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Impact of large-scale agricultural investments on the food security status of local community in Gambella region, Ethiopia

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Abstract

Background: The government of Ethiopia has been promoting large-scale agricultural investments to accelerate agricultural modernization and improve local people's food security. However, studies that quantify the actual impact of such investments on the food security status of the investment hosting community using diverse food security indicators and suitable impact estimation methods are scanty. The main purpose of this article is, therefore, to analyse the impact of large-scale agricultural investments on the food security status of the Anuak community in Gambella region. This study employed a quasi-experimental research design. Data were gathered from 352 households selected through a systematic sampling technique and analysed using a Propensity Score Matching technique.

Results: The result shows that large-scale agricultural investments have a significant negative impact on the food security status of the local community and have worsened their food insecurity problem. The investments have reduced food availability, access, and utilization of the local people and increased their vulnerability to food insecurity.

Conclusions: We conclude that the Ethiopian government and private investors have failed to generate the benefits that they aspire at the local level to ensure the food security of the affected community. We, therefore, suggest that the Ethiopian government should reform the sector in such a way that takes the local context into account and embraces local people so that they can directly benefit from employment opportunities, infrastructural development, and technological transfer.

Keywords: Agricultural investment, Food security, Gambella, Ethiopia, Propensity score matching

Introduction

Following global crises of food prices, finance, and energy [1–4] and their convergence in 2007/08 [5, 6], there was a surge in large-scale Agricultural Investments (henceforth LSAIs) in Africa, where Ethiopia became a hotspot. The Ethiopian government has adopted an open-door policy and welcomed LSAIs on the ground that such investments could help the country to modernize its agricultural sector and improve the livelihoods of the local people. The government claims that the country has a huge amount of "idle" or "unused" land (in lowland areas, such as Gambella) that can be efficiently handled by financially and technologically sound private investors without impeding the livelihood of the local people [7]. Consequently, between 1992 and 2017, over 2.2 million hectares (ha) of land was transferred to domestic and foreign private investors [8], making Ethiopia among the top rural land-leasing countries in Africa [3, 9, 10].

This phenomenon has, however, raised profound concerns and debates over the food security, livelihoods, and socioeconomic status of the societies, where these investments transpire. The proponents of such investments

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argue that LSAIs not only improve capital accumulation and result in increased job creation in the agricultural sector, but they also expand infrastructure, improve local food supply, enhance access to markets, and boost the foreign exchange reserve of the host country [2, 11, 12]. Opponents of LSAIs, in contrast, argue that such investments adversely affect host countries and communities by exploiting and degrading the natural environment, ignoring local people's legal rights, eroding indigenous farming practices, and exacerbating food insecurity and conflict [1, 7, 13, 14].

Even though the Ethiopian government claims that the country has vast arable land and water resources, poverty remains a leading challenge for people's livelihoods [15]. Particularly, inadequate access to food has been a typical characteristic of the Ethiopian poor. For example, Ethiopia is recognized as one of the poorest, drought and famine-prone, and 'ten largest international humanitarian assistance recipient' countries in the world [16]. The UN Office for the Coordination of Humanitarian Affairs (OCHA) estimates that 8.86 million Ethiopians require urgent food or cash relief [17]. This shows that the country is suffering from a severe problem of food insecurity. The Gambella region, which is endowed with fertile land and irrigable water resources and hosts the majority of LSAIs in the country, paradoxically, is one of the most food insecure [18, 19] and vulnerable [20] regions in the country. The Ethiopian government has transferred about 683,518 ha of land to domestic and foreign investors in this region [8]. However, whether or not such investments are contributing to the improvement of the food security status of the local community is a highly controversial and empirical issue which this study tries to address.

Most studies in Africa (including Ethiopia) have focused on historical and baseline trend analysis, with limited emphasis on quantifying and predicting the impacts of LSAIs on food security [21]. Several studies [7, 12, 22–26] have reported the general trends, size, and implications of LSAIs for the local communities' livelihoods in Ethiopia. Some studies have addressed governance issues by focusing on the legal frameworks, land acquisition processes, power structures, and land tenure [7, 26–29]. Other studies have tried to analyse the impact of LSAIs on the community and economy [10, 17, 25, 30–34]. Recently, Guyalo et al. [35] have examined the impact of LASI on the asset base of the *Anuak* community in Gambella region using the PSM model. They have reported a negative impact of the investment on the assets of the affected community. Nevertheless, their study is silent about how the investment affects the food security status of the local community. Besides, very few studies [10, 33] have tried to quantify the actual impact of such investments on the food security status of the local community in Ethiopia.

Food security is a multidimensional concept that could not be captured by a single or few indicators. Most current studies in African, however, do not employ all-encompassing conceptualizations of food security that address its multiple dimensions [36–38]. For example, previous studies [10, 33] that have tried to quantify the impact of LSAIs on the food security status of the local community in Ethiopia either addressed the availability or utilization dimension. Our study, however, uses various indicators intended to capture all dimensions of food security (separately and collectively) and contributes to filling knowledge and methodological gaps in the literature. This study could also contribute to the existing LSAI debates based on the primary data generated via field research in Gambella region. It addresses the following research question: What is the impact of LSAIs on the food security status of the local community in Gambella region?

The rest of the article is organized into four parts. Part two presents a brief review of the literature. Part three discusses the context and research methodology. "Results and discussion" section describes the results of the study. "Conclusion and policy implication" section winds up the article and highlights policy implications.

Literature review

Concepts and definitions

The term "LSAI" lacks a single, universally accepted, and agreed-upon definition. This is because the definition depends on various contextual factors and the interests of the parties defining it. Unfortunately, LSAI does not have an official definition in the Ethiopian context. In this article, we conceptualized LSAI as a mechanized commercial agricultural investment carried out by either foreign or domestic investors on a tract of land exceeding 200 ha [39].

For the last five or so decades, the concept of food security has passed through various evolutionary phases, from a narrow conceptualization as national and global food availability to one that comprises multiple dimensions [40]. In this article, we conceptualized food security as a household's continual access to adequate, safe, and nutritious food necessary for an active and healthy life [41]. To properly capture the concept at a household level, we further conceptualized it along four dimensions: availability, access, utilization, and stability (economic vulnerability) [42]. We defined food availability as the physical presence of food in the neighbourhood or in the home from all sources (own production, gifts, barter, or food aid). The access dimension is operationalized as a household's capacity (in terms of income and other resources) to procure sufficient amounts of food needed to maintain a healthy life. Likewise, food utilization is conceptualized as the ability of a household to get full biological benefits from food, based on food quality and diversity [43]. To address the stability dimension, we applied the conceptualization of [44], where the authors identified two components of stability: vulnerability and resilience. Vulnerability is conceptualized as the risk that the food security status of a household is destabilized by events such as LSAI and resilience as the ability and time needed to renovate from the pre-shock status [44]. This article focuses on the vulnerability dimension.

Brief empirical review

Several scholars who have attempted to analyse the phenomenon of LSAIs have taken a critical approach, questioning their potential benefits to the economies of investment-hosting countries and the livelihoods of local communities, arguing that the phenomenon does not have development potential and, in fact, harms them [45–47]. Many scholars have examined the potential impacts of such investments on the local people's livelihoods and natural environment in Africa [48–50]. Some of the scholars studied the issue from the international human rights perspective [51–53]. Others have examined the legal framework and processes via which LSAI takes place in investment hosting countries by focusing on the land tenure systems [7, 54–56].

Studies conducted in several Sub-Saharan countries reported the dispossession of local people and lack of compensation for those who lost their land [7, 50, 54, 57]; lack of consultation with local communities and their free, prior, and informed consent [7, 48]; forced evictions and endangered rights to food [51, 58–60]; and thus, deteriorated food insecurity and vulnerability of the local community [32, 51, 54, 61–69]. Some scholars reported asymmetries of power [59] that benefited the elites at the national and local levels [49, 60]; weak government institutions [70]; and pervasive corruption that paralyzed land and investment governance systems and benefited the elite [54].

In general, most of the studies mentioned above have documented potential negative effects of LSAIs on the investment-hosting countries and communities. However, in contrast, a few case studies have shown a positive contribution of LSAIs to employment and income of the local community. For example, Vath and Kirk [71], FAO [72], and Fitawek et al. [73] reported that LSAIs had contributed to job creation in Ghana, Uganda, and Madakaskar, respectively, though it is not sustainable. Ahlerup and Tengstam [74] have found that commercial farm investments are linked with a robust, moderate positive effect on income, but only for households that have a scarcity of land in Zambia. Some studies have also found that LSAIs have a positive impact on food security in SSA [21, 38, 69, 73, 75, 76]. This implies that the results of previous studies are mixed (inconclusive) and are often contradictory.

Even though the studies mentioned above broaden our understanding of LSAIs in the African context, the majority of them are dominated by qualitative case studies [77], descriptive analysis [74], and lack proper impact assessment methodologies [10, 77]. Besides, a few studies [10, 33] that attempted to investigate the impact of LSAIs on food security in Ethiopia employed a single or partial measure of food security, though the concept is multi-dimensional. Although scholars use various metrics to achieve their goals, the literature acknowledges that a single or few metrics (or metrics) cannot address all aspects of food security [36–38, 40, 78–80]. Following this reasoning, we employed various metrics to capture the diverse dimensions of food security. This study, thus, aims to contribute to the existing body of literature by filling the empirical and methodological gaps explained above.

Conceptual framework

Understanding the impact of LSAIs on the food security status of the local community requires a conceptual framework that explains the causal mechanisms via which such an impact occurs. To accomplish this, we developed a conceptual framework based on the Satiable Livelihood Approach (SLA) idea that was initiated by Chambers and Conway in 1991. This approach provides a broader perspective to understand how interventions such as LSAI affect the asset base of local people, change their livelihood strategies, and improve or impede their food security status. The central aim of SLA is to offer a way that empowers people and communities based on their everyday desires and enhances their existing livelihood strategies rather than executing top-down interventions (such as LSAI) without recognizing various assets and capabilities that local people possess [81].

The government of Ethiopia has persistently promoted LSAIs as one of the strategies to achieve its vision of ensuring food security and joining middle-income countries by 2025. The main purposes of the government for promoting such investments in the country in general, and in the study area in particular, are to (i) produce high value export crops and boost country's foreign earnings; (ii) produce non-food crops required for agro-industry; (iii) create job opportunities for the local community; (iv) develop social and physical infrastructures in the areas, where the investments are being undertaken; and (v) facilitate the transfer of technology [7].

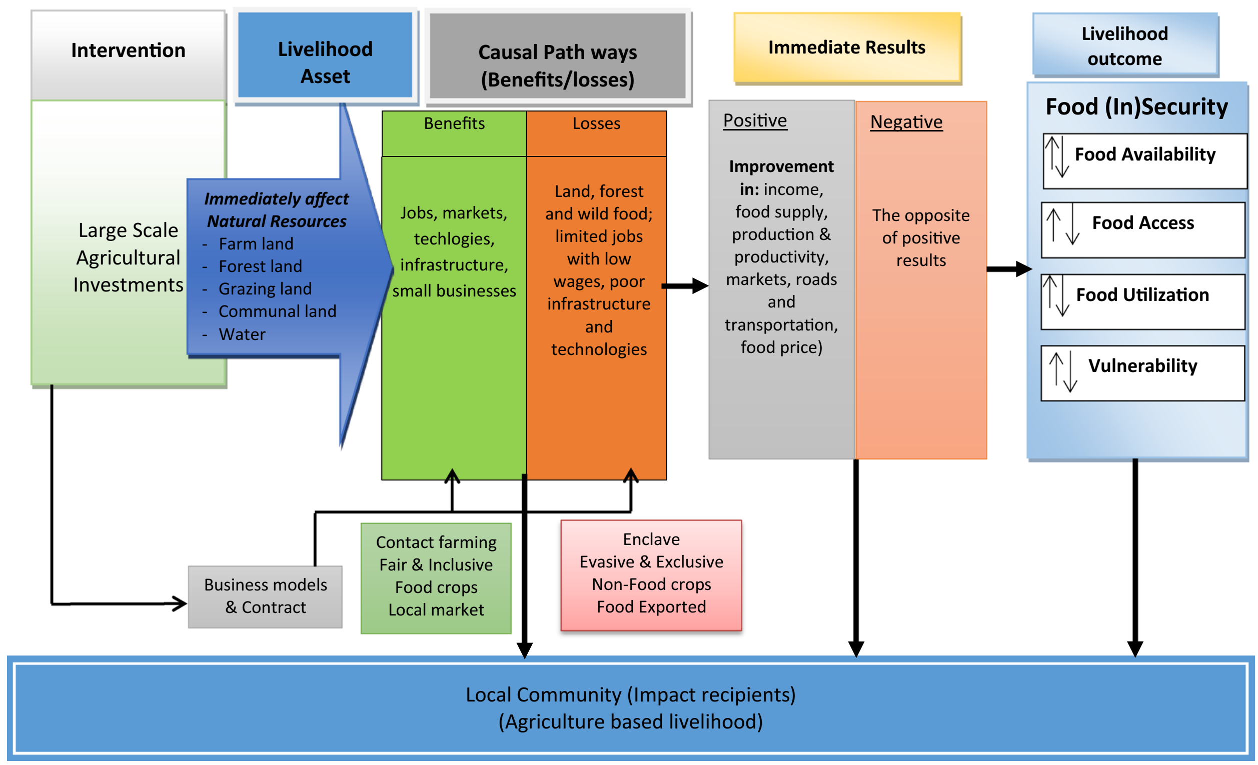

Fig. 1 Conceptual framework. Source: own construction based on livelihood framework. ↑ Denotes increase and ↓ represents decrease

However, LSAIs could have positive (virtuous) or negative (vicious) impacts on the food security status of the local community depending on the business models adopted and/or contracts concluded and the strength of land and investment governance systems and institutions. The investments could have positive effects on the food security of the local community only if inclusive and fair business models that encourage strong cooperation and integration between the local community and private investors (and create win–win conditions) are adopted. For example, if the investors use a contract farming model that integrates the community into the agricultural value chain and treats them as business partners, if they respect their right to and control over their land, transfer technologies, improve their access to inputs and markets, and increase food supply in local markets, the investment may have a positive spill over (the local community will be better off and more food secure).

The livelihood of the *Anuak* community is based on small-scale crop farming (maize mostly intercropped with pumpkin and sorghum) and augmented by hunting, fishing, and the collection of wild foods, such as fruits (*Wudo*), roots (*Modo*), and leaves of diverse plants. Interventions such as LSAIs entirely depend on the natural resources that serve as a source of livelihood (food, income, and assets) for the local community. The intervention is conceptualized to produce an immediate effect on the natural resources, which could be private farmland, water resources, and communal land (forestland, grazing land, and watershed) by changing the land tenure system of the local community and limiting their access to and use of these resources (Fig. 1). In an agrarian society, such as Ethiopia, "land is not only the primary means for generating a livelihood but also the main vehicle for investing, accumulating wealth, and transferring it between generations" ([82] p 247). It serves as a safety net for rural people in the event that other sources of their income are lost and acts as a source of identity [83]. Communal land is vital, principally for the poor [84], given that it serves as a source of food (a "hidden harvest") and fuel for many rural communities [85].

The intervention (LSAIs) is further conceptualized to generate various benefits, immediate results, and outcomes (Fig. 1). These benefits, results, and outcomes are based on the arguments of those who advocate LSAIs, comprising the Ethiopian government, claiming that such investments can generate positive results and outcomes that could benefit the investment hosting community. The perceived benefits include employment opportunities, improved food production and supply, technological transfer, better infrastructure, improved local businesses, better local revenue, and improved market linkages, among others [86].

LSAIs are expected to affect the labour supply by creating job opportunities for local people and directly impacting their income, and so their access to food. Investors are expected to adopt labour-intensive technologies and create jobs for locals to increase their income. This income, in turn, could enhance the purchasing power of the community and enable them to procure the quantity (availability) and quality (diversity) of food that meets their family's needs. Improvement in income may also increase the demand of the local people for various goods and services, which could encourage the establishment and expansion of micro and small businesses in the local areas, which could further create jobs for the local people, diversify their livelihood strategies, improve their income, and potentially boost their access to quality food (dietary diversity).

Technological transfer from investors to the local community can considerably affect agricultural production and productivity and directly impact food security [87]. This will enable households to produce food that will meet their family's food consumption needs (availability) and sell the surplus to generate extra income (access). The money saved from the product sold could further improve households' capacity to acquire (procure) diversified food items or to invest and enhance their assets in such a way that reduces their vulnerability to food insecurity. Besides, investors are supposed to produce and supply food crops to the local market, thereby boosting food availability in the local areas and calming food prices. All these together, in turn, could enable households to have stable availability of, access to, and utilization of food and to have lower vulnerability to food insecurity (stability).

Investment in physical infrastructure (roads and transportation facilities) could improve the access of the local people to the market, thereby potentially boosting their access to food. Investment in social infrastructure will improve local people's access to education, health, potable water, and training facilities and services, which will help them develop their human capital and, as a result, their productivity. The investors are also expected to pay land lease fees and taxes to the local government, which could be reinvested to enhance local infrastructure in a way that improves access of the local community to the market. In doing so, LSAIs could contribute to the sustainable and stable food security (availability, access, and utilization) of the local community.

We, thus, posit that if inclusive contracts are concluded and proper business models are adopted, if the perceived benefits such as technological transfers, infrastructure development, and adequate job opportunities with fair payment are materialized, and if participatory, transparent, inclusive, and responsive land governance systems and institutions are installed to ensure the anticipated benefits, the affected community will be likely to be much better off and more food secure.

However, the contrary of the above account could also transpire if the conditions explained above are not fulfilled. For example, if investors adopt extractive or enclave business models and convert farm and forest land to planation agriculture or commercial crop production, they will adversely affect the food security status of the local community. Above all, if local communities lose their land (their livelihood base) without compensation and alternative livelihood opportunities (due to poor/bad land governance systems and weak institutions as well as short-term profit motives of the investors), then they will be worst off and become more food insecure. If the investors produce food crops for export and non-food crops for industries, then they will reduce food availability at the local and household levels. This, in turn, could escalate food prices and make the local community more vulnerable to food insecurity. If the investment projects create limited and seasonal job opportunities for the local community and if wage rates are low, the affected community will be worst off and unable to acquire an adequate quantity and quality of food. Moreover, if investors ignore the local contexts, abortive to facilitate technological transfers, and overlook infrastructure development, their contribution to local food security would be very low.

In general, the contribution of LSAIs to the local community and its impacts are highly debatable. The results of prior studies are mixed (inconclusive) and often at odds [1, 12, 21, 73], mostly due to divergences in business models, crop types, land use, contract agreements, market outlets, and land and investment governance systems, among others. Our study, therefore, contributes to this debate by examining the impact of LSAIs on the food security status of the local community based on empirical evidence. Moreover, as indicated above, unlike previous studies which applied a single or few indicators to measure food security, our study employs assorted food security metrics to capture its multiple dimensions.

Materials and methods

Study area

This study was conducted in Abobo *woreda*,[1] in Gambella People National Regional State (GPNRS),[2] where LSAI is intensively practiced (Appendix 1). Abobo is one of the five *woredas* in *Anuak* zone, situated 47 kms away from the regional capital city. It has a total land area of 3116.17 km^2 with a population density of 5.05 people per km^2 and a total of 3108 households reside in 18 *Kebeles*[3] [88]. The *woreda* is occupied by the *Anuak* indigenous community and settlers who came to the region in the 1980s via a resettlement program. The *Anuak* community resides in 12 *kebeles* of the *woreda*. Forest and water-based agriculture is the main source of their livelihood.

The government of Ethiopia had leased about 93,159 ha of farm, forest, range, and savanna land to 123 private investors in the study area [8]. Of the 123 investors, two are foreign (granted 15,000 ha) and 121 are domestic (contracted 78,159 ha of land). Saudi Star Agricultural Development Plc., a Saudi-based corporation owned by Al-Amoudi, was granted 10,000 ha of land to produce rice for export. The other foreign firm is Green Valley Agro Plc., an Indian-owned company, which was granted 5000 ha of land for the production of exportable cotton [8]. On the other hand, domestic firms had been granted an average of 631.4 ha of land to produce sesame and green mung beans for export and cotton for industrial inputs [88]. Some of the investors had been awarded land within the Gambella National Park (the largest national park in the country) [19]. This implies that the main motivation behind the promotion of LSAIs in the region is foreign currency earnings (production of food commodities for export) and non-food commodities (cotton) for either global or domestic markets.

Research design and data

Literature classifies impact estimation research design into two categories: experimental and quasi-experimental (non-experimental). The first category (natural or pure experiment) is used when subjects are randomly assigned to both the "treatment" and "control" groups to precisely estimate the effects of the intervention on the outcome variables [89]. The second category is common and frequently employed in behavioural studies due to the fact that randomization is impossible. To estimate the effect of the intervention, this type of design employs different statistical techniques to construct comparison groups and match them with treatment ones through different matching algorithms [90–92].

Scholars have identified different typologies of quasi-experimental research design based on time and spatial variations: dynamic comparison, longitudinal comparison, spatial comparison, and counterfactual comparison [93]. The first typology makes causal interferences based on both time and space variations, that is, when treated and untreated cases are equally observed before and after intervention [93]. In the second type, treatment groups are not accompanied by comparison ones, but rather causal explanations are made based on the observation of cases overtime (before and after intervention), for example, using Difference-in-Difference (DiD) methods [93, 94]. When baseline data (before intervention) on outcome variable(s) are unavailable, the third type of quasi-experimental impact estimation design is usually used [93]. Outcome variables of the intervention (which are not even directly observed) are measured only after the intervention. To make causal interferences, this type of design constructs comparison groups through statistical techniques and matches them with treatment ones based on pre-intervention observed characteristics (using, for example, PSM methods) [93, 94]. The last typology is typically employed when there are no variants in both time and space in the variables of interest [93]. In this case, researchers reach causal inferences based on the models generated via mathematics or statistics (for example, instrumental variable) [94].

Due to a lack of randomization (the intervention was introduced in the study area in a non-random approach) and the absence of baseline (temporal) data, natural experiments and the first two types of quasi-experimental designs were not feasible in our study. Because of this, to estimate the treatment effect, we applied a "spatial comparison" typology of quasi-experimental design (PSM) that fits our data set. This type of design enabled us to construct a comparison group that resembles the treatment group in terms of some basic characteristics. In this study, "treatment group" refers to those households that reside in the *kebeles* that hosted LSAI projects, frequently interact with them, and are the first to experience the effects of investments (affected group). Conversely, the comparison group denotes those households who reside in the *kebeles,* where LSAIs have not yet commenced, and so are not affected by such investments (non-affected group).

The government of Ethiopia has introduced *a "villagization"* program in both treatment and comparison *kebeles* to relocate people from their original places to

[1] *Woreda* is a fourth-tier administrative unit in Ethiopia which is equivalent to a District.

[2] Gambella People's National Regional State is one of the nine administrative regions in Ethiopia. The region is located in the south-western part of Ethiopia, about 780 kms from the national capital, Addis Ababa, with a total land area of 34,063 km^2 and an estimated population of over 409,000 inhabitants [121]. The region is bounded to the north and east by Oromia Regional State, to the south by the South Nation and Nationalities and Peoples Regional State (SNNPRS), and to the west by the Republic of South Sudan.

[3] *Kebele* is the lowest tier of government in Ethiopian governance structure.

Table 1 Distribution of affected and non-affected households and sample size

Affected *Kebele*	Total no. of HHs and sample proportion		Total sample size	Non-affected *Kebele*	Total no. of HHs and Sample proportion		Total sample size
	No. of HHs	S. proportion			No. of HHs	S. Proportion	
Perpengo	83	83 × 43.8% = 36	36	Tegni	153	153[a]47.2% = 72	72
Pukedi	81	81 × 43.8% = 35	35	Dumbong	54	54[a]47.2% = 25	25
Terkodi	153	153 × 43.8% = 67	67	Potelam	67	67[a]47.2% = 32	32
Uchockchalla	66	66 × 43.8% = 29	29	Terichuri	65	65[a]47.2% = 31	31 + 1[a]
Total	383	167	167	Total	339	160	161*15% = 24.15 160 + 24.15 = 184.15 = 185

Source: Own computation based on the information obtained from *Abobo woreda*

HHs households

[a] We interviewed one extra household in *Terichuri Kebele*

the current new *kebeles*. Though the government claims that the goal of the program is to provide relocated people with basic socioeconomic infrastructure, most international organizations and scholars have reported that the aim of the program was rather to make way for large scale commercial agriculture [7, 26, 95, 96]. We found that both treatment and comparison *kebeles* are inhabited by the *Anuak* community, who are identical in culture, socioeconomic status, and livelihood sources and activities, *villagization*, and agroecology. The only difference is that in treatment *kebeles*, LSAI has already been started, whereas in comparison *kebeles*, though land has been made available for commercial farming, the investment projects have not yet commenced.

Both primary and secondary sources of data were used. Primary data were generated via a structured household survey questionnaire. Besides, secondary data were obtained from previous studies (journal articles), books, government documents, and other relevant materials.

Sampling procedures and sample size

We used a multi-stage sampling technique. First, GPNRS was purposely selected given that since 2008 it has been the leading destination for both domestic and foreign LSAI in the country. Secondly, we purposefully selected the *Anuak* zone because of the high concentration of LSAI projects (74% of projects in the region) in the area [97]. Third, we deliberately selected *Abobo woreda* from the *Anuak* zone due to the high volume (about 60%) of investment projects of the zone in the *woreda* [97]. Fourth, we stratified *kebeles* into affected and non-affected ones. Fifth, we randomly selected four affected *kebeles*. Finally, we applied a systematic sampling technique to select households. As food (in)security is eventually experienced at the household level [98] and/or individual level within the household [98, 99], the sampling unit and unit of analysis for this study is a household. Due to time and resource constraints, we did not go into the analysis of the impacts of LSAI at the intra-household level, but rather we limited our scope to the analysis of the impacts at the household level, considering individual members of the household as one unit.

Since this study intends to analyse the impact of LSAIs on the food security status of the local community, we need to estimate the true proportion of the population impacted by the investment with the required margin of error and confidence level. Given that our target population is finite, we calculated the sample size using the formula proposed by ([100] p 4)

$n = \frac{Z^2NP(1-P)}{d^2(N-1)+Z^2P(1-P)}$, where n is the sample size, Z^2 is significance level (1.96 for 95% confidence level), N is population size, p is a proportion of impacted population, and d is degree of accuracy or margin of error expressed as a proportion (0.05).

According to [88], there are 1345 households (*Anuak* community) in the *woreda*, among which 682 of them (in six *kebeles*) are affected by the investment. The proportion (p) of the affected households is, thus, 682/1345 = 0.50.7 ~ 51%:

$$\text{Samplesize} = \frac{(1.96)^2 1345(0.51)(1-0.51)}{(0.05)^2(1345-1)+(1.96)^2(0.51)(0.49)} = 299(\text{forallaffected}\textit{kebeles}).$$

Based on this, a proportional sample, that is, 299/682 (43.8%) of households, was taken from the four selected *kebeles*. The total sample size from these *kebeles* is 167 (Table 1). For a comparison group, four non-affected *kebeles* were randomly selected, as well. Households from these *kebeles* were selected through a systematic sampling technique. To compensate for poor matching, the number of non-affected households was oversampled by 15%. The total sample size is, therefore, 352 (167 affected + 185 non-affected). The distribution of the affected and non-affected population and the corresponding sample size is summarized in Table 1.

Method of data analysis

We analysed the data using both descriptive and inferential statistics. We employed descriptive statistics, such as percentages, mean, and standard deviation. We used various indicators (see "Food security indicators" section below) to measure and analyse the food security status of households in the study area. We applied the Principal Component Analysis (PCA) technique to create an overall food security index[4] as suggested by some scholars, such as Maxwell et al. [101]. Finally, we applied a Propensity Score Matching (PSM) technique to estimate the impact of LSAI on the food security status of the local community.

Food security indicators

The food security status of a household is used as an outcome variable we are interested in measuring and noticing whether or not it is impacted by the intervention variable (LSAI). We further operationalized food security along four dimensions: availability, access, utilization, and economic vulnerability (stability). We measured the food availability dimension using two indicators: daily calorie consumption and Months of Adequate Household Food Provision (MAHFP). The food utilization aspect is measured using two indicators: Household Dietary Diversity Score (HDDS) and Food Consumption Score (FCS). These indicators are often used as proxy indicators to capture the nutritional quality of a diet [102] since a variety of foods in the diet is required to ensure a sufficient intake of important nutrients [103]. The Household Food Insecurity Access Scale (HFIAS) was used to measure the access part of food security. The HFIAS is one of the recent tools designed to capture the common experience of household food (in)security (the access part) throughout countries and cultures [104]. To capture stability dimension, coping strategies index (CSI) and food expenditure share were used as proxy indicators (see Additional file 1 for detail discussion and computations of these indicators).

Principal component analysis (PCA)

We employed PCA to construct a composite index for food security. PCA is a type of factor analysis often used to reduce dimensions or find out hidden variables by digging out a linear combination that pre-eminently depicts the covariance among all components [105]. PCA constructs an index based on the household's food security data by creating an $m \times n$ matrix, $\mathbf{X}$, where $\boldsymbol{n}$ represents food security variables (columns) collected from $\boldsymbol{m}$ households (rows). Next, every component of the matrix $\mathbf{X}$ is normalized by deducting the column mean from it and dividing the variations by the column standard deviation to create a new $m \times n$ matrix, $\mathbf{Y}$. Furthermore, n x n correlation matrix $\mathbf{R}$ is calculated from the normalized data matrix, $\mathbf{Y}$. As per Kabudula et al. [106], the following equation can be specified, where λ and V can be solved:

$$(R - \lambda I)V = 0. \tag{1}$$

In this equation, $\boldsymbol{\lambda}$ stands for a vector of eigenvalues, $\boldsymbol{I}$ represents an identity matrix, and $\boldsymbol{V}$ represents a matrix of eigenvectors correlated to the eigenvalues in $\boldsymbol{\lambda}$. Following this, each eigenvector is balanced in a sequence that its sum of squares becomes equivalent to the total variance. The result of the normalized matrix of food security indicators, $\mathbf{Y}$, and the matrix of scaled eigenvectors, V^* creates a set of uncorrelated linear groupings of food security indicators for every household $\boldsymbol{j}$, called principal components (PCs). These components are created based on m uncorrelated principal components, where each of them is a linear combination of initial variables X_1, X_2,... X_n as follows:

$$\mathrm{PC}_m = a_{m1}X_1 + a_{m2}X_2 + a_{m3}X3 + \cdots + a_{mn}X_n \tag{2}$$

where a_{m1} is the weight for the mth principal component and the nth variable. The first principal component explains the largest variation in the original data set which was converted into factor scores. The second principal component was computed in similar manner but is uncorrelated with the first principal component and accounts for less proportion of variation. Each successive component describes extra variations but fewer percentage of variation of the variables. Once we identified the number of factors to be retained and the corresponding total proportion of variations they explain, we developed a Non-Standardized Food Security Index (NSFSI) for each household using the proportion of these percentages as weights on the factor score coefficients (PCs) based on the Krishnan work [107] as follows:

$$\mathrm{NSFSI} = {}^{V1}/_{\mathrm{T}V}(\mathrm{PC1}) + {}^{V2}/_{\mathrm{T}V}(\mathrm{PC2}) + \ldots + {}^{V_m}/_{\mathrm{T}V}(\mathrm{PC}_n) \tag{3}$$

where V_1 and V_2 are the proportion of variation explained by the 1st and 2nd principal components, TV is the total variation explained by the retained factors (components), PC_1 and PC_2 are the factor score coefficients for the 1st and 2nd components, V_m represents the proportion of variation explained by the mth principal component, and PC_n is the factor score coefficients (PCs). However, it is problematic to interpret the values of NSFSI given that they can be positive or negative. To facilitate the

[4] Food Security Index is a composite index constructed to capture the four dimensions (availability, access, utilization, and stability) of food security.

interpretation, the values were standardized using the following formula:

$$SFSI = \frac{(\text{Actual Value of NSFSI of HHn} - \text{Minimum Value of NSFSI of HHn})}{(\text{Maximum Value of NSFSI of HHn} - \text{Minimum Value of NSFSI of HHn})} * 100 \quad (4)$$

HHn represents *n*th household in the data set. The value of this index ranges from 0 to 100. The higher values of the index show better food security status of the studied households and vice versa. A similar approach was applied in previous researches [107, 108].

Before running PCA, we checked for the presence of outliers in our data set as they can distort PCA results and interpretations using the Q_Q plot. We detected outliers in daily calorie consumption (aeu_kcalF) and transformed it using a natural logarithm to correct the problem (Appendix 2). We also tested the aptness of carrying out PCA for our data set using Kaiser–Meyer–Olkin (KMO) sampling adequacy. The range of values of KMO is between 0 and 1, where values above 0.9 are considered as "excellent", between 0.8 and 0.9, "great", 0.7 and 0.8, "good", 0.5 and 0.7, "mediocre", and below 0.50, "gloomy" [107, 108]. In our case, the result was 0.694, showing PCA is appropriate for our data (Table 2). The Bartlett's Test of Sphericity was also carried out to test the strength of the relationship among variables. This measure tests the null hypothesis that the original correlation matrix is an identity matrix or that variables observed in the population correlation matrix are uncorrelated [107]. Our result showed a highly significant level of 0.000 (Table 2), a value that is sufficient to reject the null hypothesis. It can be concluded that the correlation matrix is not an identity matrix as is required by factor analysis, such as PCA to be valid.

To decide the number of factors to be retained, we applied one of the most commonly used criteria, known as Kaiser's criterion, or the eigenvalue rule. As per this rule, factors with at least an eigenvalue of one must be retained. In our analysis, only two components (factors) fulfil this criterion (Table 3) and are, therefore, used for further analysis of the food security index. We also carried out a graphic method (scree test) to check the number of factors to be retained. The result revealed that only two factors had to be extracted for analysis (Appendix 3).

Table 2 KMO test and Bartlett's test of sphericity

Measure of sampling adequacy	Bartlett's test of sphericity		
	Chi-square	***df***	**Sig**
0.694	465.597	21	0.000

Source: Own survey, 2018

We estimated factor score coefficients using the regression method. The result shows that two factors accounted for 54.9% of the total variance in the data set (Table 3). The first and second factors accounted for 36.54% and 18.35% of the total variation in the data, respectively (Table 3). Using these percentages as weights on the calculated factor score coefficients, we developed the NSFSI using Eq. 3 indicated above.

Propensity score matching (PSM)

In observational studies (like ours), to reduce selection bias that arises from treatment assignment conditional on observable characteristics, the PSM method is often recommended. This method is suitable to provide a cause-and-effect explanation in quasi-experimental design, construct statistical treatment and comparison groups, and measure the size of the impact on different outcome variables of interest [90].

Households affected by the investment (treatment group) and having similar basic observable characteristics to the non-affected ones (comparison) but differing only in intervention (LSAIs) were matched using the PSM technique. The matching was based on a distinctive variable, that is, the propensity score. Following Ronsenbaum and Rubin [90], propensity score, the conditional probability that a given household is exposed to a treatment (LSAIs) given pre-treatment characteristics X is expressed as

$$_{P}X = P(Z = 1|X) = E(Z = 0|X) \quad (5)$$

where $Z = \{0,1\}$ is the indicator of exposure to treatment (LSAIs) and X is multidimensional vector of pre-treatment characteristics (covariates). For the simplification purpose, let us define the treatment indicator as Z_i, where Z_i equals 1 if a household i is affected by the investment and zero otherwise. Let us define the potential outcomes

Table 3 Total variance explained

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.55755	1.27282	0.3654	0.3654
Comp2	1.28473	0.362981	0.1835	0.5489
Comp3	0.921748	0.117985	0.1317	0.6806
Comp4	0.803763	0.206952	0.1148	0.7954
Comp5	0.596811	0.147619	0.0853	0.8807
Comp6	0.449192	0.062989	0.0642	0.9448
Comp7	0.386203		0.0552	1.0000

Source: Own survey, 2018

Table 4 Description of the variables and measurement scale

Variable	Type	Description
Dependent (treatment) LSAIs	Dummy	1 if a household is affected by the investment, 0 otherwise
Outcome variables		
Food energy intake	Continuous	Daily Kcal per adult equivalent
MAHFP	Continuous	Months of food adequacy
HDDS	Continuous	The number of food groups consumed
FCS	Continuous	Food consumption score
HFIAS	Continuous	HFIAS score
CSI	Continuous	A composite score
Food expenditure share	Continuous	Percentage
Food security index	Continuous	A composite index
Covariates		
Sex of household head	Nominal	1 if the head is male, and 2 if female
Marital status of household head	Nominal	1 = single, 2 = married, 3 = widowed, 4 = divorces
Age of household head	Continuous	Years
Education level of household head	Categorical	0 = illiterate, 1 = read and write, 2 = primary, 3 = secondary, 4 = Certificate after high school complete, 5 = diploma and above
Main occupation	Nominal	1 if the head engaged in crop farming or mixed (crop farming and livestock rearing, and 2 all others
Family size	Continuous	Number of family members
Dependency ration	Continuous	Ratio of dependent family members to the productive age groups
Farm land size	Continuous	Size of farm land in hectares
Livestock ownership in (TLU)	Continuous	Tropical Livestock Unit
Distance to potable water points	Continuous	Walking distance in minutes from home
Distance to all weather road	Continuous	Walking distance in minutes from home
Distance to health center	Continuous	Walking distance in minutes from home
Distance to school	Continuous	Walking distance in minutes from home
Distance to market	Continuous	Walking distance in minutes from home
Livelihood index	Continuous	An index
Access to credit	Dummy	1 if a household has access, 0 otherwise
Radio as a source of information	Dummy	1 if a household use radio, 0 otherwise
Family as a source of information	Dummy	1 if a household use family, 0 otherwise
Kebele administration as a source of info	Dummy	1 if a household use *Kebele* admn., 0 otherwise
DA as a source of information	Dummy	1 if a household use DA, 0 otherwise
Improved seed or livestock breeds	Dummy	1 if a household use improved seed or breeds, 0 otherwise

Source: Own Survey, 2018

(food security) as $Y_i(Z_i)$ for each household i, where $i = 1,2,\ldots,N$. In the potential outcome model, for each household i, the difference between the outcomes of treated and comparison groups (treatment effect) can be expressed as

$$\delta i = Y_{1i} - Y_{0i}, \tag{6}$$

where δi is the treatment effect, Y_{1i} is food security status of ith affected household, and Y_{0i} is food security status of ith non-affected household. However, the fundamental challenge in this model is, we cannot estimate $\delta_i = Y_{1i} - Y_{0i}$ for each household i, for the reason that two potential outcomes (Y_1 and Y_0) for the same household cannot be observed simultaneously [90, 94]. The unobserved outcome is often called the counterfactual outcome [90, 91]—"what would have happened to food security status of the households who are exposed to the investment if they had not exposed to or experienced such event".

In general, for the treated group, the outcome after households exposed to the investment Y_{1i} can be observed, but the untreated outcome Y_{0i} cannot be directly observed. Likewise, for the non-affected group, the treatment outcome before investment (Y_{1i}) cannot be directly observed but the untreated outcome (Y_{0i}) can be observable. This problem is often called a missing data problem and can be solved by techniques of causal

Table 5 Summary statistics for outcome variables

Variable	Statistics								*t*-test
	Affected HH ($n = 157$)				Non-affected HH ($n = 185$)				
	Mean	SD	Min.	Max.	Mean	SD	Min.	Max.	
FEI	1932.86	1232.12	242.76	8006.42	2119.84	1447.85	243.54	15,049.7	− 1.4307
MAHFP	8.80	1.88	5	12	9.4	1.38	6	12	− 3.3864***
HDDS	4.1	1.71	1	9	4.65	2.00	1	11	− 2.7825**
FCS	33.1	12.13	6	57	36.9	14.6	8	84	− 2.5670*
HFIAS	9.40	6.89	0	21	8.72	7.75	0	26	0.8464
CSI	30.9	23.1	0	156.5	24.7	24.1	0	125	2.4052*
Food exp.	0.71	0.222	0	1	0.62	0.273	0	1	− 3.3974***

Source: Own survey data, 2018

$^{+}$ $p<0.10$, *$p<0.05$, **$p<0.01$, ***$p<0.001$

inference (such as PSM) executed through counterfactuals [92, 94, 109]. If the propensity score ($_pX_i$) for each household i is properly estimated, then following Rosenbaum and Rubin [90], the Average Treatment Effect on the Treated (ATT) can be estimated as follows:

$$\text{ATT} = E\{Y_{1i} - Y_{0i}|Z_i = 1\} \tag{7}$$

$$= E[E\{Y_{1i} - Y_{0i}|Z_i = 1, p(X_i)\}] \tag{8}$$

$$= E\big[E\big\{Y_{1i}|Z_i = 1, p(X_i)\big\} - E\big\{Y_{0i}|Z_i = 0, p(X_i)\big\}|Z_i = 1\big]. \tag{9}$$

The main purpose of PSM is not to predict treatment but to balance covariates across treated and comparison groups, efficiently control the confounding, and thus reduce bias [90, 91, 110, 111]. However, if serious attention is not given to the proper design and model specification as well as the use of other alternative matching methods, PSM could lead to inefficiency, augmented imbalances, model dependency, and statistical bias [112]. To address some of the shortcomings, we have checked the quality of covariate balance before and after matching and used different matching strategies (as explained below). We have also compared the results of PSM with the ones that we generated through inverse-probability weights matching (IPW) and coarsened exact matching (CEM) strategies (see Appendixes 9 and 10: Tables 12, 13, 14, 15). Overall, the results generated via IPW and CEM are fairly consistent with the ones estimated through PSM (presented in the subsequent section 4.2), indicating the robustness of our findings.

We estimated the propensity score (PS) using a logistic model, where the vector of household characteristics X was regressed on (PS). The covariates included in the propensity model were based on some theoretical reflections that recommend using covariates that are relatively stable over time or evidently exogenous to the treatment [113], are potentially related to the treatment and outcome variables [91], and previous empirical studies [10, 33]. The description of the variables used in the PSM model is summarized in Table 4.

Once we completed the estimation of a propensity score for each household, we defined the region of common support to make sure that there was an adequate overlap in the range of propensity scores for the treatment and comparison groups. We assessed the validity of common support assumptions by examining a graph of the propensity score for treated and comparison groups (Appendix 4). The graph confirms the presence of a sufficient overlap in the distribution of the propensity scores across the treatment and comparison groups, suggesting that the identification assumption of common support is met.

Following this evaluation, we carried out balancing tests to check whether or not, within each quintile of the propensity score distribution, the average propensity score and mean of covariates have a similar distribution (balance) across the treated and comparison groups. The two-sample t test result shows that the mean propensity score is not different for treated and comparison groups in each of the five-blocks at p 0.001. Five blocks ensure that the mean propensity score is not different for treated and comparison groups in each block (Appendix 5). After ensuring that the propensity score is balanced within each block across the treatment and comparison groups, we checked whether or not each covariate is balanced across both groups within blocks of the propensity score. The result of the test shows that all covariates are balanced in each block (p value is greater than 0.01) but the distance to the all-weather road (Appendix 6). In general, the result illustrates a strong confirmation that after getting the balance of propensity scores within each stratum, the covariates attain overlap in terms of distribution.

Table 6 Impacts of LSAI on the food security status

FS indicator	Matching method[a]	Matched sample		Impact (ATT)	Standard error[b]	*t*-value
		Affected	Unaffected			
Food energy intake	NN	155	60	− 0.153*	0.077	− 1.980
	Radius	114	138	− 0.113	0.081	− 1.400
	Kernel	155	148	− 0.093	0.070	− 1.335
	SS	155	148	− 0.111	0.074	− 1.493
MAHFP	NN	155	60	− 0.632*	0.290	− 2.182
	Radius	114	138	− 0.570*	0.257	− 2.219
	Kernel	155	148	− 0.899***	0.232	− 3.873
	SS	155	148	− 0.912***	0.265	− 3.438
HDDS	NN	155	60	− 0.368	0.398	− 0.925
	Radius	114	138	− 0.743*	0.347	− 2.139
	Kernel	155	148	− 0.652+	0.367	− 1.774
	SS	155	148	− 0.752+	0.398	− 1.888
FCS	NN	155	60	− 0.744	2.647	− 0.281
	Radius	114	138	− 4.689*	2.232	− 2.101
	Kernel	155	148	− 4.939**	1.868	− 2.644
	SS	155	148	− 5.368*	2.170	− 2.474
HFIAS	NN	155	60	0.697	1.254	0.556
	Radius	114	138	0.683	1.167	0.585
	Kernel	155	148	1.735	1.125	1.543
	SS	155	148	2.135*	1.047	2.038
CSI	NN	155	60	6.345 +	3.603	1.761
	Radius	114	138	7.803*	3.794	2.057
	Kernel	155	148	10.42***	2.718	3.833
	SS	155	148	10.90***	2.943	3.703
Food share expenditure	NN	155	60	0.0286	0.055	0.520
	Radius	114	138	0.106**	0.041	2.621
	Kernel	155	148	0.111**	0.040	2.771
	SS	155	148	0.113*	0.046	2.423
Overall impact (FS index)[c]	NN	155	60	− 4.523	2.925	− 1.546
	Radius	114	138	− 8.158**	2.636	− 3.095
	Kernel	155	148	− 9.050***	2.686	− 3.369
	SS	155	148	− 9.963***	2.546	− 3.914

Sources: Own survey data, 2018

[a] Radius matching was carried out with a caliper of (0.01)

[b] Bootstrapstandard error was computed based on 100 replications

[c] Food security index is created via Principal Component Analysis (PCA)

[+] $p < 0.10$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Before estimating the actual impact, we checked whether or not the treatment and comparison groups were balanced in the matched samples. We used statistical techniques, such as a two-sample *t* test, standardized bias (SB), and percent bias reduction (PBR). We also used pseudo-R^2 to check that, after matching is completed, there should be no systematic differences in the distribution of covariates between both treated and comparison groups, and so the pseudo-R^2 should be quietly low. The results of the covariate balancing test before and after matching are presented in Appendix 7. The two-sample *t* test result shows that after matching for all covariates; the mean differences are insignificant, suggesting that the covariates are balanced. Moreover, the average standardized bias difference for all covariates was reduced from 21.5 before matching to 6.5 after matching. Significant percent bias reduction (PBR) after matching (for the majority of the covariates) was also achieved (Appendix 7). Likewise, the pseudo-R^2 was notably dropped from 0.279 before matching to as low as 0.028 after matching.

Table 7 Impact attribution

Indicator	Current FS level				Counterfactual FS level				Differences
	Food secure		Food insecure		Food secure		Food insecure		
	f	%	*f*	%	*f*	%	*f*	%	
MAHFP	55	35	102	65	101	64.3	56	35.7	29.3
HDDS	57	36.3	100	63.7	91	58	66	42	21.7
FCS	71	45.2	86	54.8	100	63.7	57	36.3	18.5
HFIAS	37	23.6	120	76.4	72	45.9	85	54.1	22.3
CSI	38	24.2	119	75.8	65	41.4	92	58.6	17.2
Food exp.	50	31.9	107	68.1	82	52.2	75	47.8	20.3

Source: Own survey, 2018

When we inspect the *p* values of the likelihood tests, it shows that the joint significance test of covariates is not rejected before matching ($p<0.01$) but it could be rejected after matching ($p>0.05$) (Appendix 7). All tests suggest that the specification of the propensity score is effective in balancing the distribution of covariates between the affected and non-affected households.

Sensitivity analysis is imperative in PSM because of some strong assumptions, such as CIA, that say selection process is accounted for by observable characteristics. We carried out sensitivity analysis using the "Rosenbaum bounds approach" [114]. The result shows that the impact of LSAI on the food security status of affected households is not sensitive to hidden bias (unobserved characteristics that could bias the estimated impact) ($p<0.001$). Even when we increased the value of gamma from 1.0 to 2.0, the conclusion does not change across all outcome variables and all matching strategies used in the PSM model, showing that the result is insensitive to hidden bias (is robust) (Appendix 8).

Results and discussion

Descriptive analysis

We carried out a descriptive analysis to summarize the results of the outcome variables and check mean differences between affected and unaffected households. The result shows that the households that are affected by LSAIs, on average, consumed food items that provided 1932.86 kcal per adult equivalent per day, which is slightly below the daily caloric intake recommended (2100 kcal) for an individual. For non-affected households, it was 2119.84 kcal per adult equivalent per day, which is a bit higher than the daily caloric intake recommended for an individual (Table 5). In general, households that were affected by the LSAIs consumed 9.7% fewer calories than the non-affected ones. However, the mean difference in Kcal per adult equivalent per day between affected and non-affected households is not statistically significant (Table 5).

Using the MAHFP indicator, on average, the affected households provided adequate food for their families for 8.8 months, while non-affected households provided it for 9.4 months, which is 0.6 months less (Table 5). The mean difference in MAHFP between affected and non-affected households is statistically significant (at $p<0.01$) (Table 5). The result indicates that affected households, on average consumed 4.1 varieties of food groups, whereas the non-affected households consumed about 4.65. The mean FCS of affected and non-affected households was 33.1 and 36.9, respectively (Table 5). The mean differences between affected and non-affected households are statistically significant at $p<0.01$ and $p<0.05$ for HDDS and FCS, respectively (Table 5), showing that food insecurity is high amongst the affected households.

The HFIAS result showed that the average HFIAS scores for affected and non-affected households were 9.4 and 8.72, respectively (the higher the HFIAS score, the more a household is food insecure) (Table 5). However, the mean difference in HFIAS score is not statistically significant (Table 5). The average CSI score among the affected and non-affected households was 30.9 and 24.7 (Table 5), showing that the magnitude of food insecurity is higher among the affected households by 15.3%. The higher the value of CSI, the more food insecure the household is. The mean difference in CSI score is statistically significant (at $p<0.05$) (Table 5), indicating that affected households used more severe coping strategies (more vulnerable to food insecurity) than non-affected ones. Using the food expenditure share indicator, 68.1% and 51.4% of affected and non-affected households were food insecure (Table 5). Regarding spending on food, affected households on average spent 71% of their income on food, whereas non-affected ones spent 62% (Table 5). The difference in mean food expenditure share of affected and non-affected households is statistically significant (at $p<0.001$) (Table 5), indicating that affected households are more economically vulnerable to food insecurity. Research shows that the poor or more food-insecure households spend the lion's share of their money on food items [41].

Impact estimation

Simple comparisons of mean differences between affected and non-affected households could not explain the effect of other households' characteristics that may confound the impact of LSAIs on their food security status. Hence, for a more meticulous and actual impact estimation of LSAIs on food security, we applied the PSM model. We estimated the average treatment effect on the treated (ATT) using the nearest neighbourhood (NN), radius, kernel, and stratification (SS) matching strategies.

Impact on food availability

Using the combination of four matching strategies, LSAIs on average have decreased the average daily calorie consumption of affected households by 15.3% NN, 11.3% for radius, 9.3% for the kernel, and 11.1% for SS matching (Table 6). The result shows that, on average, LSAIs have led to a 9.3–15.3% reduction in the food energy intake of households affected by the investments, which is statistically significant at $p < 0.05$ for NN matching. The impact of LSAIs on affected households ranged from 0.57 to 0.91 in terms of the fall in MAHFP. LSAIs, on average, have reduced MAHFP by 0.632 months for NN, 0.57 for radius, 0.9 for kernel, and 0.912 months for SS matching (Table 7). The result indicates that LSAIs have a statistically significant negative impact on MAHFP at either $p < 0.05$ or 0.001. In general, on average, LSAIs have increased the number of months of food shortages of the affected households from 0.57 to 0.91 more months than those who were not affected by the investment, implying that LSAIs have intensified the food shortage problem of the community. The status of food insecurity of the affected households would have been 35.7% if they had not experienced such an event, showing that food insecurity has increased to the present 65% (Table 7) due to the loss of access to land and important forest resources.

Natural resources have vital economic and food value for the *Anuak*. However, investors in the study area have adopted an enclave business model that restricts the access of the local community to the source of their food and reduces food availability at the local and household levels. LSAIs in the study area have also been producing cash crops (food and non-food) for export and so have constrained the supply of food (availability) at the local level [115].

Impact on food utilization

In terms of HDDS, on average, LSAIs have reduced the number of food groups consumed by affected households by 0.37 for NN, 0.743 for radius, 0.652 for kernel, and 0.752 for SS matching (Table 6). On average, the affected households consumed 0.37–0.75 fewer food groups than those non-affected ones, which is statistically significant at either $p < 0.05$ or $p < 0.10$, indicating that the investments had reduced the food diversity of the affected households. When we accounted for the estimated impact of LSAIs on HDDS, the result showed that 21.7% of affected households became food insecure due to the intervention. In other words, the level of food insecurity would have been 42% without LSAIs showing that the magnitude of food insecurity has exacerbated to the current 63.7% (Table 7). Likewise, the impact of the investments on the FCS of affected households ranged from 0.744 to 5.37 reductions in values of the score. The difference in FCS between affected and non-affected households due to the investment, on average, was 0.744, 4.69, 4.94, and 5.37 for NN, radius, Kernel, and SS matching, respectively.

The result shows that affected households have a lower FCS by a score of 0.7–5.37 than their counterpart non-affected ones, which is statistically significant at either $p < 0.05$ or $p < 0.01$ (Table 6). When the impact of LSAIs is attributed, the result shows that 18.5% of affected households become food insecure due to the intervention. That is, the magnitude of food insecurity would have been 36.3% without LSAIs, showing that the magnitude of food insecurity has worsened to the current 54.8% (Table 7).

As indicated above, the livelihood of the *Anuak* is immensely interlocked with the forest, which becomes a source of a diverse variety of foods, but is destroyed by the investments. For example, according to [10] the *Anuak* collect diverse fruits, seeds, and roots from the forest to diversify and enhance their food consumption. Besides, the *Anuak* often used to collect wild honey and hunt wild animals (game meet) for consumption (diversify food), though they lost these items of food due to the demolition of the forest.

Impact on food access

The impact of LSAIs on the affected households ranged from 0.68 to 2.1 in terms of increasing HFIAS scores. The investments, on average, have increased the HFIAS score of affected households by 0.697, 0.683, 1.74, and 2.14 using NN, radius, Kernel, and SS matching, in that order. The HFIAS score of affected households was on average higher by 0.69–2.1 points than non-affected households, which is statistically significant at $p < 0.05$ (for SS matching) (Table 6). The result indicates that affected households have a higher HFIAS score than non-affected ones, suggesting that the investments have reduced food access of the *Anuak* community. This means that affected households have higher anxiety regarding not being able to acquire adequate food, lower capacity to obtain sufficient quality food, and higher experience of an inadequate quantity of food ingestion than those non-affected ones. In general, when the estimated impact of LSAIs on the affected households using the HFIAS score is accounted for, 22.3% of affected households become food insecure after the intervention. That is, the status of food insecurity of the affected households would have been 54.1% if they had not experienced the intervention, indicating that food insecurity has deteriorated to the present 76.4% (Table 7).

As pointed out above, natural resources are the major source of income for the *Anuak*. To boost their income and diversify their livelihood, the *Anuak* have the tradition of collecting and selling medical plants, forest honey, wild roots, fruits, and vegetables in the market. However, their source of income is impaired by LSAIs without creating and offering alternative livelihood opportunities to them [7, 10, 115]. Employment is also one of the major mechanisms through which LSAIs can be translated into local benefits (such as improved income, purchasing power, and thus, access to adequate quality food). Nevertheless, the income contribution of the LSAI via job creation that might offset the adverse impacts of the investments on food security (food access) is trivial in the study area [10, 115]. Employment opportunities created by LSAIs in the study area were found to be insufficient, excludable (favouring migrants), seasonal, and paying low wages [10, 115]. It is apparent that the expansion of infrastructure in less developed areas such as *Abobo wereda* could unarguably boost the prospects of the local community's access to the market and, thus, food. Even if the contractual agreement requires the investors to build hard infrastructure (such as roads, bridges, and boreholes, among other things), studies have shown that investors' attempt to develop such infrastructure are very low [115].

Impact on food stability (economic vulnerability)

Using the CSI indicator, on average, LSAIs have increased the weighted values of coping strategies by 6.35 for NN, 7.8 for radius, 10.4 for kernel, and 10.9 for SS matching (Table 6). In general, the affected households adopted coping strategies with weighted mean values 6.3–10.9 higher than those who were not affected by the investment, which is statistically significant at either $p < 0.001$, 0.05, or 0.1 (Table 6). The result suggests that the investments have augmented the magnitude of food insecurity of the affected households, as shown by the higher CSI than their non-affected comparison group. Based on this indicator, 17.2% of affected households fell into food insecurity due to LSAIs. That is, the status of food insecurity of the affected households would have been 58.6% if they had not been affected by such events, indicating that food insecurity has increased to the present 75.8% (Table 6). As far as food expenditure share is concerned, on average, LSAIs have increased the food expenditure share of the affected households by 3% for NN, 10.6% for radius, 11.1% for kernel, and 11.1% for SS matching (Table 6). On average, affected households spent more money on food (3–11.3%) than non-affected ones, which is statistically significant at either $p < 0.01$ or $p < 0.05$ (Table 6). The impact of LSAIs on food expenditure share shows that 20.3% of affected households became food insecure after the intervention, showing that the investments have aggravated the economic vulnerability of the investment hosting community. Explicitly, the magnitude of food insecurity would have been 47.8% without the intervention, showing that the scale of food insecurity has intensified to its current 68.1% (Table 7).

In general, the loss of farmland and forest resources that would otherwise serve as a vital source of consumption smoothing strategy during times of food shortages made the *Anuak* worst off and more vulnerable to food insecurity. When LSAIs result in the loss of farm and forest lands, it can have shocking effects on the targeted community, both by potentially decreasing the actual food supply and access to it and by destroying their livelihoods [61, 116].

Impact on overall food security status

Besides examining the impact of LSAIs on various dimensions of food security via multiple indicators shown above, we created a composite food security index and estimated the impact. The result shows that, on average, LSAIs have decreased the food security status of affected households by 4.5% for NN, 8.2% for radius, 9.1% Kernel, and 9.96% for SS matching (Table 6). This reveals that, on average, food security status of the affected households is lower by 4.5–9.96% of those who are not affected by the investments, which is statistically significant at $p < 0.05$ or $p < 0.001$ (Table 6). The decline in food security index of the households implies that LSAIs have significantly reduced the food security status of the local community. In general, the considerable loss of natural resources (land and forest) coupled with the failure of investors and government to generate the perceived benefits has led to a deterioration of food security in the study area.

The government of Ethiopia has an obligation to respect and protect the rights of the local community and ensure their food security. As indicated in the conceptual framework and subsequent explanations, the government has promoted LSAIs in the country in general and the study area in particular, on the grounds that the investment would play a key role in improving local-level food security. However, the government has failed to oversee the investment projects and respect the rights of the investment hosting community to food. For example, several studies have reported that the affected communities were neither consulted nor involved in the land contact decision-making process [8, 10, 12, 19, 28, 115]. Land governance systems and institutions were also found to be weak to safeguard the affected community from potential and actual costs caused by LSAI and ensure the benefits (employment, infrastructure, technological transfer) that the investment projects are expected to generate [10, 115]. The development approach that the government adopted to promote the production of food crops for export and industrial crops, along with the extractive or enclave business model adopted by the investors, have also contributed to the negative impacts of LSAIs on the food security status of the local community in the study area.

On the whole, LSAIs are expected to create employment opportunities to the investment hosting community and improve their income, and, thus, their access to food. However, the contribution of LSAIs to wage employment creation in the study area is extremely limited [10, 115]. For example, according to [115], only 40 out of 123 (32.5%) investors operating in the study area had created jobs. Out of the total of 1106 jobs created in the *woreda*, the proportion of the *Anuak* community is extremely low (174, or 15.7%). Job opportunities are also highly seasonal with low wage rates (on average 0.9–1 USD per day) [115]. This evidence shows that the employment (income) effect of LSAIs in the study area is trivial. Several studies in Africa [117–119] also reported that the expected benefits of LSAI via employment do not materialize as investors have created limited job opportunities for the investment hosting community. Besides, the government and investors have failed to materialize the promise of infrastructure development [8, 10, 115]. That is, the anticipated benefits from the construction of roads, schools, health centres, water points, irrigation facilities, and market linkages do not occur. Rather than developing infrastructure, the majority of investors have destroyed roads with the movement of heavy machinery and tracks and created a scarcity of potable water by over-utilizing water points that were developed by the government for the local community [115]. The maxims of improving agricultural production and productivity through technological transfer are also missing in the study area [8, 10, 115].

As indicated in the conceptual framework section, LSAI could have either positive or negative impacts on the food security status of local communities. Our research finds that the investment has a negative impact for the reasons explained in several sections of the paper. Our results are consistent with most of the recent studies in Africa that have shown negative impacts of LSAIs on food security [32, 54, 61–69]. Our findings are in line with a few studies that have uncovered a negative impact of such investments on the food security status of affected communities in Ethiopia [10, 33], as well. Our findings have also confirmed the assertion that LSAIs have potential negative impacts on food security in Ethiopia [7, 19, 23–25, 30, 31, 34, 59, 75, 95, 120]. Several studies, however, have reported the positive impacts of LSAIs on the food security status of investment-hosting communities [21, 69, 73, 75]. This positive spillover was observed in the areas, where investment projects have adopted inclusive and fair business models; integrated the investment hosting community into local, national, and international value chains; respected the local community's right to food and culture; and where government institutions are strong enough to create a "win–win–win" environment.

Conclusion and policy implication

Abobo Woreda is blessed with natural resources, such as forests, wetlands, woodlands, savanna grassland and water bodies (*Alwero* River and Dam). These resources are the foundation of the livelihood of the *Anuak* and their sources of food. However, LSAI projects are designed and implemented by the government and investors (via enclave and top down approaches) without considering the local context (i.e., the livelihood of the local community). Besides, alternative livelihood options are not made available to investment recipients. As a result, the investments have endangered the livelihoods of the communities and threatened their food security.

This study used multiple indicators of food security to analyse the impact of LSAI on the food security status of the *Anuak* community. The study finds that LSAIs have a negative impact on the availability, access, and utilization dimensions of food security. The investments have significantly reduced the MAHFP, HDDS, and FCS of the affected households. LSAIs have, on average, increased the HFIAS scores of the affected households, showing the shrinkage of access of the local community to food. The investments have also increased the economic vulnerability of the affected households, as detected through high scores of CSI and their expenditure share on food items. The results estimated through the composite food security index suggest that LSAIs have a significant negative impact on the overall food security status of the affected households. The message from these findings is that LSAIs have contributed to the deterioration of local communities' livelihoods and exacerbated the food insecurity problems of the affected households compared to what they would have been without the investment. We conclude that the Ethiopian government and private investors have failed to generate the benefits that they aspire at the local level to ensure the food security status of the affected community.

We, therefore, urge the government and investors to give attention to local people's needs and welfare and safeguard their right to food within the broader context of expanding their livelihood options and making LSAIs a sustainable, responsive, accountable, and people-centered endeavor. The government should also look at other complementary investment alternative models that could diversify the livelihoods of the local community. For example, as the study area is endowed with diverse natural resources, the government should design alternative investment initiatives (compatible with local people's livelihood and environment) such as controlled hunting, game ranching, fishing, ecotourism, and modern livestock nurturing that can benefit the investors, government, and local people without destructing the ecosystem, flora and fauna, and food security of the local community rather conserve, enhance, and sustain them. Besides, the government, in collaboration with other key stakeholders (private and civil society sectors), should install a transparent system that guarantees local communities' involvement in decision-making and ensures their free, prior, and informed consent at each stage of LSAI project administration in such a way that empowers them, diversifies their livelihoods, and ensures their food security.

Our study is not free from limitations. First, our results may not be generalized to other communities that have different culture and livelihood strategies than the *Anuak*. However, we believe that regardless of the differences in culture and livelihood strategies, the results can be generalized to areas and communities, where investors have adopted enclave business models, produced industrial mono-culture crops, created limited job opportunities with trivial welfare effects, and where government institutions are weak to govern the investment projects. Second, our study did not address the impact of LSAI on intra-household food security. We, therefore, suggest future studies to address intra-household food security dynamics as well as to consider communities with diversified livelihood strategies and cultures.

Appendix 1

See Fig. 2.

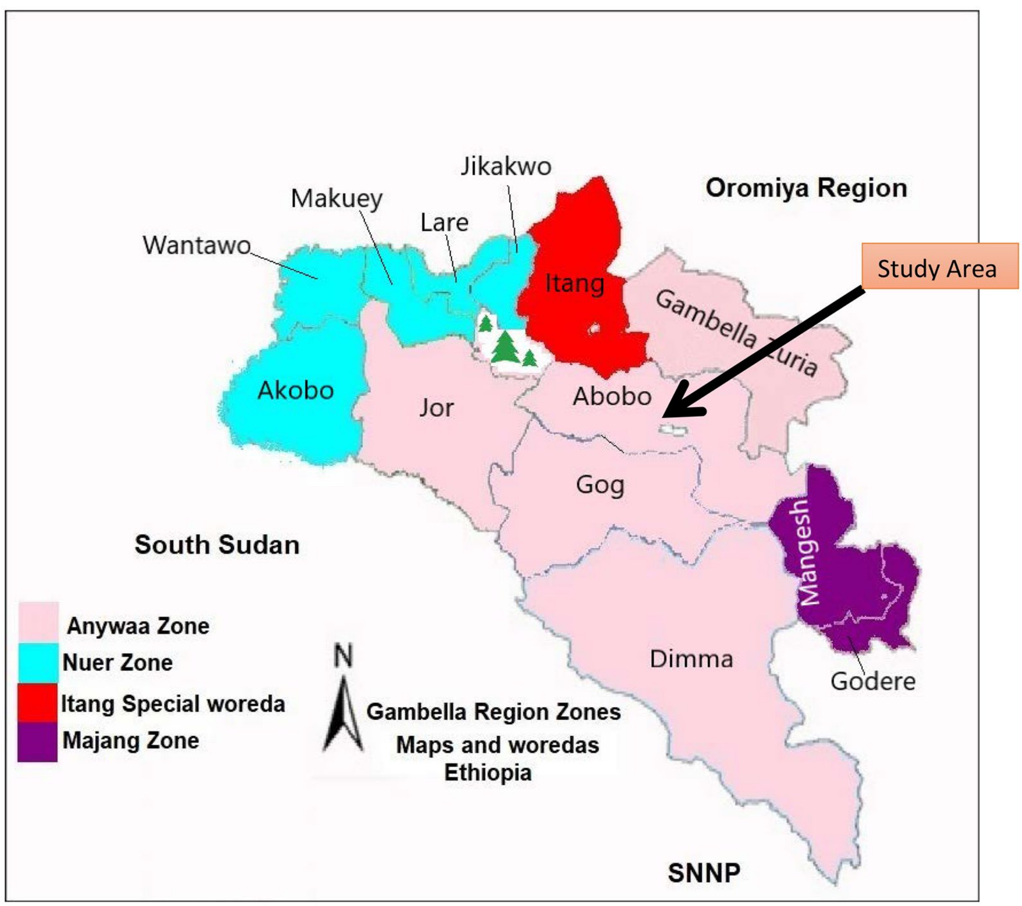

Fig. 2 Location of the study areas. Source: Gambella Region Investment Bureau, 2018

Appendix 2

See Fig. 3.

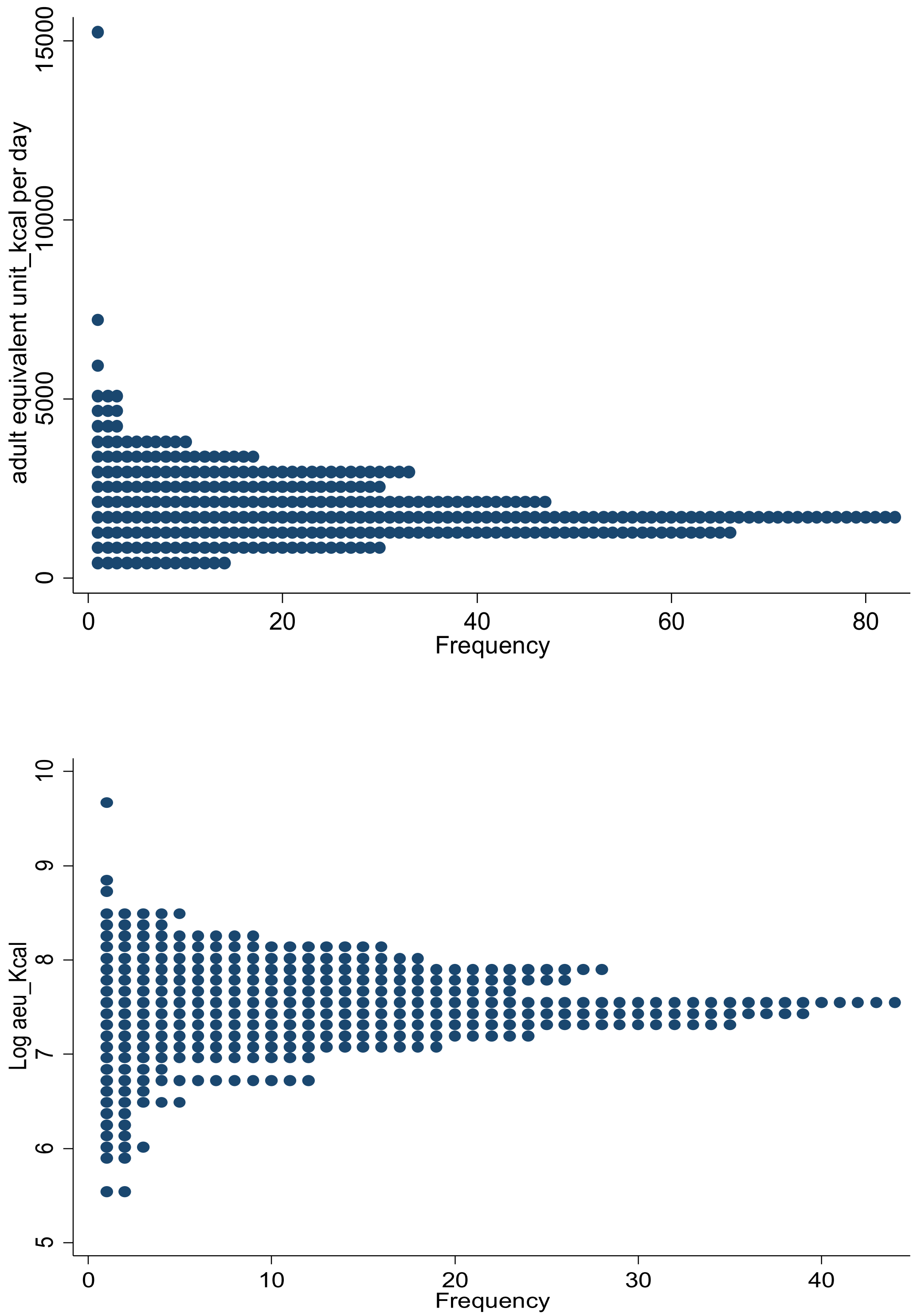

Fig. 3 Q_Q plot (A) before transforming the variable Kcal. Q_Q plot (B) after transforming the variable Kcal. Source: own survey, 2018

Appendix 3

See Fig. 4.

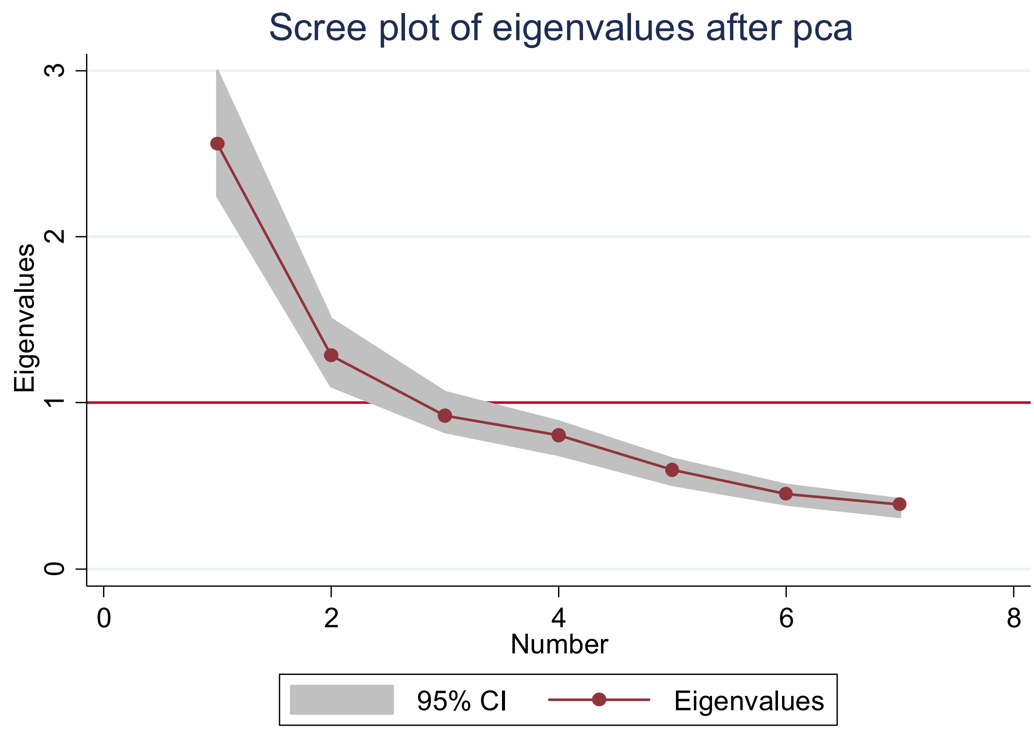

Fig. 4 Screeplot of eigenvalues of factors. Source: own survey, 2018

Appendix 4

See Fig. 5.

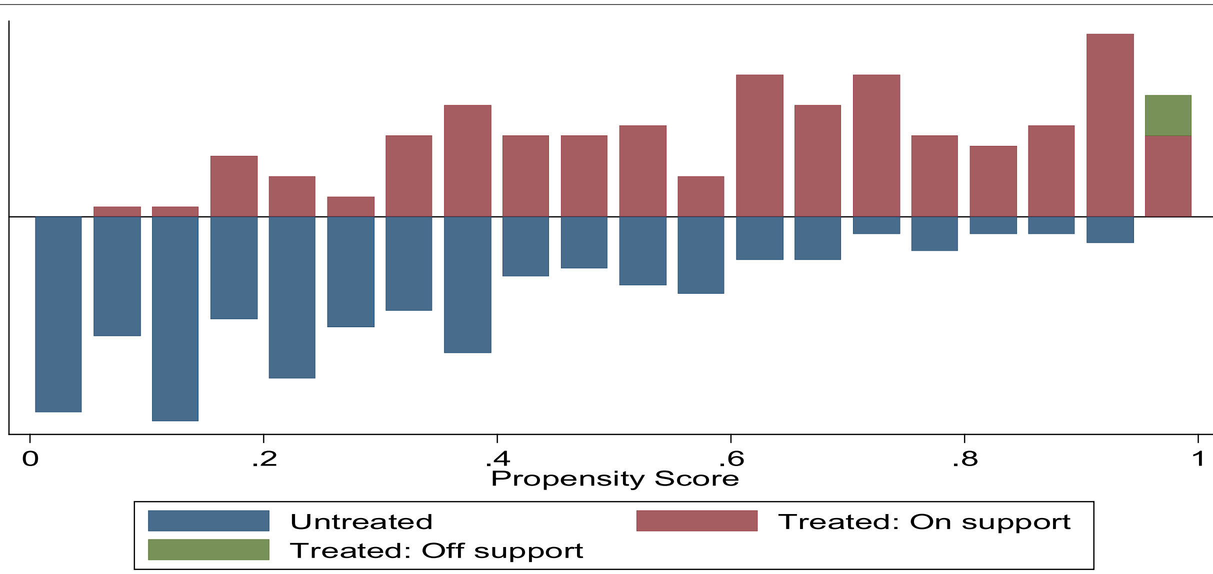

Fig. 5 Distribution of propensity score across treatment and comparison groups. Source: own survey, 2018

Appendix 5

See Table 8.

Table 8 Test of propensity score balance

Block of the pscore	Comparison group (*n*)	Treatment group (*n*)	Total (*n*)	*t*-test for matched
1	36	8	44	0.2053
2	59	25	84	0.0239
3	30	29	59	0.3128
4	16	47	63	0.7094
5	7	46	53	0.1938
Total (*n*)	148	155	303[a]	

The last column reports the p value of the mean propensity score for each block between treatment and comparison groups

Source: own survey, 2018

[a] 2 affected and 37 non-affected totally 39 households were found out of the common support areas

Appendix 6

See Table 9.

Table 9 Test of covariate balance

Variables	*t*-test for matched				
	Block ID				
	1	2	3	4	5
Sex	0.8692	0.2764	0.3632	0.9255	0.5794
Marital status	0.8135	0.1206	0.1537	0.9321	0.2720
Age	0.6959	0.8943	0.7704	0.1739	0.8333
Education	0.9118	0.5269	0.5838	0.5163	0.2263
Occupation	0.5064	0.6108	0.0727	0.0897	0.4961
Family size	0.7543	0.2214	0.5528	0.6012	0.7237
Dependency ratio	0.4582	0.7340	0.7469	0.3517	0.5850
Land size	0.7578	0.6698	0.2469	0.5430	0.1275
Livestock (TLU)	0.2249	0.6256	0.7002	0.5680	0.7612
Distance water point	0.0655	0.7668	0.7695	0.7358	0.3668
Distance to road	0.5922	0.0015	0.0576	0.7689	0.0211
Distance to education	0.7237	0.3610	0.8598	0.8377	0.2676
Distance to health	0.1028	0.2388	0.8855	0.7561	0.8138
Distance to market	0.3303	0.8451	0.4276	0.1426	0.1374
Livelihood index	0.4645	0.4892	0.6999	0.6885	0.1887
Radio as info source	0.5064	0.3137	0.9726	0.4818	0.2940
Ext. as info source	0.6271	0.9720	0.3757	0.5743	0.8925
Family as info source	0.3784	0.2261	0.8105	0.7266	0.2991
Admin as info source	0.9134	0.9407	0.5334	0.6096	0.2148
Access to credit	0.1313	0.2987	0.9099	0.9494	0.8545
Improved seed use	0.2810	0.1238	0.9327	0.8395	0.6737

The table reports the *p* value of each covariate for each stratum across affected (treated) and unaffected households (matched comparison) groups

Source: own survey, 2018

Appendix 7

See Table 10.

Table 10 Matching quality evaluation results

Variable	Un matched / Matched	Mean Treated	Mean Control	% bias	% reduct (bias)	t-test t	t-test p > |t|
Sex	U	1.3097	1.3081	0.3	− 3318.7	0.03	0.975
	M	1.292	1.3456	− 11.6		− 0.95	0.342
Marital status	U	2.3355	2.4108	− 11.2	63.2	− 1.03	0.305
	M	2.3066	2.3343	− 4.1		− 0.37	0.710
Age	U	39.187	41.389	− 20.9	31.9	− 1.90	0.058
	M	39.562	38.063	14.2		1.25	0.214
Education	U	1.9935	1.5189	31.9	94.0	2.93	0.004
	M	1.9343	1.9058	1.9		0.15	0.877
Occupation	U	1.0774	1.0649	4.9	18.6	0.45	0.654
	M	1.0876	1.0978	− 4.0		− 0.29	0.772
Family size	U	6.0581	5.5135	22.3	93.9	2.05	0.041
	M	5.9343	5.9011	1.4		0.12	0.905
Dependency ratio	U	106.39	94.115	13.4	82.9	1.23	0.219
	M	101.47	99.371	2.3		0.20	0.845
Land size	U	1.2268	1.6273	− 45.8	96.6	− 4.16	0.000
	M	1.2602	1.2466	1.6		0.15	0.881
Livestock (TLU)	U	1.2268	0.12501	21.2	37.4	1.96	0.051
	M	1.2602	0.20886	− 13.3		− 1.04	0.301
Distance to water point	U	6.0452	6.2595	− 2.4	− 296.8	− 0.22	0.823
	M	5.8248	4.9745	9.6		0.85	0.397
Distance to main road	U	19.29	9.1189	40.5	43.5	3.74	0.000
	M	17.102	22.847	− 22.9		− 1.28	0.201
Distance to school	U	7.6129	11.389	− 34.8	85.6	− 3.18	0.002
	M	8.0803	8.6234	− 5.0		− 0.48	0.632
Distance to health	U	29.284	17.859	27.3	92.5	2.55	0.011
	M	26.752	27.608	− 2.0		− 0.15	0.883
Distance to market	U	197.32	254.76	− 50.7	95.7	− 4.64	0.000
	M	200.11	202.56	− 2.2		− 0.19	0.851
Livelihood index	U	0.28966	− 0.24148	53.7	84.2	5.04	0.000
	M	0.14065	0.05648	8.5		0.74	0.459
Radio info source	U	0.11613	0.11351	0.8	− 123.3	0.08	0.940
	M	0.10219	0.09635	1.8		0.16	0.872
DA info source	U	0.60645	0.61622	− 2.0	− 176.6	− 0.18	0.855
	M	0.59124	0.61825	− 5.5		− 0.46	0.649
Family info source	U	0.33548	0.26486	15.4	41.6	1.42	0.157
	M	0.30657	0.26533	9.0		0.75	0.452
Admin info source	U	0.37419	0.21081	36.4	64.0	3.37	0.001
	M	0.30657	0.24781	13.1		1.08	0.279
Access to credit	U	0.43226	0.42703	1.1	− 241.9	0.10	0.923
	M	0.42336	0.40547	3.6		0.30	0.765
Improved seed use	U	0.34194	0.27568	14.3	100.0	1.32	0.188
	M	0.32117	0.32117	0.0		− 0.00	1.000

Sample	Ps R^2	LR chi^2	p > chi2	Mean bias	Med bias
Unmatched	0.279	130.78	0.000	21.5	20.9
Matched	0.028	10.67	0.969	6.5	4.1

Source: own survey, 2018

Appendix 8

See Table 11.

Table 11 Results of Rosenbaum sensitivity analysis

Gamma[a]	Indicators[b]							
	Kcal	MAHFP	HDDS	FCS	HFIAS	CSI	FE	FS Index
$\Gamma = 1$	0	0	0	0	0	0	0	0
$\Gamma = 1.1$	0	0	0	0	0	0	0	0
$\Gamma = 1.2$	0	0	0	0	0	0	0	0
$\Gamma = 1.3$	0	0	0	0	0	0	0	0
$\Gamma = 1.4$	0	0	0	0	0	0	0	0
$\Gamma = 1.5$	0	0	0	0	0	0	0	0
$\Gamma = 1.6$	0	0	0	0	0	0	0	0
$\Gamma = 1.7$	0	0	0	0	0	0	0	0
$\Gamma = 1.8$	0	0	0	0	0	0	0	0
$\Gamma = 1.9$	0	0	0	0	0	0	0	0
$\Gamma = 2.0$	0	0	0	0	0	0	0	0

Kcal, MAHFP, HDDS, FCS, HFIAS, CSI, FE, and FS index represent Kilocalorie per adult per day, Months of Adequate Household Food Provision, Household Dietary Diversity Score, Food Consumption Score, Household Food Insecurity Access Scale, Coping Strategy Index, Share of Food Expenditure, and Food Security Index, respectively

[a] Log odds of differential assignment due to unobserved factors

[b] Numbers presented in the column indicate upper bound significance level. The lower bound significant level is '0' for all indexes

Appendix 9

Results of covariate balance and treatment effect via inverse-probability weights matching (IPW). See Tables 12 and 13.

Table 12 Covariates balance summary

Number of observations		Raw		Weighted
		342		**342.0**
Treat observations		157		169.7
Control observations		185		172.3
Variable	**Standardized differences**		**Variance ratio**	
	Raw	**Weighted**	**Raw**	**Weighted**
hhhead_sex	0.0086092	− 0.0002477	1.008092	0.9998906
Marital_HHH	− 0.1092941	0.0383494	0.8199685	1.099758
age_hhhead	− 0.201809	0.0766109	0.7789605	0.8793335
edu_hh	0.3104894	0.0315416	0.9861348	1.021953
HHH_OCC	0.0450241	0.0006894	1.164896	1.002301
total_famsize	0.2004223	0.0120328	1.033727	0.9646712
dep_ratio	0.1230064	0.0292944	0.9124085	0.8594963
land_size	− 0.4637001	− 0.0609299	0.6501092	1.223166
livestock_tlu	0.2063226	− 0.149653	1.338235	0.4849166
distance_health	0.2681744	− 0.1253866	2.395219	0.7003591
distance_market	− 0.5013956	− 0.0364788	0.9154446	1.435774
acess_credit	0.0250797	− 0.0782048	1.007776	0.9872627
radio_infosou ~ e	0.0035633	0.1039974	1.009693	1.326099
family_infoso ~ e	0.145002	0.1440818	1.138736	1.136617
keblead_infos ~ e	0.3808343	0.0645619	1.420597	1.036628
DA_infosource	− 0.0227411	0.0940016	1.011387	.9692412
imprseed_use	0.1476102	0.1476096	1.131153	1.130154
Over identification for covariate balance test				
HO: covariates are balanced				
$Chi^2 = 10.784$				
$Prob > chi^2 = 0.9047$				

Source: own survey, 2018

We checked covariate balance by carrying out over identification test and checking the module adjusted difference in means and ratio of variance between the treated and comparison for each covariate. The result shows that the differences in weighted means are insignificant, and the variance ratio for most of the variables is close to one (Table 12). The over identification test shows that we accept the null hypothesis that says the covariates are balanced (Table 12). This test and diagnostics confirm that covariates are balanced

Table 13 Treatment effect estimation (IPW)

Treatment estimation				Number of obs = 342
Estimator				Inverse-probability weights
Outcome model				Weighted mean
Treatment model				Logit
Treatment				ATET
Indicator	**Coef.**	**Robust std. err.**	***Z***	***p* > |*z*|**
Food energy intake	− 0.1060458	− 0.0694508	− 1.53	0.127
Months of food adequacy	− 0.8144003	0.2310163	− 3.53	0.000
HDD	− 0.5938234	0.2744082	− 2.16	0.030
FCS	− 5.120672	1.964187	− 2.61	0.009
HFIAS	1.48602	1.018995	1.46	0.145
CSI	8.59194	3.004121	2.86	0.004
Food expenditure share	0.0765445	0.040002	1.91	0.05
Food security index	− 8.29121	2.451628	− 3.38	0.001

Source: own survey, 2018

Table 13 presents the results of treatment effects generated via the inverse-probability weights (IPW) matching strategy. Overall, the findings show the negative impacts of LSAI on the food security status of the local community. The results are consistent with the ones generated through CEM (Table 15) and PSM (the main manuscript).

Appendix 10

Results of covariate balance and treatment effect via Coarsened Exact Matching (CEM). See Tables 14 and 15.

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Table 14 Matching summary

Number of strata: 111							
No. of matched strata: 45							
			0				**1**
All			185				157
Matched			144				119
Unmatched			41				38
Multivariate L1 distance: 0.20343137							
Variable	**Univariate imbalance**						
	L1	**Mean**	**Min.**	**25%**	**50%**	**75%**	**Max.**
hhhead_sex	5.6e−17	4.4e−16	0	0	0	0	0
Marital_HHH	6.2e−17	8.9e−16	0	0	0	0	0
edu_hh	0.01366	0.01366	0	0	0	0	0
HHH_OCC	0.0028	− 0.0028	0	0	0	0	0
Age_headC	2.3e−16	8.9e−16	0	0	0	0	0
Family_sizeC	1.4e−16	1.1e−15	0	0	0	0	0
acess_credit	1.7e−16	2.2e−16	0	0	0	0	0
radio_infosource	0.05098	− 0.05098	0	0	0	0	0

Source: own survey, 2018

Table 14 shows that all variables are balanced in the mean value (the values are almost zero) as well as in the quantiles of all distributions (zero values). These balances in both mean values and quantiles of the distribution between treated and comparison groups can enable us to generate valid and robust results

Table 15 Treatment effect estimation (CEM)

Indicator	Coef.	Std. err.	*t*	*p* >|*t*|
Food energy intake	− 0.0918798	0.0667401	− 1.38	0.170
Months of food adequacy	− 0.7754902	0.1971752	− 3.93	0.000
HDD	− 0.5497199	0.2389546	− 2.30	0.022
FCS	− 3.645049	1.666621	− 2.19	0.030
HFIAS	1.037885	0.882693	1.18	0.241
CSI	7.393557	2.577846	2.87	0.004
Food expenditure share	0.0752113	0.0313216	2.40	0.017
Food security index	− 7.042927	2.00547	− 3.51	0.001

Source: own survey, 2018

The results presented in Table 15 show that LSAI has a negative impact on the food security status of the local community. In general, the results are similar to the ones generated through PSM and IPW matching strategies, indicating the validity and robustness of our results estimated via the PSM model

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40066-022-00381-6.

Additional file 1: Table S1. Nutrition-based adult equivalent conversion factor. **Table S2.** Description of Food Security Classification. **Table S3.** Grouping household's daily calorie intake into four point food security scale. **Table S4.** HFIAS Classification Algorithm. **Table S5.** Food groups and their weight in the FCS Approach. **Table S6.** Coping Strategy Weights.

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Author contributions

Dr. AKG designed the study, collected and analyzed the data. He also developed the draft manuscript. Dr. EAA and Professor DTD made a contribution to the research design, analysis, and revision of the draft manuscript. All the authors have read and approved the final manuscript.

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Part of the data collection expenses were covered by Addis Ababa University.

Availability of data and materials

The authors unanimously declare that they can submit the data at any time based on the request of editorial office. The corresponding author will provide the data used for this study based on sensible request.

Declarations

Ethics approval and consent to participate

Ethical approval was not applicable, but consent to participate in the research was granted by each respondent before engaging them in the data collection process.

Consent for publication

Not applicable.

Competing interests

The authors declare they have no competing interests.

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References

1. GRAIN. Briefing: Seized! The 2008 land grab for food and financial security. Saskatoon: GRAIN; 2008.
2. Deininger K, Byerlee D, Lindsay J, Norton A, Selod H, Stickler M. Rising global interest in farmland: can it yield sustainable and equitable benefits? Washington: The World Bank; 2011.
3. Cotula L. The international political economy of the global land rush: a critical appraisal of trends, scale, geography and drivers. J Peasant Stud. 2012;39(3–4):649–80. https://doi.org/10.1080/03066150.2012.674940.
4. Olanya D. From global land grabbing for biofuels to acquisitions of African water for commercial agriculture. Current African issues 50. Sweden: Nordiska Afrikainstitutet; 2012.
5. Borras S, Franco J. Global land grabbing and trajectories of agrarian change: a preliminary analysis. J Agrar Chang. 2012;12(1):34–59. https://doi.org/10.1111/j.1471-0366.2011.00339.x.
6. McCarthy JF, Jacqueline AC, Suraya A. Trajectories of land acquisition and enclosure: development schemes, virtual land grabs, and green acquisitions in Indonesia's Outer Islands. J Peasant Stud. 2012;39(2):521–49. https://doi.org/10.1080/03066150.2012.671768.
7. Dessalegn R. Land to investors: large-scale land transfers in Ethiopia. Ethiopia: Forum for Social Studies; 2011.
8. Amanuel K. Impact of large-scale agricultural investment on the livelihood of local community in Gambella region, Ethiopia. Ethiopia: Addis Ababa University; 2019.
9. Anseeuw W, Alden Wily L, Cotula L, Taylor M. Land rights and the rush for land: findings of the global commercial pressures on land research project. Rome: ILC; 2012.
10. Maru S. Economic and agricultural transformation through large-scale farming: impacts of large-scale farming on local economic development, household food security and the environment in Ethiopia. The Netherlands: Leiden University; 2016.
11. Von Braun J, Meinzen-Dick R. Land grabbing by foreign investors in developing countries: risks and opportunities. Washington D.C.: International Food Policy Research Institute (IFPRI); 2009.
12. Keeley J, Seide W, Eid A, Kidewa A. Large-scale land deals in Ethiopia: scale, trends, features and outcomes to date. London: International Institute for Environment and Development (IIED); 2014.
13. Robertson B, Pinstrup-Andersen P. Global land acquisition: neo-colonialism or development opportunity? Food Sec. 2010;2:271–83. https://doi.org/10.1007/s12571-010-0068-1.
14. Theting H, Brekke B. Land investments or land grab? A critical view from Tanzania and Mozambique. Norway: Spire; 2010.
15. The World Bank. Economic overview. Washington: World Bank; 2016.
16. GHA Team. Global humanitarian assistance report 2018. Bristol: Development Initiatives; 2018.
17. UN Office for the Coordination of Humanitarian Affairs (OCHA). Ethiopia: Red Sea 2019 Humanitarian Response Plan (HRP) Snapshot. New York: UN Office for the Coordination of Humanitarian Affairs (OCHA); 2019.
18. Belay F, Zekarias M, Aklilu A. The socio-economic impact of commune programs in Ethiopia: the case of Gambella regional state. Addis Ababa: Ethiopian Civil Service University; 2015.
19. Azeb W, Mauser W. Socio-economic and environmental impacts of large-scale agricultural investment in Gambella region, Ethiopia. J US China Public Adm. 2017;14(4):183–97. https://doi.org/10.17265/1548-6591/2017.04.001.
20. Cascão AE. Resource-based conflict in South Sudan and Gambella (Ethiopia): when water, land and oil mix with politics. Lisbon: ISCTE; 2013.
21. Jarzebski PM, Ahmed A, Boafo YA, Balde BS, Chinangwa L, Saito O, von Maltitz G, Gasparatos A. Food security impacts of industrial crop

production in sub-Saharan Africa: a systematic review of the impact mechanisms. Food Sec. 2020;12:105–35. https://doi.org/10.1007/s12571-019-00988-x.
22. Cotula L, Vermeulen S, Leonard R, Keeley J. Land grab or development opportunity? Agricultural investment and international land deals in Africa. London: IIED/FAO/IFAD; 2009.
23. Maru S. Implications of land deals to livelihood security & natural resources management in Benshanguel Gumuz Regional State, Ethiopia. Brighton: Land Deals Politics Initiative (LDPI) and Institute of Development Studies, University of Sussex; 2011.
24. Lavers T. Land grab as development strategy? The political economy of agricultural investment in Ethiopia. J Peasant Stud. 2012;39(1):105–32. https://doi.org/10.1080/03066150.2011.652091.
25. Lavers T. Patterns of Agrarian transformation in Ethiopia: state mediated commercialization and the land grab. J Peasant Stud. 2012;39(3–4):795–822. https://doi.org/10.1080/03066150.2012.660147.
26. Getnet A. Rural land policy, rural transformation and recent trends in large-scale rural land acquisitions in Ethiopia: mobilizing European research for development policies. Brussels: European Report on Development; 2011.
27. Stebek EN. Between land gabbing and agricultural investment: land rent contracts with foreign investors and Ethiopians normative setting focus. Mizan Law Rev. 2011;5(2):176–214. https://doi.org/10.4314/mlr.v5i2.1.
28. Ojulu OM. Large-scale land acquisitions and minorities/indigenous peoples' rights under ethnic federalism in Ethiopia: a case study of Gambella regional state. England: University of Bradford; 2013.
29. Schoneveld GC. The governance of large-scale farmland investments in Sub-Saharan Africa: a comparative analysis of the challenges for sustainability. Delft: Eburon Academic Publishers; 2013.
30. Baumgartner P, von Braun J, Degnet A, Müller M. Impacts of large-scale land investments on income, prices, and employment: empirical analysis in Ethiopia. World Dev. 2015;72:175–90. https://doi.org/10.1016/j.worlddev.2015.02.017.
31. Bereket A. Appraising large scale land deals in Ethiopia: food security perspective. Mod Afr Politics Hist Soc. 2014;1(2):141–66.
32. Dye J. Food security and large-scale land acquisitions: the cases of Tanzania and Ethiopia. USA: University of Cincinnati; 2014.
33. Bamlaku A, Harald G, Khalid HAS, Tesfamicheal W. Do land transfers to international investors contribute to employment generation and local food security?: Evidence from Oromia Region, Ethiopia. Int J Soc Econ. 2015;42(12):1121–38. https://doi.org/10.1108/IJSE-02-2014-0037.
34. Moreda T. The right to food in the context of largescale land investment in Ethiopia. Third World Q. 2018;39(7):1326–47. https://doi.org/10.1080/01436597.2018.1460199.
35. Guyalo AK, Alemu EA, Degaga DT. Impact of large-scale agricultural investment on the livelihood assets of local community in Gambella region, Ethiopia. Int J Soc Econ. 2021;48(3):363–83. https://doi.org/10.1108/IJSE-09-2020-0610.
36. Locke A, Henley G. A review of the literature on biofuels and food security at a local level assessing the state of the evidence. London: Overseas Development Institute; 2013.
37. Wiggins S, Henley G, Keats S. Competitive or complementary? Industrial crops and food security in Sub-Saharan Africa. London: Overseas Development Institute; 2015.
38. Bosch C, Zeller M. The Impact of wage employment on Jatropha plantation on income and food security of rural households in Madagascar—a panel data analysis. Q J Int Agric. 2013;52:119–40. https://doi.org/10.22004/ag.econ.173643.
39. Land Matrix. Land matrix: Ethiopia. Ethiopia: Land Matrix; 2016.
40. Coates J. Build it back better: deconstructing food security for improved measurement and action. Glob Food Secur. 2013;10(1):193–8. https://doi.org/10.1016/j.gfs.2013.05.002.
41. World Food Program. Consolidated approach to reporting indicators of food security (CARI): food security analysis (VAM). Rome: World Food Program; 2015.
42. FAO. International Scientific Symposium on Measurement and Assessment of Food Deprivation and Under-nutrition. Rome: FAO; 2002.
43. Thompson HE, Berrang-Ford L, Ford JD. Climate change and food security in sub-Saharan Africa: a systematic literature review. Sustainability. 2010;2(8):2719–33. https://doi.org/10.3390/su2082719.
44. Pieters H, Guariso A, Vandeplas A. Conceptual framework for the analysis of the determinants of food and nutrition security. Europe: Foodsecure; 2013.
45. Zoomers A. Globalisation and the foreignisation of space: seven processes driving the current global land grab. J Peasants Stud. 2010;37(2):429–44. https://doi.org/10.1080/03066151003595325.
46. White B, Borras SM Jr, Hall R, Scoones I, Wolford W. The new enclosures: critical perspectives on corporate land deals. J Peasant Stud. 2012;39(3–4):619–47. https://doi.org/10.1080/03066150.2012.691879.
47. Cotula L. The great African land grab? Agricultural investments and the global food system. London: Zed Books; 2013.
48. Vermeulen S, Cotula L. Making the most of agricultural investment: a survey of business models that provide opportunities for smallholders. London: IIED/FAO/IFAD/SDC; 2010.
49. Cotula L, Vermeulen S, Mathieu P, Toulmin C. Agricultural investment and international land deals: evidence from a multi-country study in Africa. Food Security. 2011;3(1):99–113. https://doi.org/10.1007/s12571-010-0096-x.
50. Schoneveld G, German L, Nutakor E. Land-based investments for rural development? A grounded analysis of the local impacts of biofuel feedstock plantations in Ghana. Ecol Soc. 2011;16(4):1–16. https://doi.org/10.5751/ES-04424-160410.
51. De Schutter O. The green rush: the global race for farmland and the rights of the land users. Harv Int Law J. 2011;52(2):504–59.
52. Claeys P, Vanloqueren G. The minimum human rights principles applicable to large-scale land acquisitions or leases. Globalizations. 2013;10(1):193–8. https://doi.org/10.1080/14747731.2013.760940.
53. Künnemann R, Suárez SM. International human rights and governing land grabbing: a view from global civil society. Globalizations. 2013;10(1):123–9. https://doi.org/10.1080/14747731.2013.760933.
54. German L, Schoneveld G, Mwangi E. Contemporary processes of large-scale land acquisition in Sub-Saharan Africa: legal deficiency or elite capture of the rule of law? World Dev. 2013;48:1–18. https://doi.org/10.1016/j.worlddev.2013.03.006.
55. Anseeuw W, Ba OC, Iyebi-Mandjeck O, Mbaya S. Large-scale land based investments in Africa: synthesis report. Addis Ababa: Land Policy Initiative; 2013.
56. Nolte K. Large-scale agricultural investments under poor land governance in Zambia. Land Use Policy. 2014;38:698–706. https://doi.org/10.1016/j.landusepol.2014.01.014.
57. Chu J, Young K, Phiri D. Large-scale land acquisitions, displacement and resettlement in Zambia. Cape Town: The University of the Western Cape, Institute for Poverty, Land and Agrarian Studies; 2015.
58. Wily LA. The law is to blame: the vulnerable status of common property rights in Sub-Saharan Africa. Dev Chang. 2011;42(3):733–57. https://doi.org/10.1111/j.1467-7660.2011.01712.x.
59. Cotula L. Property rights, negotiating power and foreign investment: an international and comparative law study on Africa. Scotland: University of Edinburgh; 2009.
60. Schoneveld G. Host country governance and the african land rush: 7 reasons why large-scale farmland investments fail to contribute to sustainable development. Geoforum. 2017;83:119–32. https://doi.org/10.1016/j.geoforum.2016.12.007.
61. FIAN International Secretariat. Land grabbing in Kenya and Mozambique. A report on two research missions—and a human rights analysis of land grabbing. Heidelberg: FIAN International Secretariat; 2010.
62. Aabø E, Kring T. The political economy of large-scale agricultural land acquisitions: implications for food security and livelihoods/employment creation in Rural Mozambique. Maputo: United Nations Development Program; 2012.
63. Twomey H, Schiavoni CM, Mongula B. Impacts of large-scale agricultural investments on small-scale farmers in the Southern Highlands of Tanzania: a right to food perspective. Germany: Bischöfl iches Hilfswerk MISEREOR e.V; 2015.
64. Yengoh GT, Armah FA. Effects of large-scale acquisition on food insecurity in Sierra Leone. Sustainability. 2015;7(7):9505–39. https://doi.org/10.3390/su7079505.
65. Fernández MLT, Schwarze J. John Rawls's theory of justice and large-scale land acquisitions: a law and economics analysis of institutional background justice in Sub-Saharan Africa. J Agric Environ Ethics. 2013;26:1223–40. https://doi.org/10.1007/s10806-013-9447-x.

66. Daniel S. Land grabbing and potential implications for world food security. In: Sustainable agricultural development. Dordrecht: Springer; 2011. p. 25–42.
67. Vieri S, Calabro G. Food security and land grabbing in low-income countries of the Sub-Saharan Africa. J Manag Syst. 2019;20(172):118–25.
68. Lis F. Land grabbing' or harnessing of development potential in agriculture? East Asia's land-based investments in Africa. Pac Rev. 2013;26(5):563–87. https://doi.org/10.1080/09512748.2013.842314.
69. Chanceline BN. Land grabbing and its impact on food security in Sub Saharan Africa. Socio Econ Challenges. 2019;3(4):72–85. https://doi.org/10.21272/sec.3(4).72-85.2019.
70. Santangelo GD. The impact of FDI in land in agriculture in developing countries on host country food security. J World Bus. 2018;35(1):75–84. https://doi.org/10.1016/j.jwb.2017.07.006.
71. Lavers T. The impact of agricultural investments on state capacity: a comparative analysis of Ethiopia and Ghana. Geoforum. 2016;72:94–103. https://doi.org/10.1016/j.geoforum.2016.02.004.
72. Vath S, Kirk M. Do property rights and contract farming matter for rural development? Evidence from a large-scale investment in Ghana, vol. 16. Marburg: Philipps-University Marburg, Faculty of Business Administration and Economics; 2014.
73. Food & Agriculture Organization of the United Nations (FAO). Trends and impacts of foreign investment in developing country agriculture: Evidence from case studies. Rome: Food $ Agriculture Organization of the United Nations (FAO); 2013.
74. Fitawek W, Hendriks SL, Reys A, Fossi F. The effect of large-scale agricultural investments on household food security in Madagascar. Food Sec. 2020;12:1349–65. https://doi.org/10.1007/s12571-020-01055-6.
75. Ahlerup P, Tengstam S. Do the land-poor gain from agricultural investments? Empirical evidence from Zambia using panel data. Sweden: University of Gothenburg, Department of Economics; 2015.
76. Lay J, Nolte K, Sipangule K. Large-scale farms and smallholders: evidence from Zambia. Hamburg: German Institute of Global and Area Studies (GIGA); 2018. p. 310.
77. Barbanente G, Aisbett E. Large scale land acquisition and rural development: empirical evidence from Ethiopia. In: Land and poverty. Washington D.C.: The World Bank; 2016.
78. Oya C. Methodological reflections on 'land grab' databases and the 'land grab' literature 'rush.' J Peasant Stud. 2013;40(3):503–20. https://doi.org/10.1080/03066150.2013.799465.
79. Ballard TJ, Kepple AW, Cafiero C. The food insecurity experience scale: development of global standard for monitoring hunger worldwide. Rome: FAO; 2013.
80. Jones AD, Ngure FM, Pelto G, Young SL. What are we assessing when we measure food security? A compendium and review of current metrics. Adv Nutr. 2013;4(5):481–505. https://doi.org/10.3945/an.113.004119.
81. Perez-Escamilla R, Gulbert MB, Rogers B, Hromi-Fieldler A. Food security measurement and governance: assessment of the usefulness of diverse food insecurity indicators for policy makers. Glob Food Secur. 2017;14:96–104. https://doi.org/10.1016/j.gfs.2017.06.003.
82. De Haan L, Zoomers A. Exploring the frontier of livelihood research. Dev Chang. 2005;36(1):27–47. https://doi.org/10.1111/j.0012-155X.2005.00401.x.
83. Deininger K, Binswanger HP. The evolution of the World Bank's land policy: principles, experiences, and future challenges. World Bank Res Obs. 1999;14(2):247–76.
84. Lund C, Boone C. Introduction: land politics in Africa—constituting authority over territory, property and persons. Africa. 2013;83(1):1–13. https://doi.org/10.1017/S000197201200068X.
85. Place F, Otsuka K. Population pressure, land tenure, and tree resource management in Uganda. Land Econ. 2000;76(2):233–51. https://doi.org/10.2307/3147226.
86. Stellmacher T, Mollinga PP. The institutional sphere of coffee forest management in Ethiopia: local level findings from Koma forest, Kaffa Zone. Int J Soc For. 2009;2(1):43–66.
87. Federal Democratic Republic of Ethiopia, Ministry of Finance and Economic Development (MoFED). Growth and Transformation Plan (GTP I). Ethiopia: MoFED; 2010.
88. Yamano T, Otsuka K, Place F. Emerging development of agriculture in East Africa markets, soil, and innovations. Amsterdam: Springer; 2011.
89. Abobo Woreda Agriculture Office. Official rural households demographic and socioeconomic information. Washington: World Bank; 2017.
90. Banerjee AV, Duflo E. The experimental approach to development economics. Annu Rev Econ. 2009;1:151–78. https://doi.org/10.1146/annurev.economics.050708.14323.
91. Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. Biometrika. 1983;70(1):41–55. https://doi.org/10.1093/biomet/70.1.41.
92. Austin PC. An introduction to propensity score methods for reducing the effects of confounding in observational studies. Multivar Behav Res. 2011;46(3):399–442. https://doi.org/10.1080/00273171.2011.568786.
93. Smith J, Todd P. Does matching overcome Lalonde's critique of non-experimental estimators? J Econom. 2005;125(1–2):305–53. https://doi.org/10.1016/j.jeconom.2004.04.011.
94. Gerring J, McDermott R. An experimental template for case study research. Am J Political Sci. 2007;51(3):688–701.
95. De Silva I. Evaluating the impact of microfinance on saving and income in Sri Lanka: Quasi-experimental approach using propensity score matching. Margin J Appl Econ Res. 2012;6(1):47–74. https://doi.org/10.1177/097380101100600103.
96. Oxfam International. Land and power—the growing scandal surrounding the new wave of investments in land. Nairobi: Oxfam; 2011.
97. Human Rights Watch. Waiting here for death: forced displacement and "Villagization" in Ethiopia's Gambella region. New York: Human Rights Watch; 2012.
98. Gambella Regional State Investment Agency. Data on large-scale agricultural investment in Gambella regional state. Addis Ababa: Gambella Regional State Investment Agency; 2018.
99. Maxwell D. Measuring food insecurity: the frequency and severity of coping strategies. Food Policy. 1996;21(3):291–303. https://doi.org/10.1016/0306-9192(96)00005-X.
100. Quisumbing AR. Generating evidence on individuals' experience of food insecurity and vulnerability. Glob Food Sec. 2013;2(1):50–5. https://doi.org/10.1016/j.gfs.2012.11.004.
101. Krejcie RV, Morgan DW. Determining sample size for research activities. J Educ Psychol Meas. 1970;30:607–10.
102. Maxwell D, Coates J, Vaitla B. How do different indicators of household food security compare? Empirical evidence from Tigray. Medford: Feinstein International Center, Tufts University; 2014.
103. Hatløy A, Torheim LE, Oshaug A. Food variety—a good indicator of nutritional adequacy of the diet? A case study from an urban area in Mali, West Africa. Eur J Clin Nutr. 1998;52(12):891–8. https://doi.org/10.1038/sj.ejcn.1600662.
104. Faber M, Schwabe C, Drimie S. Dietary diversity in relation to other household food security indicators. Int J Food Saf Nutr Public Health. 2009;2(1):1–15. https://doi.org/10.1504/IJFSNPH.2009.026915.
105. Coates J, Swindale A, Bilinsky P. Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide (3). Washington D.C.: Food and Nutrition Technical Assistance Project (FANTA); 2007.
106. Abeyasekara S. Statistical analysis of survey data. In: Household sample surveys in developing and transition countries. New York: United Nations; 2005.
107. Kabudula CW, Houle B, Collinson MA, Kahn K, Tollman S, Clark S. Assessing changes in household socioeconomic status in rural South Africa, 2001–2013: a distributional analysis using household asset indicators. Soc Indic Res. 2017;133(3):1047–73. https://doi.org/10.1007/s11205-016-1397-z.
108. Krishnan V. Constructing an area-based socioeconomic index: a principal components analysis approach. Early Child Development Mapping Project (ECMap). Edmonton: University of Alberta; 2010.
109. Antony GM, Rao KVA. composite index to explain variations in poverty, health, nutritional status and standard of living: use of multivariate statistical methods. Public Health. 2007;121(8):578–87. https://doi.org/10.1016/j.puhe.2006.10.018.
110. Heckman J, Smith J, Clements N. Making the most out of social experiments: reducing the intrinsic uncertainty in evidence from randomized trials with an application to the National JTPA Experiment. Rev Econ Stud. 1997;64:487–535.

111. Khandker SR, Koolwal GB, Samad HA. Handbook on impact evaluation: quantitative methods and practices. Washington DC: The World Bank; 2010.
112. Brookhart MA, Schneeweiss S, Rothman KJ, Glynn RJ, Avorn J, Stürmer T. Variable selection for propensity score models. Am J Epidemiol. 2006;163(12):1149–56.
113. King G, Nielsen R. Why propensity scores should not be used for matching. Political Anal. 2019;27(4):435–54. https://doi.org/10.1017/pan.2019.11.
114. Caliendo M, Kopeinig S. Some practical guidance for the implementation of propensity score matching. Bonn: IZA; 2005.
115. Rosenbaum PR. Observational Study. In: Everitt BS, Howell DC, editors. Encyclopedia of statistics in behavioral science. West Sussex: Wiley; 2005. p. 1451–62.
116. Amanuel KG, Esubalew AA, Degefa TD. A crisis of the green gold: a case study of large scale agricultural investment in Gambella Region, Ethiopia. East Afr Soc Sci Res Rev. 2020;36(2):53–94. https://doi.org/10.1353/eas.2020.0006.
117. Sen AK. Food, economics and entitlements. In: Dreze J, Sen AK, editors. The political economy of hunger: entitlement and well-being. Oxford: Oxford University Press; 1990. p. 1–21.
118. Anseeuw W. The rush for land in Africa: resource grabbing or green revolution? South African. J Int Aff. 2013;20(1):159–77. https://doi.org/10.1080/10220461.2013.780326.
119. Byerlee D, Deininger K. The rise of large farms in land-abundant countries: do they have a future? World Dev. 2012;40(4):701–14. https://doi.org/10.1016/j.worlddev.2011.04.030.
120. Palliere A, Cochet H. Large private agricultural projects and job creation: from discourse to reality. Case study in Sella Limba, Sierra Leone. Land Use Policy. 2018;76:422–31. https://doi.org/10.1016/j.landusepol.2018.02.017.
121. The Oakland Institute. Understanding land investment deals in Africa Country report. The Oakland Institute: Ethiopia; 2011.
122. Central Statistical Authority. The 2007 population and housing census of Ethiopia: Ethiopian statistical abstract of 2013/14. Addis Ababa: Central Statistical Authority; 2015.

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