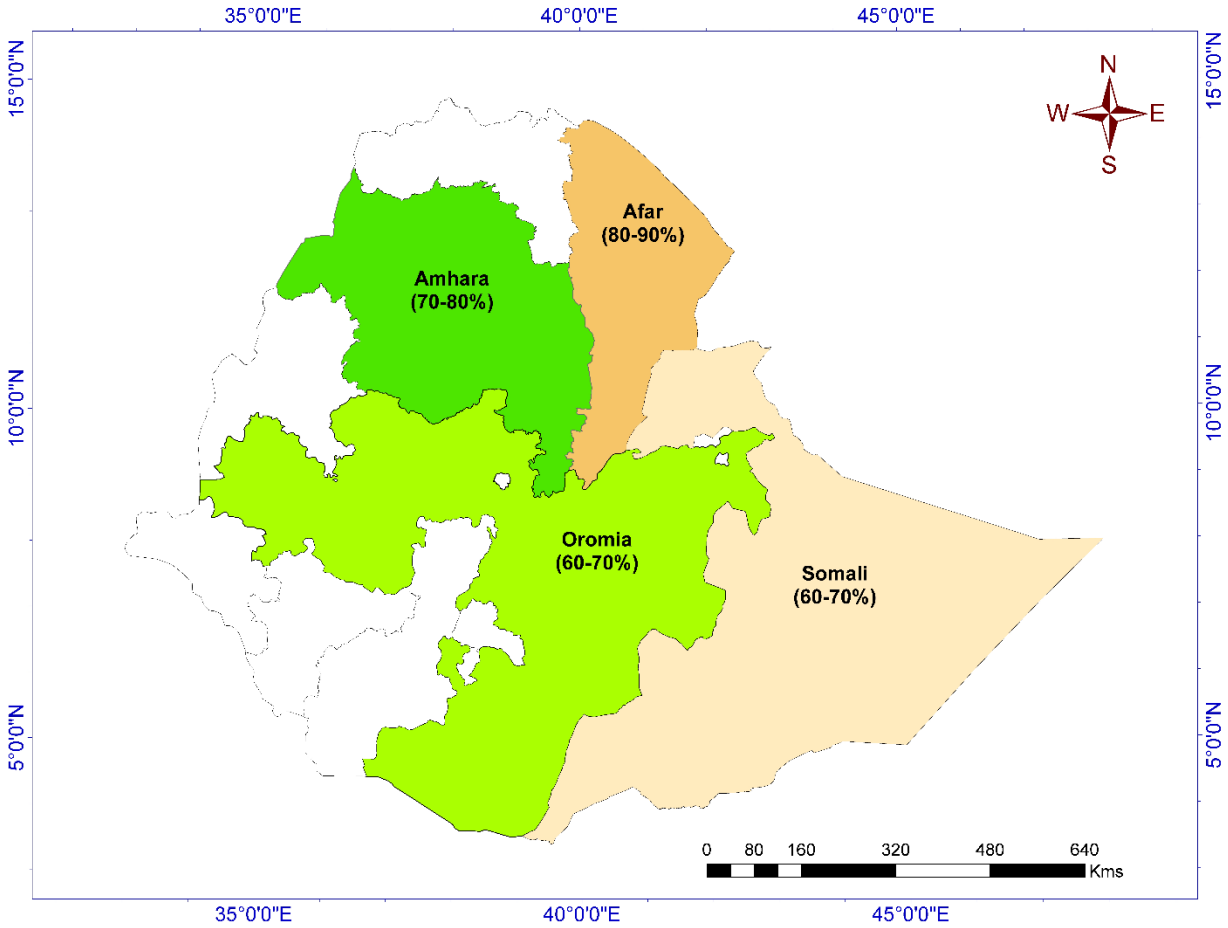

Figure 1: Map of the study area

2.4. Analytical Framework

To analyze the LSMS data, the study integrated datasets from the 2015 and 2017 surveys, harmonizing them to account for variations in survey instruments and methodologies (Jolliffe and Banerjee, 2015). The analysis involved both descriptive and econometric methods. Descriptive statistics were used to summarize key variables, while advanced econometric models, specifically panel data models, were employed for a more detailed analysis (Wooldridge, 2002). Qualitative insights were also incorporated where available to provide additional context. Results were compared across the two survey waves (2015 and 2017) to ensure consistency and accuracy (Hox and Bechger, 1998). This comprehensive approach aimed to offer a subtle understanding of living standards and the factors influencing them across different regions and time periods.

2.5. Method of Data Analysis: Econometric Model Specification

The data analysis for this research project included simple descriptive statistics and panel data econometric techniques. To estimate the level of human capital and explore the dynamics among different livelihoods, descriptive statistics were used. In addition to simple descriptions, the study examined how various aspects of human capital related to different factors. To understand the contribution of these factors in determining human capital, panel data modeling was employed. For addressing the second and third objectives, a panel data model was utilized. The following model was estimated to capture the effect of human capital on agricultural income in Ethiopia:

$$Y_{it} = \omega + X'_{it}\delta + \phi H_{it} + c_i + \upsilon_{it}$$

where Y_{it} denotes household income, measured in natural log, from crops, livestock, and non-farm activities. The constant is ω, and X'_{it} includes time-varying variables affecting income, such as access to credit, household size, socio-economic factors (TLU), human capital (indexed by education, health, and agricultural extension), land cultivated, and environmental and market shocks (shock index from principal component analysis). δ and φ are parameters to estimate. C_i represents household-specific effects, and υ_{it} is the error term, assumed to have zero mean.

Panel data models were estimated using three primary methods: pooled Ordinary Least Squares (OLS), fixed effects, and random effects models. Pooled OLS assumed homogeneity among individuals, treating all observations as if they came from a single group. While this simplified the analysis, it overlooked individual heterogeneity, which could lead to misleading conclusions. In contrast, the fixed effects method accounted for unobserved heterogeneity by controlling for omitted variables that might affect household earnings. If these unobserved factors were uncorrelated with the other explanatory variables, it was acceptable to capture them in the error term. However, if they were correlated with any explanatory variables, ignoring them could result in inconsistent parameter estimates (Wooldridge, 2002). The random effects and fixed effects models, on the other hand, assumed individual heterogeneity. Ultimately, the choice between these methods was guided by rigorous hypothesis testing to determine the most appropriate model for the data.

Similarly, to address the objective of identifying the determinants of human capital, the panel data model was deemed suitable given the longitudinal nature of the data. Human capital was measured using education, health for adults, and agricultural extension. Human capital among rural residents was influenced by various factors, including parental background and individuals' attitudes. The panel data model was employed to identify the determinants of human capital across different livelihoods, accounting for individual heterogeneity. The panel data provided the basis for this analysis.

$$H_{it} = \alpha + X'_{it}\beta + Z'_{i}\gamma + c_i + \upsilon_{it}$$

where H_{it} is the dependent variable representing human capital, measured by index from adult education, access to agricultural extension services and household health. The constant term is α, and X_{it} includes time-varying explanatory variables like parental education, household size, economic status (agricultural wealth index), and institutional environment. Z'_i represents time-invariant variables affecting human capital. Parameters $ß$ and γ are to be estimated, with C_i as the individual-specific effect and υ_{it} as the error term.

Estimator Selection

The choice of estimator in panel data analysis involved a two-step hypothesis testing procedure. The first step examined whether to use a pooled Ordinary Least Squares (OLS) model, which assumed that all households shared the same characteristics, or to adopt a model that accounted for heterogeneity among households. This assessment was conducted using the Breusch-Pagan Lagrange Multiplier test. This test evaluated the null hypothesis that there were no panel effects against the alternative hypothesis that such effects existed. When the test rejected the null hypothesis, it indicated that the pooled OLS model was inappropriate, suggesting that models accounting for heterogeneity, such as fixed effects or random effects models, were more suitable.

The second step involved determining whether there was a significant difference between the fixed effects and random effects estimators. This comparison was conducted using the Hausman test. If the result of this test was significant, it indicated that the fixed effects model was preferred over

the random effects model. Conversely, if the test was not significant, the random effects model was deemed more appropriate.

3. RESULTS

3.1. Descriptive Results

3.1.1 Household characteristics and labor investment

Household characteristics and labor investments further illustrate the differences between pastoralists and crop producers. Pastoralist households are larger, averaging 6.22 members compared to 5.55 members in crop producing households, with this difference being statistically significant (t-value = 5.91). The average age of household heads is slightly higher among pastoralists, at 47.12 years, compared to 46.99 years for crop producers, though this difference is marginally significant (t-value = -2.15). Crop producers utilize significantly more cultivated land, averaging 1.40 hectares compared to 0.31 hectares for pastoralists, with this difference being highly significant (t-value = -6.35). Furthermore, crop producers invest substantially more in agricultural labor, averaging 715.33 hours and 89.42 man-days, while pastoralists contribute only 103.94 hours and 12.99 man-days, with both differences being highly significant (t-values = -29.56). The cost of labor is also markedly higher for crop producers, averaging 6.05 thousand Birr compared to 1.06 thousand Birr for pastoralists, reflecting a significant financial commitment (t-value = -29.65). Additionally, the proportion of male household heads is slightly higher among pastoralists (77%) compared to crop producers (75%), though this difference has not been quantified for statistical significance.

3.1.2 Income and economic differences

The comparison between pastoralists and crop producers reveals notable differences in income and economic activities. Pastoralists earn a significantly higher average income from livestock, averaging 7.07 thousand Birr, compared to only 0.97 thousand Birr for crop producers. However, the variability in pastoralists' income is considerably higher, ranging from 0 to 145.99 thousand Birr, and this difference in income is not statistically significant (t-value = 0.84). In contrast, crop producers achieve substantially higher income from crops, with an average of 12.01 thousand Birr compared to 7.23 thousand Birr for pastoralists. This discrepancy is statistically significant (t-value

= -2.92). Additionally, crop producers have a higher mean total income per capita, averaging 4.36 thousand Birr compared to 3.30 thousand Birr for pastoralists, which is also statistically significant (t-value = -3.35). Pastoralists manage a significantly higher average of 8.36 Tropical Livestock Units (TLU) compared to 4.54 for crop producers (t-value = 9.98), underscoring their greater reliance on livestock.

3.1.3 Education and health expenditure

Differences in educational attainment and expenditure also highlight the disparities between the two groups. Crop producers have an average education level of 3.82 years, higher than the 3.27 years for pastoralists, with this difference being statistically significant (t-value = -3.68). Despite this, pastoralists spend more per capita on education, averaging 0.41 thousand Birr compared to 0.30 thousand Birr for crop producers, though this difference is not statistically significant (t-value = 1.81). In terms of healthcare, pastoralists allocate slightly more resources, with an average expenditure of 7.92 thousand Birr compared to 6.67 thousand Birr for crop producers. This difference is marginally significant (t-value = 1.93), reflecting a trend where pastoralists invest slightly more in health services. Maternal education levels are similar across both groups, with averages of 0.15 years for pastoralists and 0.12 years for crop producers, showing no significant difference (t-value = 0.67).

Table 1: Comparative analysis of socioeconomic variables between crop producer and pastoralist households

Characteristics	**Pastoralists (N = 637)**				**Crop Producers (N = 2659)**				
	Mean	**SD**	**Min**	**Max**	**Mean**	**SD**	**Max.**	**Min.**	**t-value**
Income from Livestock (in '000 Birr)	7.07	0.60	0	145.99	0.97	1.22	3200	0	0.84
Income from Crop (in '000 Birr)	7.23	0.42	0	149.59	12.01	0.79	1800	0	-2.92**
Total Income Per Capita (in '000 Birr)	3.30	0.19	0.006	60.75	4.36	0.25	400	0	-3.35***
Education	3.27	0.12	0	19	3.82	0.05	18	0	-3.68***
Education EXP (in '000 Birr)	0.41	0.04	0	9.35	0.30	0.02	13.70	0	1.81
Health	7.92	0.70	0	90	6.67	0.30	100	0	1.93
TLU[1]	8.36	0.47	0	65.79	4.54	0.10	78.25	0	9.98***
Age	47.12	0.68	20	20	46.99	0.32	99	8	-2.15
HH Size	6.22	0.12	1	16	5.55	0.05	15	1	5.91***
Mother Education	0.15	0.04	0	9	0.12	0.02	14	0	0.67
Sex (% of male HH head)	77	-	-	-	75	-	-	-	-
Cultivated Land	0.31	0.02	0	7.48	1.40	0.17	426.51	0	-6.35***
labour_input_hrs_agriculture	103.94	7.37	0	1452	715.33	19.33	17476	0	-29.56***
labour_mans_day	12.99	0.92	0	181.5	89.42	2.42	2184.5	0	-29.56***
own_labour_cost (in '000 Birr)	1.06	0.07	0	8.75	6.05	0.15	115.20	0	-29.65***

[1] Tropical Livestock Unit (TLU) is a hypothetical animal equals to 250 kg body weight. It is used to bring different animal species under a common denominator. Standard conversion factors for different animal species are Camels = 1.0; Cattle = 0.7; Sheep and goats = 0.1.

3.1.4 Trends in income and human capital development over time

Changes in income across livelihood regions

The analysis of income data between the two waves reveals significant trends for both pastoralist/agro-pastoralist and sedentrized crop producing regions, as depicted in Figure 1. Both regions experienced an increase in average incomes from livestock and crop production. Notably, crop producing regions showed more substantial growth compared to pastoralist/agro-pastoralist regions. Specifically, income from livestock in crop producing regions surged by 281.08%, whereas in pastoralist/agro-pastoralist regions, it increased by 88.83%. Similarly, income from crop production grew by 66.58% in crop producing regions, compared to a 35.12% increase in pastoralist/agro-pastoralist regions.

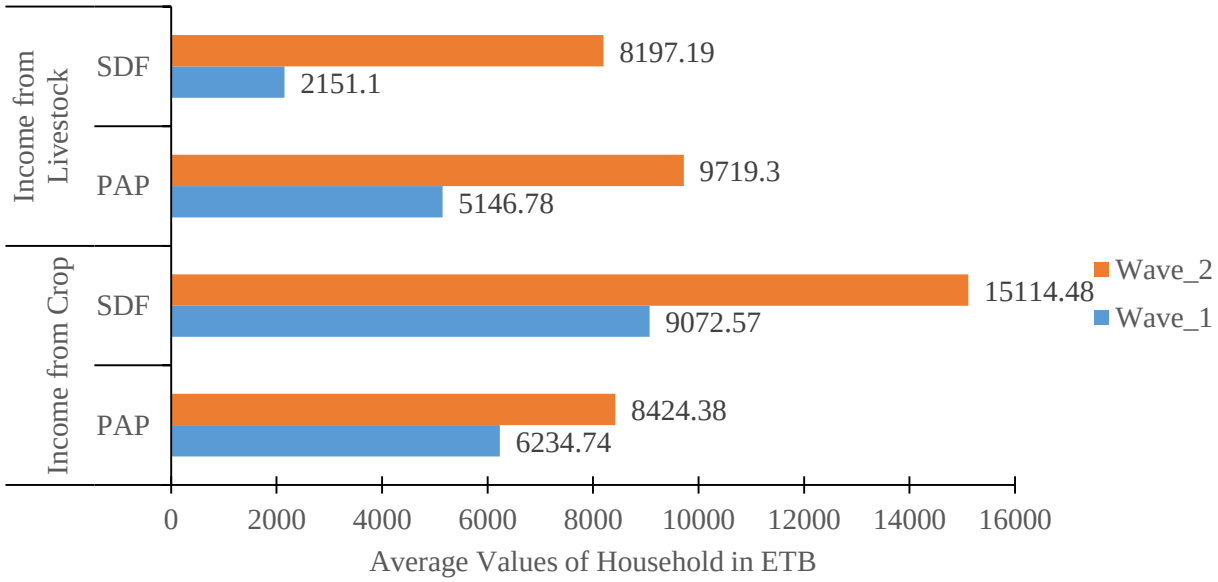

Figure 2: Average annual incomes from different sources by wave. Note that SDF = sedentrized crop producers and PAP = pastoralists and agro-pastoralists; Pastoralists (N = 637) Crop Producers (N = 2659); Wave_1 = data from 2015 and Wave_2 = data from 2017

Impact on human capital development

The effects of rising incomes on human capital development indicators varied, as depicted in Figure 2. There was no significant improvement in educational attainment across either region. However, health-related metrics showed notable progress. In sedentary crop producing regions,

the average number of days households were absent from agricultural work due to health issues decreased significantly from 9.75 days to 3.38 days. In pastoralist/agro-pastoralist regions, absenteeism due to health reasons reduced from 10.43 days to 5.06 days. These results highlight that while income levels have increased in both regions, the improvements in educational outcomes were limited, with the most significant advancements observed in reducing health-related work absences.

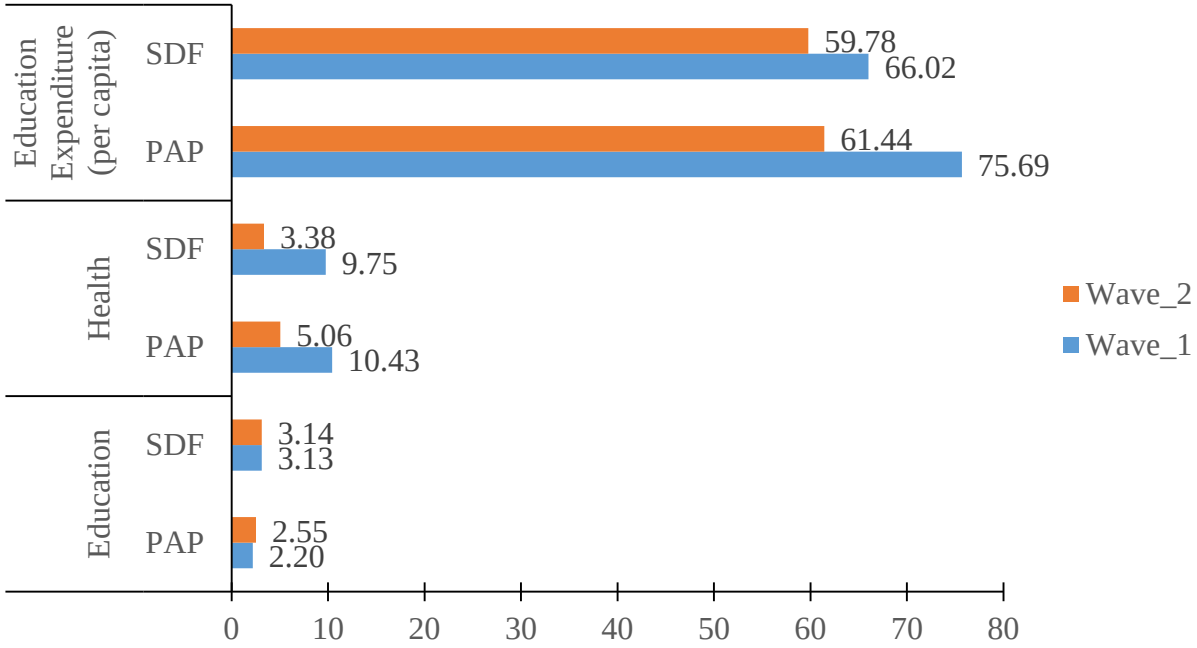

Figure 3: Average education level and health absentee from work by wave, Note that SDF = sedentrized crop producers and PAP = pastoralists and agro-pastoralists; (N = 637 for PAP) (N = 2659 for SDF)

3.1.5 Child nutritional status

Anthropometric measurements are essential for evaluating human capital, offering valuable insights into health and nutritional status, which significantly affect individual productivity. For children under five, key indicators such as stunting, underweight, and wasting are particularly important. These indicators impact not only individual well-being but also broader societal productivity. Poor nutrition during early childhood can impair physical and cognitive development, leading to long-term consequences for both individuals and their communities.

This study analyzed anthropometric indicators using data from the Living Standards Measurement Study (LSMS) for the years 2015 and 2017, applying the World Health Organization (WHO) reference standards from 2006. The analysis uncovered significant disparities in child health and nutritional status between crop producing and pastoralist communities in Ethiopia. These differences, detailed in Table 2 and illustrated in Figures 4 to 6, highlight the varying levels of nutritional outcomes across these two agricultural contexts.

In crop producing areas, the mean Height-for-Age Z-score (HAZ06) was -1.52, with 43% of children falling below -2 standard deviations (SD), indicating notable stunting. The mean Weight-for-Age Z-score (WAZ06) was -1.15, with 22% of children below -2 SD, reflecting underweight issues, though less severe than stunting. The Weight-for-Height Z-score (WHZ06) had a mean of -0.45, with only 11% of children below -2 SD, indicating a lower prevalence of wasting.

Table 2: Summery statistics for child anthropometric indicators in Ethiopia; Source: Authors Computation; *HAZ06: is Height for Age Z-score WAZ: weight for age Z-Score and WHZ: weight for height Z-score with 2006 reference

Variables		Mean	SD	% below -2 SD		Observation
				2015	2017	
		Crop-Producers				
HAZ06	Overall	-1.52	1.65	43	37	N=1454
	Between		1.31			n=727
	Within		1.00			T=2
WAZ06	Overall	-1.15	1.14	22	20	N=1454
	Between		0.95			n=727
	Within		0.61			T=2
WHZ06	Overall	-.41	1.32	11	10	N=1454
	Between		1.04			n=727
	Within		0.84			T=2
		Pastoralists				
HAZ06	Overall	-1.60	1.71	45	38	N=178
	Between		1.34			n=88
	Within		1.06			T=2
WAZ06	Overall	-1.51	1.07	35	29	N=178
	Between		0.88			n=88
	Within		0.61			T=2
WHZ06	Overall	-.86	1.29	21	19	N=178
	Between		0.92			n=88
	Within		0.91			T=2

In contrast, children in pastoralist communities faced more pronounced nutritional challenges. The mean HAZ06 for pastoralists was -1.60, with 45% falling below -2 SD, showing a higher rate of stunting compared to crop producers. The mean WAZ06 was -1.51, with 35% below -2 SD, indicating a greater prevalence of underweight. The WHZ06 for pastoralists had a mean of -0.86, with 21% of children below -2 SD, demonstrating a higher rate of wasting.

In 2015, 43% of children in crop producing areas were stunted, 22% were underweight, and 12% were wasted. In pastoral areas, the rates were higher, with 45% stunted, 35% underweight, and 22% wasted.

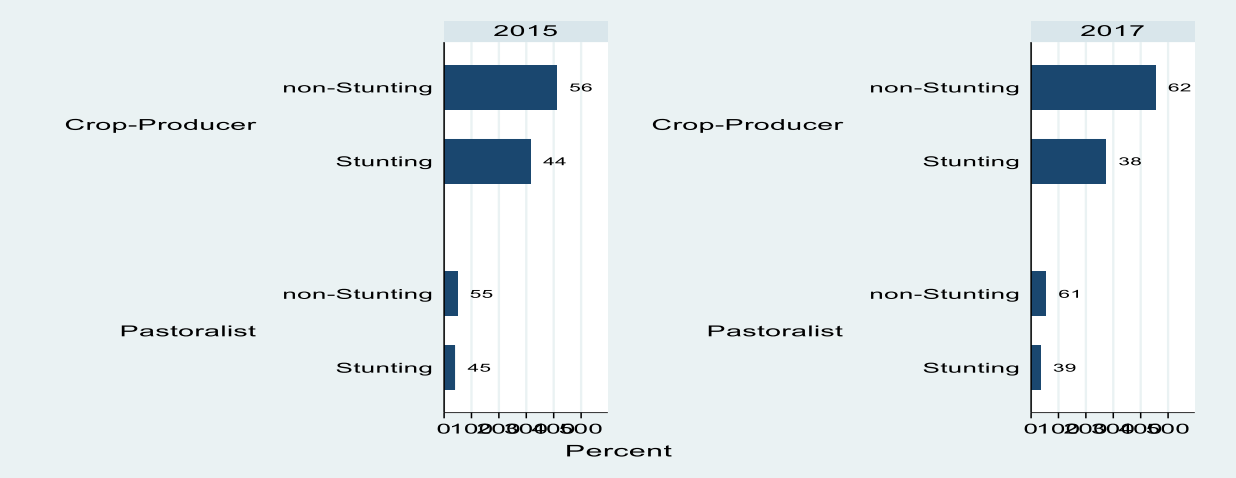

Figure 4: Stunting by years and livelihoods base in Ethiopia; Source: Authors Computation

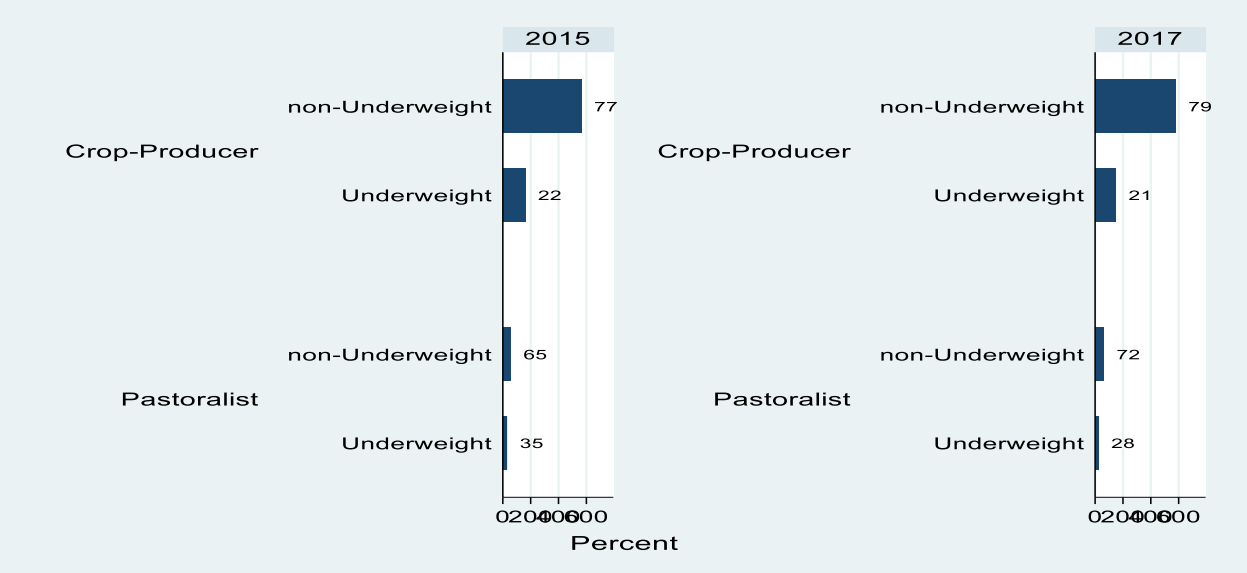

Figure 5: Underweight by Years and Livelihoods Base in Ethiopia; Source: Authors computation

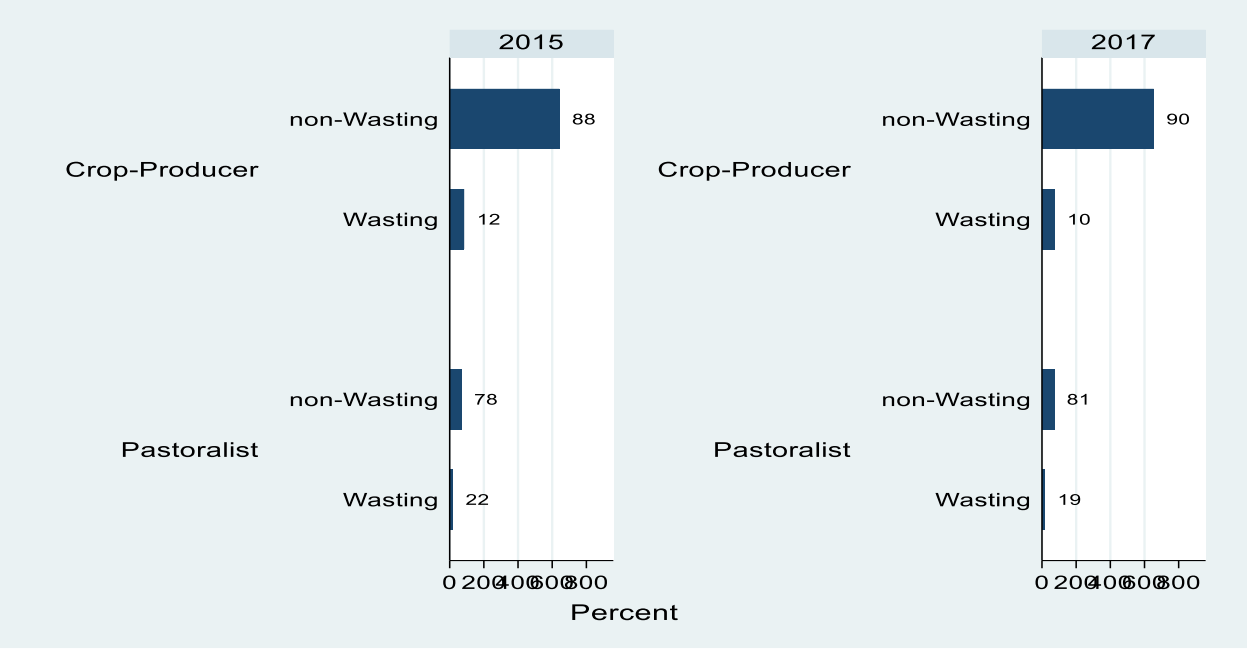

Figure 6: Wasting by years and livelihoods base in Ethiopia; Source: Authors computation

By 2017, there was a noticeable improvement in the prevalence of these conditions in both areas (Figures 4 to 6). In crop producing regions, the percentage of stunted children decreased to 38%, underweight prevalence dropped to 21%, and wasting reduced to 10%. In pastoral regions, the proportion of stunted children fell to 39%, while underweight and wasting rates decreased to 28% and 19%, respectively. Despite these improvements, the levels of stunting, underweight, and

wasting remain concerning in both agricultural contexts, underlining the need for continued efforts to address these nutritional challenges.

3.2. Econometric Results

3.2.1 Effect of human capital on rural household income

The Breusch and Pagan Lagrangian Multiplier (LM) test yielded a statistic of chibar^2 (01) = 63.75 with a p-value of 0.00, leading to the rejection of the null hypothesis of no panel effects. This result indicates that the Pooled OLS model is not suitable, and either the Random Effect or Fixed Effect models should be considered. To determine whether the Fixed Effect or Random Effect model is more appropriate, the Hausman test was performed. The test statistic was χ^2 (10) = 37.67 with a p-value of 0.00. Since the p-value is below 0.05, we reject the null hypothesis that the Random Effect model is appropriate. This suggests that the fixed effect model is more suitable for the data.

The fixed effects model shows that age, human capital, total livestock units, and the interaction term are significant determinants of rural income, while factors like sex, land cultivated, fertilizer amount, shock index, and credit access do not significantly affect income in this model. Age has a significant positive effect on rural income, with a coefficient of 0.307 (standard error: 0.071), indicating that as age increases, rural income tends to rise, likely due to accumulated experience or skills. Household size shows a small but significant positive impact on income, with a coefficient of 0.0551 (standard error: 0.029). This effect is weaker compared to the Pooled OLS model, suggesting that larger households contribute slightly to higher income.

Table 3: Determinants of rural income: regression results with standard errors in parentheses. *, ** and*** show significance levels at 10%, 5% and 1%, respectively.

Variables	Pooled OLS Model Coef.	Fixed Effects Model Coef.	Random Effects Model Coef.
Sex (male=1)	0.1740*** (0.045)	-0.120 (0.146)	0.171*** (0.049)
Age	-0.0443** (0.018)	0.307*** (0.071)	-0.0355* (0.020)
Household size	0.0674*** (0.010)	0.0551* (0.029)	0.0682*** (0.011)
Human Capital	0.0527*** (0.018)	0.0945** (0.039)	0.0553*** (0.019)
TLU_All	0.0579*** (0.003)	0.0466*** (0.007)	0.0569*** (0.004)
Land Cultivated	0.0062*** (0.002)	0.0023 (0.003)	0.0055** (0.002)
Fertilizer amount	0.0317* (0.018)	0.0544 (0.050)	0.0328* (0.019)
Shock Index	0.0058 (0.018)	-0.0081 (0.023)	0.0035 (0.018)
Credit Access	-0.0110 (0.018)	0.1280 (0.087)	-0.0080 (0.0197)

Interaction	-0.0613***(0.020)	-0.0737*** (0.026)	-0.066*** (0.020)
Constant	8.530*** (0.048)	8.869*** (0.168)	8.5350*** (0.052)
Observations	3,214	3,296	3,296
R-squared	0.147	0.059	
Number of Household		1,648	1,648

Human capital also significantly affects rural income. With a coefficient of 0.0945 (standard error: 0.039), this underscores the importance of skills and education in enhancing income. Total livestock unit (TLU_All) positively influences rural income, with a coefficient of 0.0466 (standard error: 0.007), highlighting the economic value of livestock. The interaction term has a significant negative effect on income, with a coefficient of -0.0737 (standard error: 0.026), indicating that the combined effect of the interacting variables reduces rural income. The constant term, at 8.869 (standard error: 0.168), represents the baseline income when all other variables are zero.

3.2.2 Determinants of human capital in rural households in Ethiopia

We conducted the Breusch and Pagan Lagrangian Multiplier test to assess the need for panel effects. The test statistic was chibar^2 (01) = 687.75 with a p-value of 0.00, leading us to reject the null hypothesis that states no panel effect. This indicates that OLS is inappropriate, and we should use either the random effects (RE) or fixed effects (FE) models.

Following this, to choose between RE and FE models, we performed the Hausman test, which tests null hypothesis which reads difference in coefficients not systematic (i.e., random effects is appropriate) against alternative hypothesis which states fixed effects is appropriate. The Hausman test resulted in a chi-squared statistic of 9.71 with a p-value of 0.084. Since the p-value is greater than 0.05, we do not reject the null hypothesis, suggesting that the RE model is appropriate for our analysis. Thus, we interpret the results from the RE model. Table 4 displays the findings from the random effects model examining the determinants of human capital. The analysis reveals that household size and income are significant factors influencing human capital.

Overall, the model highlights that while larger household sizes tend to diminish human capital, higher income significantly enhances it, reflecting the critical role of financial resources in human capital development.

Table 4: Regression model results for determinants of human capital with standard errors in parentheses. *, ** and*** show significance levels at 10%, 5% and 1%, respectively.

Variables	Pooled OLS Model Coef.	Fixed Effects Model Coef.	Random Effects Model Coef.
Sex	-0.0476 (0.044)	0.0385 (0.094)	-0.0447 (0.050)
Age	-0.0021 (0.018)	-0.0989** (0.046)	-0.0183 (0.021)
Household size	-0.0812*** (0.019)	-0.0034 (0.038)	-0.0616*** (0.021)
Agricultural_Wealth_Index	0.0115 (0.018)	-0.0490 (0.056)	0.0038 (0.021)
Lnincome	0.0470*** (0.016)	0.0348** (0.016)	0.0366*** (0.014)
Constant	-0.4000***(0.154)	-0.352** (0.165)	-0.305** (0.131)
Observations	3,215	3,296	3,296
R-squared	0.009	0.006	
Number of HouseholdID		1,648	1,648

In the random effects model, two key determinants of human capital emerge. The coefficient for Household Size is -0.0616 (standard error: 0.021), which is significant at the 1% level. This finding indicates a significant negative relationship between household size and human capital. Specifically, larger household sizes are associated with lower human capital, suggesting that as the number of household member increases, the available resources and attention for human capital development become more diluted.

Conversely, the coefficient for the log of Income (Lnincome) is 0.0366 (standard error: 0.014), also significant at the 1% level. This positive relationship implies that higher income is strongly associated with improved human capital outcomes. This result underscores the importance of income in enhancing human capital, as increased income contributes to better human capital status.

4. DISCUSSION

4.1. Dynamics of Household Human Capital across Crop Producers and Pastoralists

The disparity in educational attainment between crop producers and pastoralists in rural Ethiopia highlights significant differences in human capital investment across these two livelihood systems. Crop producers average 3.82 years of education, compared to 3.27 years for pastoralists. This difference, while statistically significant (t-value = -3.68), is indicative of a broader pattern observed in various studies of rural livelihoods.

4.1.1 Educational attainment and expenditure

Educational attainment disparities

Concerning educational attainment disparities, our results reveal that crop producers generally have higher educational levels compared to pastoralists. This finding aligns with the hypothesis that household human capital development differs significantly between these groups due to their distinct livelihood strategies and resource access (Catley and Aklilu, 2013; Tesema and Berhanu, 2018). Supporting this, Barrett et al. (2019) found that sedentary agricultural systems typically provide better access to educational resources than mobile pastoralist systems. Rodrik et al. (2004) and Gyimah-Brempong and Wilson (2004) similarly noted that settled agricultural communities usually benefit from more established educational infrastructures and institutions, which support higher educational attainment.

In contrast, pastoralist communities face challenges that contribute to their lower educational levels. Research by Tofu et al. (2023) highlights that pastoralists often reside in remote and semi-arid areas with limited educational facilities and access. The nomadic lifestyle of many pastoralist groups further hinders consistent school attendance, resulting in lower average years of education (Becker, 2009; Gammino et al., 2020). These barriers are consistent with earlier studies, such as those by Smith and Subandoro (2022), which emphasize the difficulties pastoralist children encounter in accessing and continuing their education.

Educational expenditure

The results show that, despite the lower average educational attainment, pastoralists allocate more per capita to education, with an average expenditure of 0.41 thousand Birr compared to 0.30 thousand Birr for crop producers. This counterintuitive finding suggests that pastoralists are investing significant resources in education, despite the inherent challenges. The higher per capita educational expenditure in pastoralist communities can be attributed to several factors. Research by Ndour (2017) and Kenea (2019) indicates that the costs of accessing education in pastoralist areas are disproportionately high. These costs include not only direct expenses, such as school fees and materials, but also indirect costs, such as transportation to distant schools and opportunity costs related to missing labor. Furthermore, the limited availability of educational facilities often means that pastoralists must travel long distances or pay for private education, increasing the per

capita expenditure (Wu et al., 2017). This situation is corroborated by the Karine (2021), which notes that educational expenditures in remote areas are often higher due to logistical difficulties and the need for additional support to facilitate access to education. Consequently, this leads to a paradox where increased spending does not always result in better educational outcomes, as the fundamental barriers to accessing quality education remain significant (Hanushek and Wößmann, 2007; Ali et al., 2018).

In nutshell, the significant disparity in educational attainment and expenditure between crop producers and pastoralists has several implications for policy and development strategies. To address these issues, targeted interventions are required (Attanasio et al., 2020). For instance, Gammino et al. (2020) and Karine (2021) suggest implementing mobile and remote education solutions tailored to pastoralist communities to overcome access barriers. Additionally, improving infrastructure and investing in localized educational facilities can help reduce the financial and logistical burdens faced by pastoralist families (Rodrik et al., 2004). Furthermore, policies that address the unique needs of pastoralist communities, such as providing subsidies for educational materials and transportation, could alleviate some of the financial pressures and improve educational outcomes (Ndour, 2017; Kenea, 2019; Smith and Subandoro, 2022).

4.1.2 Health metrics

The observed reduction in health-related absenteeism due to rising incomes in both sedentary crop producing and pastoralist/agro-pastoralist regions reflects an important link between economic improvement and health outcomes. This discussion explores the impact of increased income on health metrics, using recent and relevant research to contextualize these findings.

Impact of rising incomes on health-related absenteeism

The significant decrease in health-related absenteeism in sedentary crop producing regions—from an average of 9.75 days to 3.38 days—is indicative of a broader trend observed in various studies. Recent research shows that increased income often leads to better health outcomes due to improved access to healthcare services and better living conditions (Schultz, 2003; Kenea, 2019; Smith and Subandoro, 2022). As incomes rise, households typically have more resources to spend on healthcare, which can reduce the frequency and duration of work absences due to health issues.

For instance, a study by Lee et al. (2021) found that higher household income is associated with reduced incidences of illness and fewer days missed from work in rural areas. This is particularly relevant in crop producing regions, where economic growth has been linked to enhanced access to medical services, better nutrition, and improved living standards. These improvements contribute to a decrease in health-related absenteeism and a more stable workforce.

Similarly, the reduction in absenteeism in pastoralist/agro-pastoralist regions – from 10.43 days to 5.06 days – highlights that income growth can also positively impact health outcomes in more mobile and dispersed communities. Higher income can improve health outcomes by making healthcare more accessible and reducing the financial burden of medical expenses, even in remote areas (Jones et al., 2013; Donkin et al., 2014). For pastoralists, this improvement often translates into fewer days lost due to health issues, despite the ongoing challenges of accessing healthcare in remote locations (Gammino et al., 2020).

Economic improvement and health care access

The link between income and health-related metrics can be understood through the lens of increased access to healthcare services and better overall living conditions. Higher income levels generally enable households to afford better healthcare, including preventive care and treatment for illnesses, which reduces the frequency of health-related absences from work (Mwabu, 2007). This trend aligns with the findings of a study by Husereau et al. (2022), which noted that economic improvements lead to increased healthcare spending and better health outcomes, particularly in regions with previously limited access to medical services.

In both crop producing and pastoralist regions, rising incomes often allow for the purchase of better healthcare services, improved sanitation, and enhanced nutritional intake. These improvements collectively lead to a reduction in health-related absenteeism (Schultz, 2003; Attanasio et al., 2020; Lee et al., 2021). Improved healthcare access, in particular, helps mitigate the impact of illness, leading to fewer work absences and a more productive workforce.

Comparative impact on health versus education

The pronounced impact of rising incomes on health-related absenteeism compared to educational outcomes is noteworthy. Recent studies suggest that while increased income can significantly improve health metrics, its effects on educational outcomes might be less direct and more complex. For example, Barrett et al. (2019) found that while higher income levels can enhance access to educational resources, the improvements in educational attainment often lag behind health improvements due to persistent structural barriers in the education system, such as inadequate infrastructure and limited educational support in rural areas.

This discrepancy may be attributed to the more immediate and direct benefits that increased income brings to health, such as the ability to pay for healthcare services and improved living conditions, which directly impact absenteeism. In contrast, educational improvements require more systemic changes, including better educational infrastructure and policies, which take longer to materialize (Schultz, 2003; Gyimah-Brempong and Wilson, 2004; Becker, 2009).

4.1.3 Child nutritional status

The anthropometric indicators for children in Ethiopia, as detailed in Table 1 and Figures 4 to 6, reveal significant disparities in nutritional status between crop producing and pastoralist communities. These findings underscore ongoing challenges and improvements in child health and nutrition within different agricultural contexts.

The results indicate a notable disparity in nutritional outcomes between crop producing and pastoralist communities. Children in pastoralist communities exhibit poorer nutritional indicators compared to their crop producing counterparts. Specifically, the mean Height-for-Age Z-score (HAZ06) for pastoralists was -1.60, with 45% of children falling below -2 SD, compared to -1.52 and 43% for crop producers. This higher rate of stunting among pastoralists aligns with broader literature highlighting the impact of environmental and socio-economic factors on child growth (Davenport et al., 2017; Smith and Subandoro, 2022; Dwomoh et al., 2023). Stunting is a critical indicator of chronic undernutrition and reflects long-term deficiencies in food and health services (Rivera et al., 2016).

Similarly, the mean Weight-for-Age Z-score (WAZ06) was -1.51 for pastoralists, with 35% below -2 SD, compared to -1.15 and 22% for crop producers. Underweight is often associated with inadequate caloric intake and poor dietary diversity (Gizachew et al., 2024). The elevated rates of underweight in pastoralist children may be linked to the economic and logistical challenges faced by these communities, which often include limited access to diverse food sources and healthcare services (Mbow, 2020).

The Weight-for-Height Z-score (WHZ06) for pastoralists was also lower, with a mean of -0.86 and 21% of children below -2 SD, indicating a higher prevalence of wasting compared to crop producers. Wasting, which reflects acute malnutrition, is of particular concern as it is associated with higher mortality risk and immediate health consequences (Tofu et al., 2023; Jokhu and Syauqy, 2024). The higher prevalence of wasting among pastoralists may be exacerbated by seasonal fluctuations in food availability and recurrent environmental stresses (Barrett and Beegle, 2023).

The data also show a general improvement in the nutritional indicators from 2015 to 2017 across both community types. In crop producing regions, the percentage of stunted children decreased from 43% to 38%, underweight from 22% to 21%, and wasting from 12% to 10%. In pastoral regions, stunting decreased from 45% to 39%, underweight from 35% to 28%, and wasting from 22% to 19%. These improvements may reflect successful interventions or changes in local conditions, such as better access to nutrition programs or improved agricultural practices (Arimond et al., 2011). However, despite these positive trends, the persistence of high levels of stunting, underweight, and wasting highlights the need for sustained and targeted efforts.

The persistent high levels of malnutrition, particularly in pastoralist communities, indicate a need for continued focus on improving nutritional outcomes. Strategies should include enhancing food security, increasing access to diverse and nutritious foods, and strengthening healthcare systems to address both acute and chronic malnutrition (Gillespie et al., 2013). Additionally, addressing the specific challenges faced by pastoralist communities, such as seasonal food shortages and mobility constraints, is essential for effective intervention (Turner et al., 2014; Wu et al., 2017; Barrett and Beegle, 2023).

4.2. The Nexus between Human Capital and Agricultural Income in Rural Ethiopia

The fixed effects model results (Table 3) offer important insights into the factors driving rural income, highlighting the significant role of human capital. Our findings show the importance of factors like age, human capital, household size, and livestock in determining rural income.

4.2.1 Key determinants of agricultural household income

Human capital demonstrates a significant positive effect on rural income, with a coefficient of 0.0945, significant at the 5% level. This result supports the hypothesis that there is a positive correlation between human capital investment and agricultural income, suggesting that enhanced education and skills lead to better economic outcomes (Mankiw et al., 1992; Schultz, 2003; Barrett et al., 2019). Recent research corroborates this expectation, showing that improved educational attainment and skill development are crucial for increasing agricultural productivity and income (Schultz, 2003; Abraham and Mallatt, 2022; Barrett and Beegle, 2023; Mrabet, 2023). The positive correlation observed in our study highlights the critical role of human capital in driving economic growth in rural areas (Gyimah-Brempong and Wilson, 2004; Hanushek and Wößmann, 2007; Hippe, 2014; Ali et al., 2018; Mengesha and Singh, 2023).

Our findings also reveal that age has a strong and positive impact on rural income, with a coefficient of 0.307, significant at the 1% level. This suggests that older individuals tend to earn more in rural settings, likely due to accumulated experience and potentially greater access to resources (Aikaeli, 2010). This result aligns with the findings of previous studies, which have emphasized the role of experience and longevity in enhancing income prospects (Crespo Cuaresma et al., 2014; Case and Deaton, 2022). However, this result contrasts with Zhong's (2011) findings, which indicate that population aging exacerbates income inequality in rural areas of developing countries. The study highlights that as populations age, income disparity between younger and older generations increases, primarily because the elderly often have fewer income sources and less labor market participation.

Household size is associated with a moderate increase in rural income, with a coefficient of 0.055, significant at the 10% level. This finding suggests that larger households may benefit from collective resources and shared responsibilities, which can enhance income generation (Reardon

et al., 2007). This is consistent with literature that points to the advantages of larger family units in terms of labor allocation and resource utilization in agricultural settings (Fafchamps and Quisumbing, 2002).

Total livestock units (TLU_All) exhibit a strong positive association with rural income, with a coefficient of 0.0466, significant at the 1% level. This highlights the crucial role of livestock as a key asset in rural economies, contributing significantly to income generation (Herrero et al., 2013). Livestock not only provides direct income but also enhances agricultural productivity through various forms of support (Catley and Aklilu, 2013).

The interaction term exhibits a significant negative effect, with a coefficient of -0.0737 at the 1% level. This suggests that the combined effect of specific variables may actually diminish rural income. This finding highlights the importance of understanding the complex interplay between different factors and their joint impact on income (Christiaensen et al., 2013). Specifically, the interaction term reveals an additional effect of human capital on income for pastoralist households compared to crop producing households, indicating that the benefits of human capital investments may vary significantly across different types of rural livelihoods.

However, variables such as land cultivated, fertilizer amount, shock index, and credit access do not show significant effects in our model. This could suggest that within the fixed effects framework, these factors may not play a substantial role in explaining variations in rural income. Previous studies have also found mixed results regarding the impact of land and fertilizer on income, highlighting the complexity of agricultural productivity (Tesema and Berhanu, 2018; Fentie et al., 2023).

4.2.2 Income disparities between crop producers and pastoralists

Income disparities between pastoralists and crop producers are significant (Table 1). Pastoralists earn an average of 7.07 thousand Birr from livestock, markedly more than the 0.97 thousand Birr earned by crop producers, highlighting the critical role of livestock in their economies (Smith and Subandoro, 2022). However, pastoralist income varies widely, from 0 to 145.99 thousand Birr, reflecting the high risks associated with livestock farming, including disease, market fluctuations,

and environmental challenges (Rojas-Downing et al., 2017; Ali et al., 2018; Bareke et al., 2023; Tofu et al., 2023).

In contrast, crop producers report an average income of 12.01 thousand Birr, compared to 7.23 thousand Birr for pastoralists. This difference is attributed to technological advancements such as high-yield crop varieties and efficient irrigation systems, which enhance productivity and income stability (Mankiw et al., 1992; Hannum and Buchmann, 2005; Shen et al., 2013; Barrett et al., 2019). While technological improvements have significantly boosted crop yields and stability, the mobile nature of livestock-based livelihoods limits similar gains for pastoralists (Turner et al., 2014).

Economic stability is another key factor. Crop production provides more predictable income streams compared to the volatility of livestock farming, which is affected by market price fluctuations and environmental challenges (Ali et al., 2018). Additionally, crop producers benefit from better market access and infrastructure, whereas pastoralists face challenges in these areas, impacting their income and economic growth (Rodrik et al., 2004; Ali et al., 2018; Smith and Subandoro, 2022).

The average income disparity – 4.36 thousand Birr for crop producers versus 3.30 thousand Birr for pastoralists – highlights the economic benefits of crop production driven by technological advancements and stability (Barrett et al., 2019; Bareke et al., 2023). Human capital factors, such as education and health, also play a role in these income differences, underscoring the need for targeted improvements in these areas (Abraham and Mallatt, 2022; Smith and Subandoro, 2022).

Addressing these disparities requires policies focused on improving livestock health, market access, and infrastructure for pastoralists (Karine, 2021), alongside continued investment in agricultural technologies for crop producers. Risk management strategies, including disease control and income diversification for pastoralists, are essential for income stability (Tofu et al., 2023; Jokhu and Syauqy, 2024). Moreover, investing in infrastructure can enhance economic opportunities and reduce disparities for both groups (Smith and Subandoro, 2022).

4.3. Determinants of Human Capital in Different Livelihood Systems

4.3.1 Insights from random effects modeling

The random effects model reveals a significant negative effect of household size on human capital, with a coefficient of -0.0616 (standard error: 0.021). Larger households generally have lower human capital levels, consistent with Downey (1995) and Lawson and Mace (2010), who note that increased household size often dilutes resources, reducing investments in education and health. Fafchamps and Quisumbing (2002) and Timmer (1997) also support this, indicating that larger families face trade-offs between additional labor and decreased investments in human capital.

Conversely, the log of income (Lnincome) shows a significant positive effect on human capital, with a coefficient of 0.037 (standard error: 0.014). This pinpoints that higher income enhances human capital, aligning with and Mincer (1974), Satriawan and Swinton (2005) and Becker (2009), who found that increased income supports better education and skill development. Bane (2018) further confirm that higher income improves access to essential resources. Further, the constant term of -0.305 (standard error: 0.131) is significant at the 5% level, representing the baseline human capital when other variables are zero. This baseline is crucial for understanding variations in human capital (Mincer, 1974; Becker, 2009).

4.3.2 Comparing human capital determinants in crop producers and pastoralists

The study hypothesizes that the factors influencing human capital development differ between crop producers and pastoralists. This is evident from the contrast in educational attainment and expenditure between the two groups. Crop producers generally achieve higher education levels, while pastoralists spend more per capita on education, highlighting the need for tailored educational policies.

Crop producers benefit from higher education, which enhances agricultural practices and economic outcomes (Hanushek and Wößmann, 2007; Hippe, 2014). Better education helps them adopt modern techniques and improve productivity (Heckman and Masterov, 2007; Ndour, 2017). In contrast, pastoralists face significant barriers to education, such as limited access and mobility issues (Gammino et al., 2020; Smith and Subandoro, 2022).

Pastoralists spend slightly more on healthcare, averaging 7.92 thousand Birr compared to 6.67 thousand Birr for crop producers, reflecting higher costs in remote areas. They also manage more livestock (8.36 TLU) than crop producers (4.54 TLU), underscoring their reliance on livestock

(Wu et al., 2017). Crop producers, on the other hand, invest more in land and labor, managing an average of 1.40 hectares and investing more hours and costs in labor (Barrett et al., 2019; Mengesha and Singh, 2023).

The findings underline the need for targeted educational policies for pastoralists, including improved access to education, mobile schools, and the integration of traditional knowledge (Rodrik et al., 2004; Attanasio et al., 2020; Gammino et al., 2020). Our analysis shows that while household size negatively impacts human capital, income has a positive effect. Effective policies should address these dynamics to enhance human capital and economic outcomes.

5. CONCLUSIONS AND POLICY IMPLICATIONS

This study highlights significant disparities in human capital development between crop producers and pastoralists in Ethiopia, based on data from the 2015 and 2017 Living Standards Measurement Study (LSMS). Crop producers generally have higher educational attainment and income compared to pastoralists, who, despite spending more per capita on education, face challenges such as higher costs and limited resources. Health improvements linked to rising incomes are noted, but educational progress remains slow, especially among pastoralists, indicating a need for targeted interventions. Persistent malnutrition, particularly among pastoralist children, further emphasizes the need for strategies to enhance nutrition and overall health.

Economic analysis shows that while pastoralists earn more from livestock, crop producers benefit from higher total incomes due to better crop earnings and technological advancements. This economic disparity contributes to differences in human capital development. To address these challenges, policymakers should implement tailored educational programs: mobile schools and flexible solutions for pastoralists, and advanced agricultural training for crop producers. An integrated approach that improves both healthcare and education is essential, alongside investments in infrastructure like roads, schools, and healthcare facilities. Special attention should be given to improving nutrition through food security initiatives and strengthening healthcare systems. Economic diversification is crucial, with pastoralists benefiting from new income opportunities and crop producers from continued agricultural innovation.

Ongoing research and evaluation are vital for refining policies to address the needs of both groups, reduce disparities, and promote equitable development across Ethiopia's rural communities.

6. ACKNOWLEDGEMENTS

This work was financially supported by African Economic Research Consortium (AERC) with funding Grant No. AE/FAC/24-052 (Award 2448).

7. REFERENCES

Abraham, K.G. and Mallatt, J., 2022. Measuring human capital. *Journal of Economic Perspectives*, *36*(3), pp.103-130.

Aikaeli, J., 2010. Determinants of rural income in Tanzania: An empirical approach.

Ali, M., Egbetokun, A. and Memon, M.H., 2018. Human capital, social capabilities and economic growth. *Economies*, 6(1), p.2.

Arimond, M., Hawkes, C., Ruel, M.T., Sifri, Z., Berti, P.R., Leroy, J.L., Low, J.W., Brown, L.R. and Frongillo, E.A., 2011. Agricultural interventions and nutrition: lessons from the past and new evidence. In *Combating micronutrient deficiencies: Food-based approaches* (pp. 41-75). Wallingford UK: CABI.

Attanasio, O., Cattan, S., Fitzsimons, E., Meghir, C. and Rubio-Codina, M., 2020. Estimating the production function for human capital: results from a randomized controlled trial in Colombia. *American Economic Review*, *110*(1), pp.48-85.

Bane, J., 2018. Human capital and economic growth in developing countries: Evidences from low and middle income African countries. *Determinants of Economic Growth in Africa*, pp.237-258.

Bareke, M.L., Agezew, B.H., Dedho, N.H., Herut, A.H., Demissie, M.M., Yimer, B.M. and Lebeta, M.F., 2023. Trends of human capital development in Ethiopia: a comparative analysis. *International Journal of Learning and Intellectual Capital*, *20*(2), pp.149-165.

Barrett, C. B., and Beegle, K., 2023. The role of seasonal food availability and environmental shocks in child malnutrition. *Global Food Security*, 34, 100638.

Barrett, P., Treves, A., Shmis, T. and Ambasz, D., 2019. The impact of school infrastructure on learning: A synthesis of the evidence.

Becker, G.S., 2009. *Human capital: A theoretical and empirical analysis, with special reference to education*. University of Chicago press.

Case, A. and Deaton, A., 2022. The great divide: education, despair, and death. *Annual Review of Economics*, *14*(1), pp.1-21.

Catley, A. and Aklilu, Y., 2013. Moving Up or Moving Out?: Commercialization, growth and destitution in pastoralist areas. In *Pastoralism and Development in Africa* (pp. 85-97). Routledge.

Central Statistical Agency (CSA)., 2019. *Ethiopian Rural Socio-Economic Survey*. Addis Ababa: Central Statistical Agency.

Christiaensen, L., De Weerdt, J. and Todo, Y., 2013. Urbanization and poverty reduction: the role of rural diversification and secondary towns 1. *Agricultural Economics*, *44*(4-5), pp.435-447.

Crespo Cuaresma, J., Lutz, W. and Sanderson, W., 2014. Is the demographic dividend an education dividend?. *Demography*, *51*(1), pp.299-315.

Davenport, F., Grace, K., Funk, C. and Shukla, S., 2017. Child health outcomes in sub-Saharan Africa: a comparison of changes in climate and socio-economic factors. *Global Environmental Change*, *46*, pp.72-87.

Downey, D.B., 1995. When bigger is not better: Family size, parental resources, and children's educational performance. *American sociological review*, pp.746-761.

Dwomoh, D., Sewor, C., Annim, S.K., Stranges, S., Kandala, N.B. and Amegah, A.K., 2023. Do dietary practices and household environmental quality mediate socio-economic inequalities in child undernutrition risk in West Africa?. *Public Health Nutrition*, *26*(5), pp.1022-1033.

Fafchamps, M. and Quisumbing, A.R., 2002. Control and ownership of assets within rural Ethiopian households. *Journal of development Studies*, *38*(6), pp.47-82.

Fentie, A., Hassen, S. and Sebsibie, S., 2023. Climbing up the ladder: Households' fuel choice transition for lighting in Ethiopia. *Energy Economics*, *128*, p.107162.

Gammino, V.M., Diaz, M.R., Pallas, S.W., Greenleaf, A.R. and Kurnit, M.R., 2020. Health services uptake among nomadic pastoralist populations in Africa: a systematic review of the literature. *PLoS neglected tropical diseases*, *14*(7), p.e0008474.

Gemedo-Dalle, Isselstein, J. and Maass, B.L., 2006. Indigenous ecological knowledge of Borana pastoralists in southern Ethiopia and current challenges. *The International Journal of Sustainable Development and World Ecology*, *13*(2), pp.113-130.

Gillespie, S., Haddad, L., Mannar, V., Menon, P. and Nisbett, N., 2013. The politics of reducing malnutrition: building commitment and accelerating progress. *The lancet*, *382*(9891), pp.552-569.

Gizachew, T., Lencha, B., Beressa, G. and Geda, B., 2024. Determinants of underweight among lactating mothers in public health facilities, Siraro District, Southern Ethiopia: unmatched case–control study. *BMC nutrition*, *10*(1), p.116.

Gyimah-Brempong, K. and Wilson, M., 2004. Health human capital and economic growth in Sub-Saharan African and OECD countries. *The quarterly review of economics and finance*, *44*(2), pp.296-320.

Hannum, E. and Buchmann, C., 2005. Global educational expansion and socio-economic development: An assessment of findings from the social sciences. *World development*, 33(3), pp.333-354.

Hanushek, E.A. and Wößmann, L., 2007. The role of education quality for economic growth. *World Bank policy research working paper*, (4122).

Heckman, J.J. and Masterov, D.V., 2007. The productivity argument for investing in young children.

Herrero, M., Grace, D., Njuki, J., Johnson, N., Enahoro, D., Silvestri, S. and Rufino, M.C., 2013. The roles of livestock in developing countries. *animal*, *7*(s1), pp.3-18.

Hippe, R., 2014. Human capital and economic growth: Theory and quantification. *Economies et sociétés, AF*, 49(8), pp.1233-1267.

Hox, J.J. and Bechger, T.M., 1998. An introduction to structural equation modeling. *Family science review*, *11*, pp.354-373.

Husereau, D., Drummond, M., Augustovski, F., de Bekker-Grob, E., Briggs, A.H., Carswell, C., Caulley, L., Chaiyakunapruk, N., Greenberg, D., Loder, E. and Mauskopf, J., 2022. Consolidated health economic evaluation reporting standards (CHEERS) 2022 explanation and elaboration: a report of the ISPOR CHEERS II good practices task force. *Value in health*, *25*(1), pp.10-31.

Jokhu, L.A. and Syauqy, A., 2024. Determinants of concurrent wasting and stunting among children 6 to 23 mo in Indonesia. *Nutrition*, *122*, p.112390.

Jolliffe, D. and Serajuddin, U., 2015. Estimating poverty with panel data, comparably: an example from Jordan. *World Bank Policy Research Working Paper*, (7373).

Karine, H.A.J.I., 2021. E-commerce development in rural and remote areas of BRICS countries. *Journal of Integrative Agriculture*, *20*(4), pp.979-997.

Kenea, A., 2019. Education for Pastoralist Community Children in Ethiopia: Where the Opportunity Cost Defines It All. *East African Journal of Social Sciences and Humanities*, *4*(2), pp.63-82.

Lawson, D.W. and Mace, R., 2010. Optimizing modern family size: trade-offs between fertility and the economic costs of reproduction. *Human Nature*, *21*, pp.39-61.

Mankiw, N.G., Romer, D. and Weil, D.N., 1992. A contribution to the empirics of economic growth. *The quarterly journal of economics*, *107*(2), pp.407-437.

Mbow, C., Rosenzweig, C.E., Barioni, L.G., Benton, T.G., Herrero, M., Krishnapillai, M., Ruane, A.C., Liwenga, E., Pradhan, P., Rivera-Ferre, M.G. and Sapkota, T., 2020. *Food security* (No. GSFC-E-DAA-TN78913). IPCC.

Mengesha, Z.D. and Singh, L., 2023. Human capital accumulation and economic growth of Ethiopian economy. *African Journal of Science, Technology, Innovation and Development*, *15*(2), pp.211-226.

Mincer, J.A., 1974. Schooling and earnings. In *Schooling, experience, and earnings* (pp. 41-63). NBER.

Mrabet, R., 2023. Sustainable agriculture for food and nutritional security. In *Sustainable agriculture and the environment* (pp. 25-90). Academic Press.

Mwabu, G., 2007. Health economics for low-income countries. *Handbook of development economics*, *4*, pp.3305-3374.

Ndour, C.T., 2017. Effects of human capital on agricultural productivity in Senegal. *World Scientific News*, (64), pp.34-43.

Reardon, T., Berdegué, J., Barrett, C.B. and Stamoulis, K., 2007. Household income diversification into rural nonfarm activities. *Transforming the rural nonfarm economy: opportunities and threats in the developing world*, pp.115-140.

Rivera, R.L., Maulding, M.K., Abbott, A.R., Craig, B.A. and Eicher-Miller, H.A., 2016. SNAP-Ed (Supplemental Nutrition Assistance Program–Education) increases long-term food security among Indiana households with children in a randomized controlled study. *The Journal of nutrition*, *146*(11), pp.2375-2382.

Rodrik, D., Subramanian, A. and Trebbi, F., 2004. Institutions rule: the primacy of institutions over geography and integration in economic development. *Journal of economic growth*, *9*, pp.131-165.

Rojas-Downing, M.M., Nejadhashemi, A.P., Harrigan, T. and Woznicki, S.A., 2017. Climate change and livestock: Impacts, adaptation, and mitigation. *Climate risk management*, *16*, pp.145-163.

Sajoh, A.A., 2021. The effect of human capital on economic growth in some Sub Sahara African countries (SSA). *American Journal of Economics*, *5*(1), pp.1-24.

Satriawan, E. and Swinton, S.M., 2005. Does Human Capital Raise Farm or Non-farm Earning More? New Insight from Rural Pakistan Panel Survey.

Schultz, T.P., 2003. Human capital, schooling and health. *Economics and Human Biology*, *1*(2), pp.207-221.

Shen, J., Cui, Z., Miao, Y., Mi, G., Zhang, H., Fan, M., Zhang, C., Jiang, R., Zhang, W., Li, H. and Chen, X., 2013. Transforming agriculture in China: From solely high yield to both high yield and high resource use efficiency. *Global Food Security*, *2*(1), pp.1-8.

Šlaus, I. and Jacobs, G., 2011. Human capital and sustainability. Sustainability, 3(1), pp.97-154.

Smith, L. C., and Subandoro, A., 2022. Food security and nutrition outcomes in agricultural and pastoralist communities. *Food Security*, 14, 601-617.

Tesema, D. and Berhanu, A., 2018. Rural livelihood strategies and household food security of farmers surrounding Derba cement factory, Oromia Region, Ethiopia. *Rural sustainability research*, *40*(335), pp.2-17.

Timmer, C.P., 1997. Farmers and markets: The political economy of new paradigms. *American journal of agricultural economics*, *79*(2), pp.621-627.

Tofu, D.A., Fana, C., Dilbato, T., Dirbaba, N.B. and Tesso, G., 2023. Pastoralists' and agro-pastoralists' livelihood resilience to climate change-induced risks in the Borana zone, south Ethiopia: Using resilience index measurement approach. *Pastoralism*, *13*(1), pp.1-14.

Turner, M.D., McPeak, J.G. and Ayantunde, A., 2014. The role of livestock mobility in the livelihood strategies of rural peoples in semi-arid West Africa. *Human Ecology*, *42*, pp.231-247.

Wooldridge, J.M., 2002. Econometric analysis of cross section and panel data MIT press. *Cambridge, ma*, *108*(2), pp.245-254.

World Bank., 2020. *Living Standards Measurement Study (LSMS) Data*. Retrieved from World Bank website.

Wu, Z., Li, B. and Hou, Y., 2017. Adaptive choice of livelihood patterns in rural households in a farm-pastoral zone: A case study in Jungar, Inner Mongolia. *Land use policy*, *62*, pp.361-375.

Zhong, H., 2011. The impact of population aging on income inequality in developing countries: Evidence from rural China. *China economic review*, *22*(1), pp.98-107.