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The impacts of gold mining on the welfare of local farmers in Asutifi-North District in Ghana: A quantitative and multi-dimensional approach

Adator Stephanie Worlanyo [a,**], Sikpaam Issaka Alhassan [b], Li Jiangfeng [a,*]

[a] Department of Land Resources Management, College of Public Administration, China University of Geoscience (Wuhan), Wuhan, 430074, China
[b] School of Metallurgy and Environment, Department of Environmental Engineering, Central South University, Changsha, 410083, China

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ABSTRACT

Farming is the major economic activity of the people in the Asutifi-North District of Ghana however, farmers in this District are mainly characterized by small-farm holdings of less than 3 acres per farmer as a result of shrinking agricultural land due to increasing small and large-scale mining in the District. Currently, mining has become the major competitor to farming in terms of land-use conversion within the District. Though mining activities have led to several land-use conversions, little or no studies have been done in that regard. Studies over the years have focused on the environmental impacts of mining with less emphasis on the impacts of mining on farmers' welfare. This paper examines the factors influencing farmers' participation in land-use conversion for mining, its impacts on farmers' welfare, and the criteria of compensation given to affected farmers by the large-scale mine. Multi-staged sampling comprising both purposive and random sampling techniques was employed to gather data from 300 farmers in 5 mining communities in the district. The data obtained were analyzed using descriptive statistics and the Heckman two-stage model involving the Probit and OLS equations. Results indicate that variables such as farmer's age, sex, distance from household to farm, farmer's experience, total land size, and distance to the nearest access road were factors that influenced farmers' decision to participate in land-use conversion. Also, participants of land-use conversion had an annual income of (GH₵ 189)-$31.68 more than the non-participants however, their incomes are not sustainable hence compelling them into illegal mining. This paper has a guiding significance for policy decision making for gold mining in Ghana.

1. Introduction

It is not surprising that Ghana was hitherto called the Gold Coast considering the rich mineral resources which were identified by both the early Arab traders and the precolonial traders around the 15th through to the 18th century. Before Ghana's independence in 1957, the name Gold Coast reflected the rich deposits of gold particularly in the Western, Eastern, and Southern areas of the country. Gold mining was comparatively cheap and easy as it is believed that gold was so abundant that even sediments around rivers were fetched, washed, and gold grains separated from it (McQuilken and Hilson, 2016). It was a major source of wealth especially for most mining communities that engaged in it. Over time, it was revealed that deposits of major minerals such as diamond, iron, limestone, kaolinite, and other clay minerals existed in varying quantities. Though Ghana's economy was predominantly agriculture-based, most people within the southern belt of the country engaged in small-scale mining and smuggling of these minerals for sale outside the country for their livelihood (Aryee et al., 2003).

Gold mining in Ghana can be divided into two major types based on the scale of production thus the large-scale mining (LSM) and small-scale mining (SSM). The SSM in Ghana also includes artisanal small-scale mining (ASSM) which is primarily made up of only indigenous people. Both the SSM and the SSAM have been classified as one under this study hence referred to as small-scale mining. According to the International Labour Organisation (ILO), small-scale mining (SSM) is a type of mining that is less intense and operates with basic or rudimentary machines. In Ghana, however, SSM involves "the mining of gold by a technique not involving extensive spending by a person or group of persons not more than nine (9) in number or by a supportive society made up of ten or more persons" (Akabzaa and Darimani, 2001; Worlanyo and Jiangfeng, 2020). Large-scale mining, however, often involves huge capital investment, a sizable number of workers, and sophisticated

* Corresponding author.
** Corresponding author.
E-mail addresses: princess.adat@yahoo.com (A.S. Worlanyo), jfli@cug.edu.cn, princess.adat@yahoo.com (L. Jiangfeng).

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technology (Amponsah-Tawiah and Dartey-Baah, 2011). It generates more than 95% of the world's total mineral production and employs approximately 2.5 million people globally. In Ghana, 15 large-scale mining companies are operating currently with approximately 13 gold mines, one bauxite mine, and one manganese mine (Ghana Chamba of mines, 2019).

In 2011, the mining industry contributed around 37% to the country's total exports, 38.3% of Ghana's total corporate tax, and 27.6% of government revenue (Ministry of Economy and Industry report, 2020). Just like other developing countries such as Zambia, South Africa, and Mongolia, Ghana's mining sector is a pivotal asset for both micro and macroeconomic development. Aside from gold mining in Ghana, other natural resources such as diamond, bauxite, crude oil deposits, and timber have offered significant contributions to economic growth and development (Worlanyo and Jiangfeng, 2020). In 2018, Ghana surpassed South Africa to become the leading gold producer in Africa and among the top-10 gold-producing countries in the world (Ministry of Economy and Industry (MEI), 2020). Currently, mining accounts for about 9.1% of Ghana's gross domestic product (GDP) with gold accounting for about 90–96% of all extracted minerals. The total employment from both small and large-scale mining in Ghana is estimated to be over 1 million from direct sources and indirectly supporting more than 4.5 million people (McQuilken and Hilson, 2016). In a report, Akudugu et al. (2013) estimated that over 200,000 people are illegally involved in the extraction of gold and diamonds whereas more than 300,000 people are legally involved in varying degrees of small-scale gold mining. More so, the large-scale gold mining sector alone employs over 300,000 people both directly and indirectly (Ghana living standards survey (GLSS) report, 2017bib28).

Despite all these, many stakeholders have questioned the positive impacts of gold mining vis-a-vis its negative impacts on farmers' economic growth and its environmental ramifications. Samuel et al. (2012), argued that the negative impact of mining on socioeconomic development outweighs its positive gains especially Small-scale surface mining. Among other things, the study concluded that the major adverse effects of mining on mining communities were on economic activities such as agriculture, education, health, and the environment. The negative impacts resulting from mining are far-reaching, Wilson et al. (2015), asserted that the contribution of gold mining in Ghana at the macro-level is enormous, however, at the micro-level, the individual suffers the consequences such as pollution, deforestation, land degradation, high cost of living, poverty, and lack of basic needs. Similar findings were made in Siera Leone in selected mining edge communities. Data were analyzed quantitatively, and the authors observed an increased rate of land degradation, deforestation, destruction of farmlands, water, noise, and air pollution (Mabey et al., 2020). In the Asutifi-North District, large-scale underground mining by Newmont Ghana Gold Limited (NGGL) is responsible for displacing most of the farmers. Kapstein and Kim (2011) reported an incidence of rapid eroding livelihood diversifications of farmers in the Asutifi-North District in Ghana due to extensive leasing of lands by farmers to the Newmont Ghana Gold Limited for compensation in the form of liquid cash. Famers in this district are given poor compensations which do not commensurate with the land they lease out to the mining company (NGGL). A similar report was made by Dasor Johnson and Onwuegbuzie (2004) on the Tarkwa Nsuaem Municipality, Ghana. The study among other things found out that an increase in large-scale mining concessions leads to decreasing agricultural land which leads to joblessness and loss of labor for agriculture. The study also added that most farmers become jobless after their farmlands have been taken over by mining concessions because the compensation they receive is too small to invest into any better business and they do not have the requisite skills to be employed by these large-scale mining companies. A farmer leasing his farmland to the mining company means that he can no longer have access to farm on such land. After spending the little money received in the form of compensation, most farmers are left with the only option of engaging in illegal gold mining. Most compensation packages are given in lump sum and are not enough to cater for the disruption caused by the mining company. Darko (2017) reported many bottlenecks regarding the compensation packages given to farmers in the Asutifi-North District by NGGL. The major findings were late compensations and insufficient compensation and that most farmers finished spending the money (compensation) within one to three years.

The purpose of this study is to use a mixed approach to examine (i) factors influencing farmers' participation in land-use conversion thus from farming to mining, (ii) the impact of land-use conversion on farmers welfare, and (iii) the criteria of compensation given to farmers who were affected by the activities of NGGL. The theoretical framework for the study objectives is built on the utility maximation theory which underscores the fact that a farmer is likely to release his farmland for a mining concession if the utility (satisfaction) he would get from the mining company in the form of compensation is higher than engaging in farming. We then applied the Heckman two-staged model involving OLS (treatment equation) and probit (outcome equation) to estimate the factors driving farmers into participating in land-use conversion and its impacts on their welfare.

2. Overview of small-scale mining and large-scale mining in Ghana

2.1. Small-scale mining (SSM)

This section of the study reviews relevant literature regarding SSM and provides some highlights on the regional differences between Ghana and elsewhere. The section also discusses the different SSM in Ghana based on (1) mode of operation, and (ii) their registration status. Small-scale mining usually requires less capital investment and is mostly executed by indigenous people with rudimentary tools. Bansah et al. (2016) defined small-scale mining as "the mining of ore deposits by individuals or groups of persons with little technical know-how and characterized by minimal or no mechanization". While some countries limit the definition of SSM to output and human resources, the mining Act 2006 (Act 703) by the minerals and mining commission of Ghana defines small scale gold mining operation as the mining of gold by any efficient and effective process that does not encompass substantial expenditure by an individual or group of persons not exceeding nine (9) people or by a co-operative society made up of 10 or more persons. SMM can be classified into surface and underground mining (Arah, 2015; Al-Hassan and Amoako, 2014). Surface mining constitutes a broad spectrum of mining whereby the soil and rock overlying the mineral deposit are removed. It purposely exhumes ores very close to the earth's surface for example open-pit mining, strip mining, dredging, and mountaintop removal (Yirenkyi, 2008; Arah, 2015). Among the different types of surface mining listed, the most common one's practice in Ghana is the open-pits and the dredging methods. The practice of surface mining requires a large area of land to carry out more than underground mining. Currently, small-scale surface mining in Ghana is rapidly increasing as the quest for minerals continues to gain ground and causes more damage to the vegetation cover than any other type of mining. Nearly every region in Ghana has had a taste of surface mining stretching from Nangodi, Yale, and Gbani in the Upper East Region of the Northern part of Ghana to Tarkwa in the Southwestern part of Ghana (Tom-Dery et al., 2012). Consequently, it constitutes the greatest threat to agricultural and other alternative land-uses in Ghana due to the enormous land degradation and pollution of water resources. Underground mining as the name suggests, is where the miners go deep down the ground to excavate mineral ore lying beneath the surface of the earth example is hard-rock mining (Balasubramanian, 2017). Unlike surface mining, underground mining usually requires sophisticated machinery with less demand for labor and huge capital investment. However, in the case of small-scale underground mining in Ghana, simple local tools such as a pickaxe, cutlass, hoes are being used. Sticks and stones are

mostly used to build the tunnel to prevent it from collapsing (Fig. 1).

Moreover, SSM in Ghana can also be classified based on their registration status. Those who are legally registered and therefore are permitted to carry out their functions as stipulated in the current Minerals and Mining (Amendment) Act, 2019 (Act 995) and those operating illegally perhaps due to some bottlenecks described as economic, social, political, regulatory, and technological factors (Bansah et al., 2018; Owusu et al., 2019). While about 1000,000 people engage in licensed SSM, at least it is estimated that about twice that number operate in unlicensed/unregistered SSM (Bansah et al., 2016, 2018). About 1 million Ghanaians are engaged in legalized small-scale mining whereas over 1 million people are involved in illegal small-scale mining activities which together benefit more than 4.5 million Ghanaians (McQuilken and Hilson, 2016).

The registration and legalization of mining in Ghana is the sole responsibility of the Mining and Minerals Commission. As of 2002, a total of 420 SSM concessions were registered and licensed in Ghana for operation out of which 411 were gold licensed and 9 were diamond licensed. By 2016, the number increased to one thousand four hundred and thirty-six (1436) licenses with gold licenses dominating (Ntibrey, 2016). Common historical SSM methods in Ghana are the "anomabu", "chisel and hammer", "underground "ghetto", and the "dig and wash methods" (Bansah et al., 2016). Some other SSM mining methods in Ghana are "Changfan", "alluvial washing plant", "More blade method" and "Dredging method" (Acheampong, 2009; Bansah et al., 2016; Botchway, 2015; Ofosu-Mensah and Ababio, 2011; Yamoah, 2002).

2.2. Large-scale mining (LSM) in Ghana

According to the World Gold Council (WGC), large-scale mines are usually companies with many employees at one or more large sites which usually stay until the metal or mineral is completely excavated. They have defined operational plans, regulations, tenure and pay more attention to the environmental damages. In Ghana, there is no strict definition for LSM, however, any license mine with an employment capacity of 100 people with tenure is often considered as LSM and it could be surface mining or underground mining. Unlike SSM, LSM produces less environmental degradation and most of them are involved in underground mining (Mining and Comission, 2015). LSM in Ghana constitutes the biggest contributor to the economy in terms of direct employment creation and growth in GDP. Currently, there are about sixteen (16) registered LSM in Ghana (Table 2) which in totality have invested about US$ 3.73 billion in the 2019 production year with a total gold output of 2,986,837 (oz) in 2019. In 2018, however, the total investment made by all the LSM in Ghana was US$ 2.51 billion indicating an increase in the 2019 investment from 83% in 2018 to 87% in 2019 of mineral revenue respectively. LSM in Ghana has contributed significantly to both direct and indirect employment creation. Between the 2018 and 2019 production years, the total direct workforce engaged in LSM alone increased from 10,109 in 2018 to 11,899 in 2019 (Ghana

Table 2
Names of all registered LSGM in Ghana and their output as at 2019.

S/N	Name of Gold producing Company	Yearly Output (Ounce)		
		2018	2019	* % Change
1	Newmont Ghana Gold Limited	436,106	643,067	47%
2	Gold Fields Ghana Limited	524,869	519,072	−1%
3	Newmont Golden Ridge Limited	414,427	422,099	2%
4	AngloGold Ashanti Iduapriem Limited	253,487	274,665	8%
5	Asanko Gold Mines Limited	223,152	251,044	12%
6	Abosso Goldfields Limited	180,844	208,381	15%
7	Chirano Gold Mines	226,370	201,037	−11%
8	Perseus Mining (Ghana) Limited	217,219	179,574	−17%
9	Golden Star Wassa Limited	149,698	156,168	4%
10	Adamus Resources Limited	103,731	84,197	−19%
11	Golden Star Bogoso Prestea Limited	75,087	47,533	−37%
	Total Gold production	**2,804,990**	**2,986,837**	**6%**

Source: Ghana Chamber of Mines (2020) * Computed from 2018 to 2019 production figures.

Fig. 1. Effects of small-scale illegal underground mining on arable land: an ongoing illegal small-scale underground mine **(a);** an abandoned illegal underground mine close to a community (Yawwusukrom) which has been turned into a refuse dump **(b);** an abandoned underground mine at a site **(c)**.
Source: Authors' field survey, (2021)

living standards survey, 2017). This represents 18% growth in employment creation which was primarily as a result of the expansion in employment at four mines thus the Newmont Ghana Gold Limited (Ahafo Mine), Asanko Gold Mine, Golden Star Resources' (Wassa Mine), and the AngloGold Ashanti Limited (Obuasi Mine). Of significant importance is the fact that out of the direct workforce of 11,899 in 2019, only a paltry of 144 were expatriates and the remaining were Ghanaian nationals representing only 1.2% of the workforce in 2019 as against 1.6% of expatriates' workforce in 2018. According to The Ghana Chamba of Mines Annual Report (2019), the total real value of final goods and services in Ghana increased from GH 154.548 billion (over US $ 26 million) in 2018 to GH 164.560 billion in 2019 (over US$ 28 million) using the 2013 constant prices. This represented a growth rate of 6.5% in 2019 and it compares favorably with the outturn of 6.3 percent in 2018. According to the report, one of the major drivers of such a phenomenal increase in real economic boast was the expansion in the mining sector especially Large-scale mining. This was considered significant especially because global gold demand decreased by a percentage to 4335 tonnes in 2019 from 4401 tonnes in 2018 (World Gold Council report, 2019). Despite the world contraction in demand for gold, the Ghanaian gold market still recorded a boast in the 2019 production year. In 2018, the total gold production from all SSM (1,984,370 ounces) exceeded that of LSM (2,807,918 ounces), however, in 2019, gold produced by LSM (2,989,446) surpassed that produced from SSM (1,588,191). Table 1 below shows the comparative gold production between LSM and SSM in Ghana over 20 years (2000–2020).

3. Microeconomic effects of mining on livelihoods

The impact of mining at the microeconomic level is always poorly felt. Over the years, many studies have indicated that majority of the proceeds from the mining sector are mostly enjoyed by the government and other leading stakeholders while the community from which the minerals are mined suffer the consequences (Dontala et al., 2015; Ocansey, 2013). In the midst of all these, both LSM and SSM provide a lot of livelihoods supports to the resident, proximate and distant communities at the microeconomic level. Especially in resident and proximate communities, mining serves as buffer and shock absorbers (Wilson et al., 2015). This is to say that mining at the individual level serves as a means of survival for impoverished farmers and citizens and as an engine for the growth of both small and medium-sized businesses. Advocates of mining and mineral expansion have also argued that rural farmers could use the proceeds from mining for agricultural expansion (Wilson et al., 2015). According to Okoh and Hilson (2011), there is a strong correlation between subsistence agriculture and SSM especially in rural Ghana, arguing that such mining signifies an important means of income diversification for many farmers, making it important to instantaneously address both agriculture and mining issues while improving their lives. The study further argued that mining provides an alternative source of livelihood to farmers especially in areas with distinct cycles of dry and rainy seasons. They added that while small-scale illegal mining provides farmers and the mining communities with income-generating opportunities during the dry season, subsistence agriculture occupies them during the rainy season. The informal nature by which the small-scale mining industry employs makes it difficult to get official records making it almost impossible to quantify, however its boast local employment capacity. According to Widana (2019), although the contribution of mining at the microeconomic level is not well documented, nevertheless, some people who engage in mining get about 90% of their income through mining activities either directly or indirectly especially families directly engaged in mining. A similar study in Kenya by Barreto et al. (2018) discovered that gold miners from Kenya get about USD140 per month, which contributed to their livelihood support in several ways. Furthermore, mining also provides a lot of local raw materials to local goldsmiths, provides basic amenities to communities within mines such as schools, clinics, and good roads which facilitate easy transport of agricultural commodities (Aryee, 2012). Hentschel et al. (2012) argued that if enhanced revenues and infrastructures are reinvested in the same locality from which the mining concessions exist, it can produce a domino effect where the majority of residents would enjoy the benefits. Moreover, the existence of both LSM and SSM in a particular locality drives demand for goods and services through the generation of purchasing power. For example, in small-scale mining communities, both men and women engage in income-generating activities such as the selling of food, drinks, clothes, and mining-related products such as gold and other minerals (Emmanuel et al., 2018). By so doing, they also create complementary firms or affiliates for small-scale mining. Some of these people who engage in these complementary activities end up even employing other people as their employees. For instance, in the Upper East Region, where a certain small-scale gold mining concession exists in Tongo, the pumps and generators to run the machines were being purchased from local sellers to remove water from deep mining (Hentschel et al., 2012). Also, other studies (Bansah et al., 2018; Chupezi et al., 2009) have explained that the marginalization of agriculture has forced most rural women to engage in SSM as an alternative means of survival. Therefore, the role of mining as a backbone of some local economies should not be undermined rather should be seen as an economic venture that facilitates the development of complementary, sustainable, and revenue-generating activities, which may serve as a source of finance for local investors to run their small businesses (Hentschel et al., 2012; Zhang and Moffat, 2015; Mason et al., 2014). Both earlier and recent works (Amponsah--Tawiah and Dartey-Baah, 2011; Haddaway et al., 2018) on mining's impact on the individual farmer have summarized the many ways in which the existence of a mine in a particular locality may benefit the individuals there. According to these authors, some of the microeconomic gains from mining include but are not limited to employment creation, infrastructure improvement, and essential services such as adult literacy education and primary healthcare provision. According to David et al. (2016), mining companies especially large-scale mines also provide essential services and facilities such as good drinking water, private schools, community clinics to proximate and affected communities which improves the lives of citizens. Additionally, large-scale mines provide farmers and other individuals with capacity-building workshops within the operational area and supply inputs and extension services to the affected farmers (Mahar et al., 2016; Ocansey, 2013).

Table 1
Comparative gold production of LSM vs SSM from 2000 to 2020.

Year	LSM (OZ)	SSM (OZ)	Total output (OZ)	% change
2000	2,168,802	145,662	2,314,464	6.3
2001	2,184,313	185,596	2,369,909	7.8
2002	2,075,954	160,879	2,236,833	7.2
2003	2,085,070	221,063	2,306,133	9.6
2004	1,783,400	246,570	2,029,970	12.1
2005	1,913,534	225,411	2,138,945	10.5
2006	2,095,553	247,063	2,342,616	10.5
2007	2,239,678	388,594	2,628,272	14.8
2008	2,378,012	418,943	2,796,955	15.0
2009	2,564,095	555,737	3,119,832	17.8
2010	2,624,391	767,196	3,391,587	22.6
2011	2,697,612	978,611	3,676,223	27.0
2012	2,848,409	1,464,781	4,313,190	33.96
2013	2,808,405	1,441,497	4,249,902	33.92
2014	2,851,885	1,489,722	4,341,607	34.31
2018	2,804,990	-	-	-
2019	2,986,837	-	4819.900	-
2020			4633.100	

Source: Ministry of Finance (2019) **and** https://www.gold.org/goldhub/data/gold-supply-and-demand-statistics *The production outputs for 2015, 2016, and 2017 could not be sourced as it was not available in the sourced documents.

4. Study area and research methodology

4.1. The study area

Asutifi-North district is one of the six districts of the newly created Ahafo region located between latitudes 6°40′ and 7°15′ North and Longitudes 2°15′ and 2°45′ West as shown in Fig. 2 below. The district is one of the smallest in the region with a total land surface area of 1500 km^2. The urban forms thirty-two percent (32.0%) of the district while rural constitutes seventy-eight percent (78.0%) indicating that the district is principally a rural settlement area. The land size of the Asutifi North District is 936.31 square kilometers with a Population of 52,259 representing 2.7 percent of the then region's total population (Brong Ahafo region). Out of the total number, males constitute 51.2% and females represent 49.8% (Adiyahba, 2015).

4.2. Data type and sampling technique

Primary data was obtained from a cross-section of the district. The survey employed a mixed method for the study. Mixed methods approach moves beyond the qualitative-quantitative division to take advantage of the strengths of both (Johnson and Onwuegbuzie, 2004). A multi-stage sampling technique was used in this study combining both purposive and simple random sampling techniques. Asutifi North district was purposively selected due to its prevalent long-standing existence of both small-scale and large-scale mining activities in the area. The district is one of the oldest gold mining hotspots in Ghana known for its rich deposit of gold by both local and international investors. Five communities that are affected by the activities of both SSM and LSM (particularly the Ahafo branch of Newmont Ghana Gold Limited, NGGL) were selected randomly from the district. A total of sixty (60) respondents both land-use converters and non-converters were interviewed from each community for this study making a total sample size of 300 respondents from the five communities.

4.3. Theoretical framework

The study employed the utility maximization theory thus stating that a farmer will prefer to engage in mining activities or release his land for mining purposes if the satisfaction/utility derived from mining is greater than the satisfaction/utility they would get from farming. Assuming V_1 and V_0 are the satisfaction or utilities that a farmer will get for participating (V_1) and not participating (V_0) in mining activities respectfully.

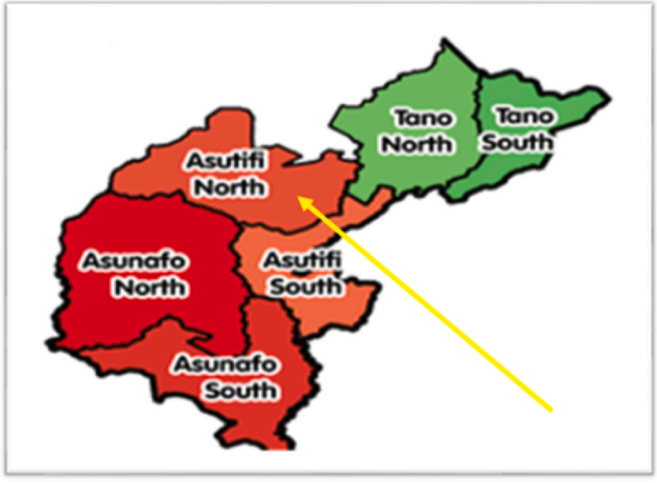

Fig. 2. Map of the newly created Ahafo region showing Asutifi-North district (Keyansi).
Source; https://commons.wikimedia.org/wiki/File:Districts_of_the_Ahafo_Region_(2019).png

The linear random model for the utility (V_1) of participators, the utility for participating is expressed as a function of independent or explanatory variables X_1:

$$V_1 = \beta_1 X_1 + \varepsilon_1 \quad (1)$$

Likewise, (V_0) the utility for not participating is also given below:

$$V_0 = \beta_0 X_1 + \varepsilon_0 \quad (2)$$

X_1 is the explanatory or independent variable, β_1 and β_0 are the parameters to be estimated, ε_1 and ε_0 are the error terms for participants and non-participants in mining activities.

Before a farmer will prefer mining to farming, the expected benefit should be greater than that of the non-participants. Therefore;

$$E(V_1) > E(V_0)$$

The probability for participating in mining activity is given by:

$$P(V=1|X) = P\left[\left(\beta_1^* X_1 + \varepsilon_1\right) > \left(\beta_0^* X_1 + \varepsilon_0\right)\right] \quad (3)$$

$$P\left(V=1|X\right) = P\left[\left(\beta_1^* X_1 + \varepsilon_1\right) - - \left(\beta_0^* X_1 + \varepsilon_0\right) > 0 \middle| X\right] \quad (4)$$

$$P\left(V=1|X\right) = P\left[X_1\left(\beta_1^* - \beta_0^*\right) + \left(\varepsilon_1 - \varepsilon_0\right) > 0 \middle| X\right] \quad (5)$$

$$P\left(V=1|X\right) = P\left[\left(\beta_1^* X_1 - \varepsilon^*\right) > 0 \middle| X\right] \quad (6)$$

$$P(V=1|X) = F(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_n X_n) \quad (7)$$

P is the probability function,

$\varepsilon^* = \varepsilon_1 + \varepsilon_0$ is a random term,
$\beta^* = \beta_1 - \beta_0$ is a vector of unknown parameters and F depending on the distribution of the error term.

4.4. Conceptual framework

Fig. 3 below illustrates the conceptual framework of the study which describes what influences farmers' land-use conversion for mining purposes and their involvement in mining activities. Two major factors were being considered as influential "push" factors that could probably lure a farmer to lease his farmland to a mining concession thus the farmer's socioeconomic and institutional factors. The socioeconomic characteristics of farmers such as gender, age, farm size, farming experience, membership of farmer-based organizations (FBO) among others, may certain degree of influence on farmers' decision to participate in mining activities. More so, institutional factors such as the availability of ready markets, extension services, and credits services may well play a determining role in participating in mining or leasing out one's farmland to a mining concession. It is expected that farmers who have more extension contact on input use and adoption of new technologies coupled with access to inputs will be more efficient in utilizing the inputs and will engage less in mining activities.

4.5. Specification of the heckman two-staged models

4.5.1. 1st stage: selection model

The selection model consists of a binary probit model which is the first step and is known as the sample selection probit model. The binary probit model was used to determine the factors that influence farmers' decisions to participate in mining activities/lease out their land for mining.

$$participation(v) = b_0 + b_1 x_1 + e_1 \quad (8)$$

b_1 is the parameter to be estimated from the probit model, the decision to

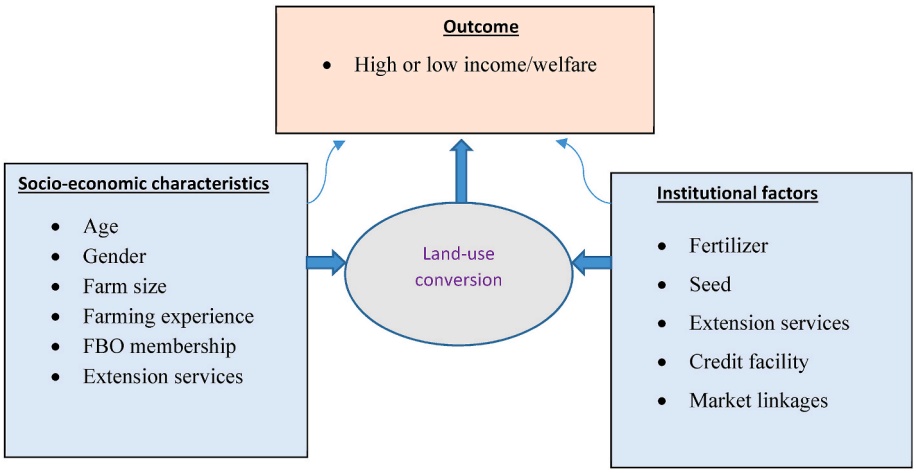

Fig. 3. Analytical framework.
Source: Author's illustration, (2021)

participate in mining activities through land-use conversion, and it is used to calculate the inverse Mill's ratio. For farmers' who participate in the activities, inverse Mill's ratio is given as:

$$\lambda_{y1i} = \frac{\varphi b_i x_i}{1 - \Phi b_i x_i}$$

For non-participants in the mining activities, inverse Mill's ratio is given as:

$$\lambda_{y0i} = \frac{\varphi b_i x_i}{1 - \Phi b_i x_i}$$

Where λ_{y1} and λ_{y0}represents the inverse Mills ratios for participants and nonparticipants in the land-use conversion respectively, φ is the standard normal density function, Φ is the standard normal cumulative distribution function, and $b_i$is the parameter to be estimated from the probit model and x_i is a vector of explanatory variables.

4.5.2. The 2nd stage: the outcome model

The outcome model in this stage was estimated using the OLS with the conventional inputs and the socioeconomic variables X as well as the inverse Mill's ratio. The outcome model is therefore given as:

$$Welfare(\pi) = \alpha_i x_i + \sigma\lambda_{y1i} + \varepsilon_i \quad (9)$$

Where σ is the covariance between the error terms of farmers' decision to either participate or not. The selection model (π) and outcome or output model (ε) with zero correlation between them. Note that x_i is a vector of explanatory variables added in the Outcome model and α_i depicts the coefficient in the outcome model.

4.6. Modeling the effect of mining activities on the welfare of farmers

To assess the effect of farm use conversion for mining purposes on welfare, the Heckman sample treatment effect model was employed. This model consists of two main functions that are estimated simultaneously. The first is the substantive or outcome equation, while the second is the selection or treatment function. The substantive (welfare) model is specified as:

$$y_i = \beta_{im} x_{im} + \lambda\omega + e_i \quad (10)$$

but E $(E, e_t)\neq 0$, which implies that there is likely endogeneity due to sample selection bias.

y = welfare, x_{im} = a vector of independent variables that influence welfare, ω = land-use conversion for mining purposes e_i = error term. The following is the empirical output equation:

$$y = \beta_0 + \alpha_1\, plot\ size\ + \alpha_2 H\_size + \alpha_3 acc\_ext + \alpha_4 non - farm\ income + \alpha_5 quantity\ of\ fertilizer + \gamma L\_conversion + e \quad (11)$$

Since there are likely biases due to inherent differences between participants and non-participants which could relate to welfare, it is important to compare the participants and non-participants to find out the differences. For this reason, a probit selection or treatment effect model will be estimated as indicated earlier in the model specification. After estimating the probit model, the inverse mills ratio (IMR) is generated and included as an estimator in the outcome equation to correct for sample selection bias.

The dependent variable in the probit analysis is a dummy indicating whether or not a farmer participated in mining activities. The variable takes the values of 1 if a farmer participated through land conversion and 0 if otherwise. The probit model is therefore chosen to determine factors influencing smallholder farmer participation in the mining program.

$$\omega = \beta_i x_i + \lambda\xi + e \quad (12)$$

ξ = land use conversion for mining activities; x_i = is a vector of independent variables that can influence participation; β_i = are unknown parameters, ω = participation in mining activities e = error term.

- The latent dependent variable is observed through the decision to participate or not such that

$$y_i = \begin{cases} 1 & if \quad y^* > 0 \\ 0 & if \quad y^* \leq 0 \end{cases}$$

Since y_i is unobserved, it is believed to relate to the observed characteristics of the individual farmer by the relation:

$$\omega = \beta_0 + \beta_1 age + \beta_2 distance\ from\ household\ to\ the\ farm + \beta_3 H\_size + \beta_4 education + \beta_5 total\ land\ size + \beta_6 farmers\ experience + u_i \quad (18)$$

In the probit analysis, the effects of these variables on participation decisions are estimated. But what is needed is the unmeasured characteristics of the respondent on participation decision. However, the inverse mills ratio (IMR) as stated previously produce unbiased estimates when included in the following equation; $y = \beta_{im} x_{im} + \lambda\omega$.

5. Results and discussion

5.1. Socio-demographic characteristics of respondents

In every quantitative research, estimating descriptive statistics of the socio-demographics of the respondents gives an overview of the distribution of the data being examined (Table 3). The gender distribution of household heads of the data was biased against women thus 87.4% for men as against 12.6% for women. This is not surprising, in a typical Ghanaian household, the headship of the household is a prerogative of the man unless, in a few circumstances where the female is either a widow, divorced, single, or in cases where the man is unable to carry out household responsibilities hence, the female assumes the position as head of the household. Abatania et al., 1999 indicated that females become household heads mostly when there is no adult male considered capable of being the household head. On the issue of marital status, the majority of the household heads were married (82.11%), single household heads (6.63%), divorced household heads (3.32%), and widowed household heads (7.95%). All other things being equal, it is a widely held belief that married household heads have the advantage of family labor over unmarried heads as such could use the available labor to either engage in illegal small-scale mining or farming. Education is an important tool for the acquisition of knowledge and skills and the gainful utilization of such knowledge. The study found out that the majority of the survey respondents (67.54%) had no formal education. This is immediately followed by household heads with Junior High School level of education (13.24%), Primary level education (10.50%), Senior High School level education (5.86%), and the least being Tertiary education (2.65%). These results of the educational attainment are somewhat consistent with the reports of the Ghana Statistical Service (Odoom, 2020), that about half of the adults in Ghana neither attended school nor completed JHS.

Table 3
Selected socio-demographic characteristics of Respondents.

Characteristic		Percentage (%)
Gender		
Female	37	12.58
Male	263	87.42
Total	**300**	**100**
Marital status		
Married	247	82.12
Single	20	6.62
Divorced	10	3.31
Widowed	23	7.95
Total	**300**	**100**
Level of education		
Primary	31	10.60
JHS	40	13.65
SHS	18	5.96
Tertiary	8	2.65
No-formal education	203	67.55
Total	**300**	**100**

5.2. Summary statistics of some variables

The mean age of the farmers who leased out their lands for mining purposes (or converted their lands into mining concessions) and those who did not engage in land-use conversion for mining purposes were 52.24 years and 42.14 years respectively (Table 4). Averagely, participants of the land-use conversion are about 10 years older than the non-participants, though both fall within the active working-age bracket. This suggests that as local farmers age, they prefer to lease out their farmlands to mining concessions in return for compensation to farming. The reason could be due to the laborious and demanding nature of farming requiring the use of more physical strength. The mean household size of participants and non-participants were respectively 9.39 and 7.55 members. These make sense because the larger the household size, the greater the number of mouths to feed. This can stimulate participation in land-use conversion because of the income they will gain from the mining activities as well as compensation in the form of liquid cash. On average, a participant had 2.21 years of education while that of a non-participant is 3.02 years. This means that farmers who are more educated are less willing to convert their farmlands into mining concessions or give out their lands to mines. It presupposes that farmers with more education are well aware of the negative ramifications of mining on the environment and hence are unwilling to give out their lands to mining concessions. It could also mean that they are aware of the insufficient and unsustainable nature of the compensation from the mines as opposed to farmers with lesser education. Moreover, the average distance from residence to farm for the participants is 56.75 min by walking, while that of non-participants is 69.90 min. Considering the average time spent by both farmers, participants spend less time walking to the farm which should have reduced their involvement in leasing out their farmlands to mining companies, however, this is contrary to our a priori expectation. With distance to input markets, the meantime in minutes of the participants is 43.31 while that of the non-participants is 63.24 min. Considering the distance to the nearest access road, the mean distance in minutes for the participants is 31.42 by walking while that of the non-participants is 41.02 by walking. This indicates that, on average, the participants are located in areas that have accessible roads than the non-participants. This is in agreement with Emmanuel et al. (2018) who disclosed that most large-scale mining concessions construct roads within the mining communities to make them easily accessible by commuters. With regards to the distance to the nearest output market, the mean distance in minutes of the participants is 35.59 while that of the non-participants is 23.07. The average distances to input market, output market, and nearest access to road signify that the participants have improved built environmental factors. Advocates of mining and mineral expansion believe that some of these benefits emanating from large-scale mining to both proximate and resident communities are the reasons that farmers easily give out their farmlands to large-scale mining concessions (Akudugu et al., 2013). Land is the most important resource for the farmer. All other things being equal, the larger the farm size the greater your output. From the survey, the participants cultivate an average farm size of 8.95 acres, while the non-participants cultivate an average of 5.27 acres. Similarly, the mean years of experience of the participants are 30.71 years while that of the non-participants is 17.09 years. This shows that those who participated in leasing out their farmlands to mining concessions are people who have kept long in the farming business. This also suggests that they are quite sure that subsistence farming does not pay off as such, better to lease out one's land to a mining company and be compensated than to engage in subsistence farming. The study found no difference between the average labor used

Table 4
Summary statistics of explanatory variables.

Variable	Converters				Non-converters				
	Mean	Std. Dev	Minimum	Maximum	Mean	Std. Dev	Minimum	Maximum	T-test
Age	55.24	13.54	26	90	42.14	13.43	17	79	8.38***
Household size	9.39	3.93	2	24	7.55	3.75	1	23	4.13***
Education (years)	2.2	3.75		15	3.02	4.62	0	15	1.63*
Distance from household to the farm (minutes)	56.75	41.73	3	240	69.90	52.90	2	240	2.34***
Distance to the nearest input market (minutes)	43.31	17.55	3	120	63.24	43.42	15	280	5.00***
Distance to the nearest access road (minutes)	31.42	16.53	1	70	41.02	33.64	1	180	3.02***
Distance to the nearest output market (minutes)	44.05	19.13	3	150	52.27	31.87	15	240	2.62***
Farm size (acres)	8.95	5.54	2	30	5.27	3.68	1	40	6.90***
Experience (years)	30.71	13.65	4	60	17.09	12.28	1	60	9.10***
Labour	29.90	14.69	5	100	29.30	17.69	5	105	0.31
Non-farm income	189.40	209.93	0	900	111.67	212.61	0	1000	3.16***

NB: ***,**, and * indicates significance at 1%, 5% and 10% respectively. Eigenvalues and.
Source: Author's field survey, (2021)

by both participants and non-participants. This means there is no statistically significant difference between participants and non-participants in terms of labor used in production. Non-farm income is a critical personal conversion factor that improves one's abilities and economic standard of living. The mean amount of non-farm income is GH₵189.40 and GH₵ 111.67 for both participants and non-participants respectively. This shows that on average the participants have income from other sources such as mining than the non-participants. This could be a clear reason why they chose to lease out their farmlands to mining companies. Since the farmers were in two categories thus those who leased out their farmlands to mining concessions otherwise referred to in this study as either participants or convertors and those who did not, referred to as non-participants or non-converters, a *t*-test was done to examine whether there are statistically significant differences among the socio-economic, institutional, and production characteristics. All variables tested were significant except labor (t = 0.31) as shown below in Table 4.

Table 5
Heckman 2-stage treatment effect model results for factors influencing land-use conversion and its effect on farmers welfare.

Variable	Coefficient	Std. Error	P-value
Treatment equation (Land use conversion)			
Age	.029***	.0079	0.000
Distance from farm household to the farm	-.0035**	.00183	0.056
Distance to the nearest access road	-.0096**	.0037	0.009
TLsize	.0649***	.01938	0.001
Sex	.582**	.27876	0.037
Farmers experience	.0160**	.0085	0.060
Cons	−2.348	.4342	0.000
Outcome equation (Welfare)			
Good price	−114.57***	115.4618	0.321
Tamount	.9129	.5264	0.083
Rent	169.914	124.658	0.173
VAEA	548.878***	290.842	0.059
Qherbicides	26.910	25.9805	0.300
Sex	−155.375***	156.682	0.321
Hsize	−18.553***	13.520	0.170
x1	1.0179	1.04827	0.332
employment	170.11	124.1249	0.171
M_status	661.65	101.832	0.000
Land_convert	821.6369	218.833	0.000
Constant	1159.487	186.172	0.000
Rho	−0.2749		
Sigma	833.162		
Lambda	−229.048***	135.355	0.091
Model diagnostics			
Wal chi2 (13) = 67.50, p > chi2 = 0.0000, N = 300			

Author's computation (2021).

5.3. Factors influencing land-use conversion among farmers

The model results of the factors that determine land-use conversion among farmers are shown in Table 5 below. The Lambda is negative and significant at 10%, indicating that there are sample selectivity bias and that unobserved factors that make the land-use conversion more likely tend to be associated with welfare. From the results, the Wald chi-square test at 13°' freedom is 67.50, which is statistically significant at 1% thus indicating a good fit for the data. All the seven variables in the treatment equation are significant. For the outcome equation, the total amount obtained from produce, marital status, and land-use conversion are influential in determining farmers' welfare.

Age was statistically significant at 1% and has a positive effect on the probability for a farmer to lease out his land for mining purposes. Holding all other things equal, when age increases by a year, the probability to have one's land converted for mining purposes increases. The interpretation is that younger farmers are less likely to convert their land for mining activities. This result could be because the elderly is less energetic to engage in farming activities due to the demanding nature of farming. So, the elderly prefers to release their lands for mining purposes for compensation to cater for themselves. Though this finding shows the significant influence of age in land-use conversion for mining purposes, Arthur et al. (2016) indicated that artisanal and small-scale mining has played an important role in the expansion of the Ghanaian mining sector which resulted in obtaining the second position after South Africa (Note: Ghana is now the leading gold producing country in Africa). The researchers realized that about 59.5% of the respondents who were interviewed acknowledged that mining activities have played a major role in income generation and job creation as such farmers were willing to convert their farmlands into mining. They also did indicate that most of the inhabitants engaged in the mining activities were mostly women and children because of economic hardship as it contributes to income generation for the betterment of their livelihoods. Gender was also positive and statistically significant at 5%. This suggests that male-headed households are more likely to convert their lands for mining purposes than their female counterparts. In the Ghanaian context, besides males having the prerogative of household decisions which may include decisions regarding land use, some cultural norms do not allow females the allodial title of land ownership thus granting men more access to land than women. A study conducted on customary land ownership and gender disparity in the Upper West Region, Ghana found that males had 68% land ownership and females had only 32% (Kuusaana and Gerber, 2015). The distance from a farmer's household to the farm was significant at 10% with a negative effect on participation in land-use conversion. This means that proximity to the farm has a negative influence on the decision to convert land to be used for mining purposes. The plausible reason could be that lack of good roads coupled with longer distances to farms could serve as a disincentive for

small-scale miners due to the distance, especially judging from the strict rules that the current government has placed on the activities of the small-scale miners. Farmer's experience was another important variable measured. The experience level of a farmer was measured by the number of years he/she has spent in farming. The study observed that it had a positive effect on participation in land-use conversion, but only statistically significant at 10%. This means households having more experience in farming have a higher probability to convert or sell their lands out for mining than households with less experience. One possible reason could be that households with higher experience in farming have over the years seen that converting one's land for mining is more rewarding than engaging in subsistence farming hence could make better decisions with regards to land-use conversion for mining purposes. Besides that, such farmers may have identified the importance of involving themselves in mining activities thereby providing an edge to participate over households with less farming experience. The Ahafo branch of the Newmont Ghana Gold Limited (NGGL) which is the only large-scale mining firm in the district provides many economic, infrastructure, and human resources and capacity-building opportunities to farmers and households who lease out their farmlands to mining (Boakye et al., 2018). This could be another possible reason and source of motivation for some experience farmers to lease their lands to the mining giant to also enjoy those benefits. The total land size of an individual farmer was found to have a significant positive effect on participation in land-use conversion at a 1% level of significance holding all other things constant. This means farmers with larger farm sizes are more likely to convert their lands for mining purposes. This finding is in line with the a priori expectation as farmers with larger land sizes will be ready to release some for mining purposes to get some form of compensation to enable them to reinvest into their farming activities. The coefficient tells that if farm size increases by one acre, the probability for an individual to convert his/her land for mining increases, all things held constant. The distance to the nearest access road was measured in minutes and was found to have a negative influence on participation at a 1% level of significance. Since the distance to the nearest access roads is a function of cost, it means that farmers who live far away from accessible roads participate less in converting their lands for mining purposes. The coefficient of distance to the nearest access road indicates that as the distance to the access road increases by 1 min by walking, the probability to participate in land use conversion decreases by 1%, ceteris paribus.

5.4. Impact of land-use conversion on farmer's welfare

Land-use conversion had a direct relationship with output at a 1% level of significance on farmers' welfare (Table 5). The result indicated that farmers who converted their lands for mining purposes have higher welfare in terms of annual income than those who didn't engage in land-use conversion. This result could be a challenge against the government's priority of increasing agri-food production. The result means that since there is an increase in welfare among farmers who convert their lands for mining purposes, there is the likelihood that several others might want to engage in that which will further jeopardize the Ghanaian government agenda of achieving food security and sustainable livelihoods. The reason is that with the claim of lands from the farmers by the mines with inadequate, sometimes no compensations given, most of these farmers are not in a good position to buy even basic items at high prices because of competitive miners' income (Taabazuing et al., 2012). Food items could potentially become scarce because as land grabbing by mines increases, both agricultural extensification and intensification are also decreasing. The situation is worsened by the fact that after realizing that the compensation could not be sustainable, most of these poor farmers venture into small-scale illegal farming. This leads to a stage that food items have to be brought to the market from other towns (Hilson and Garforth, 2013). Though farmlands were taken over as concessions by mines, crop compensations were either disproportionate or not been paid on time which further impacted negatively on the livelihoods of the people. In situations where compensations are given, the money given is insufficient and far incommensurable (Table 6 below) from the total amount received from the sale of farm produce. This significantly influenced the welfare of farmers in the study area and was statistically significant at 10%. When the annual income of a respondent increases by one Ghana cedi, there is a corresponding increase in welfare as the results indicate. This result could also be a result of the fact that households with a good amount of income can invest in other businesses that help to improve their welfare. Previous research in Ghana showed how financial management training, has provided new skills and knowledge through which additional incomes could be obtained by the respondents (Aryee et al., 2011). A little over twenty-five percent of the heads of households interviewed in the study communities admit that the introduction of mines into their communities and the operation of the mines, in general, have enhanced their livelihoods which were in agreement with previous works (Aryee et al., 2011; Benach et al., 2014; Wilkinson and Pickett, 2006; Yip et al., 2007). Positively in the sense that income can improve the living conditions of people because they can afford basic food and services and hence improve upon their wellbeing.

Table 6
Comparative compensation for affected farmers 2020 and 2010 production years.

Type of crop	Compensation (2020)	Compensation (2010)	Rate of increased (%) over 10 years
1 acre of cocoa	GHC 28,000 ($4868.13)	GHC 3400	723.5
1 acre of teak	GHC 19,000 ($3.303,37)	GHC6,900	175.4
1 acre of palm	GHC 12,000 ($2086.34)	GHC900	1233
1 acre of cashew	GHC 8000 (1390.89)	n/a	n/a
Arable crops	GHC 4000 ($695.45)	n/a	n/a

Source; Field survey (2021). n/a = Not available. All conversions were made at the time of compensation.

Access to extension services as well as inputs like fertilizer and insecticides must be enhanced to increase technology adoption and output in agricultural businesses. Extension access is the source of information for farmers on new agronomic practices, therefore, it is not surprising that access to extension agents has a positive influence on the welfare of the participants. This means that apart from their involvement in land-use conversion for mining, access to the extension has also got an influence on their welfare. The results show that members who had access to agricultural extension services at the time the data was collected had an increase in welfare at a 1% level of significance as compared to members who didn't have access to the extension. The findings from this study are in agreement with earlier studies which noted that large-scale mines provide farmers and with capacity-building workshops and supply inputs and extension services to the affected farmers (Mahar et al., 2016; Ocansey, 2013). In a nutshell, the respondent's marital status was also significant at a 1% level of significance. Apart from the fact that married couple does pull their resources together to achieve better outcomes in terms of livelihood improvement, they also have an advantage of family labor to be able to work effectively on their farms, unlike unmarried couples. The large-scale mines provide adult literacy education to couples within the study area which could be an important avenue for acquiring life-changing skills. Earlier studies have also indicated that mining competes with agriculture for family labor as such married people may turn to have more labor than their unmarried counterparts hence may be more willing to offset their labor into other livelihood activities such as mining to get more money (Boon and Ababio, 2009).

5.5. Mode of compensation from NGGL to affected farmers

Compensation is simply rewarding someone for service rendered or making up for someone's loss, injury or damage. In literal terms, the word compensation can be summarized as indemnification. With regards to this study, compensation is defined as the total cash and non-cash payments made to an affected farmer who has lost either his piece of farmland, crops or even a house. Regardless of the level of severity of the damage, compensation of any kind remains the primary requirement for land acquisition in Ghana by either a person or a group of persons. Since the beginning of mining in the Asutifi North district by the Ahafo branch of the Newmont Ghana Ghana Gold Limited in 2006, many farmers whose farmlands were taken by the mining concessions have been compensated in various forms.

However, there have been various concerns of serious infractions from the mining company to affected farmers. These infractions span from late payment of compensations, low compensations, and non-payment of compensations for some crops. Aboagye (2014), noted two different infractions by the Ahafo branch of NGGL regarding payment of compensations of affected farmers. The study disclosed among others that the company refused to pay for compensation for affected uncultivated and fallow lands during the initial stages of its operations. The study also further indicated that the company had their shade of cover from the Minerals Commission noting that the mining Act did not adequately address the compensation of land loss and hence the company's inability to compensate for the land loss. Also, Kidido et al. (2015) put it this way, that the most important principle for paying compensation is to guarantee that anyone whose land is taken from him or her does not end up being worse off than before. This current study observed that the compensation criteria were based on two major factors thus, the land and the types of crops on the land. Different types of crops have different compensation packages. Generally, compensation for cash crops was higher than that of arable crops. Comparing the current figures for compensation of various crops to those reported in Yaro (2010), we noticed that there has been a steady increase in compensation over the years. However, this is still not enough to meet the long-term need of the farmers. In 2010, the compensation for an acre of teak was valued more than that of cocoa. This led to most farmers cultivating more teak plantations than cocoa. The repercussions of this phenomenon were that those who could not have their pieces of teak plantations taken over by NGGL on time, could not make any money from it. Unlike cocoa which yields fruit every time within the season, thereby generating income for the farmer on regular basis, teak does not bear fruit hence cannot guarantee such revenue for the farmer. This was corrected and an acre of the cocoa farm is now valued more than that of teak as shown in Table 6. Currently, a bag of cocoa is now sold at GHC 660 in Ghana and an acre of cocoa on average can produce 10 bags of cocoa annually (Cocobod report, 2020). So, if an acre of cocoa farm produces an average of 10 bags of cocoa annually, then it would take approximately 4.5 years for a farmer with one acre of cocoa farm to get GHC 28,000 ($4868.13) or even more ($660 \times 10 \times 4.5 =$ GHC 29,700) which is the compensation package farmers receive for leasing an acre of cocoa farm to the mining company. Considering this, then one could describe the compensation given to the farmers as incommensurable. This results in farmers engaging in illegal small-scale mining to make up for their needs. These findings are in agreement with the work of Darko (2017) who observed that insufficient compensation and late payment of compensation packages were the two most compelling factors affecting farmers who lease their lands to NGGL in the Asutifi-North District.

During the questionnaire administration, some of the farmers recounted their stories that the compensation they received from the mining company was so low that they could not invest it into any meaningful or sustainable business. So, the money finished over time and they are left with no choice but to venture into illegal mining to meet the daily need of their families. Some farmers indicated that the leadership of the farmers' caucus has met severally with the leadership of the mining company to ensure an improved compensation package, but this has since been an issue. However, Adonteng-Kissi (2017), have questioned the skills and ability of farmers to negotiate and arrive at meaningful packages during compensation negotiation.

6. Conclusion and policy recommendation

Mining is a normalized activity in Ghana with a long history dating back to the precolonial era. Gold mining has often been seen as a poverty alleviation tool for marginalized farmers in rural communities. However, its exact effect on farmers' welfare in terms of monetary value in Ghana is lacking. This current study explored the impacts of gold mining on farmers' welfare taking into account the hidden factors that push farmers to lease out their land to large-scale mining concessions with its resulting impacts on their welfare and the compensation criteria offered to farmers in return for their displaced lands. The study used a mixed-method approach thus combining both quantitative (Heckman two-stage model) and qualitative data from questionnaires and interviews which spanned for 9 months. Results from the treatment equation show that factors such as farmer's age, distance to farm, distance to the nearest access road, total land size, sex, and farmer's experience influenced their decision to convert their land for mining in return for compensation. In the outcome equation, good price, extension visit, household size, and sex were the factors that significantly influenced farmers' welfare. Also, farmers who leased out their farmlands to mining had higher welfare value (GH₵ 189)-$31.68 than those who did not. However, this amount is not enough as a sustainable income for the farmer's household upkeep in the long run thus forcing them into small-scale illegal mining which was observed as a common phenomenon in the district. The study again observed a direct linkage between insufficient compensation packages and the exponential growth of small-scale illegal mining within the area. Quantifying individual household, and communal assets were problematic to the large-scale mine. As such, the extent to which the amount of compensation equals the value of a loss incurred by farmers both in the short-term and long-term is not the focus of the NGGL. Compensation is based on what NGGL can offer to affected farmers, not based on its compatibility with the loss farmers incur. From our calculations, the compensation given to a farmer for one acre of the cocoa farm taken could be recouped within 4.5 years of production by the farmer if the farm had not been taken by the mine. This shows that such compensation packages were not enough. Consequently, farmers are compelled to engage in illegal mining as a means of alternative income for family upkeep since they have leased all or major portions of their farmland to the mining concession. Based on the findings from the study, the following policy recommendations are made. The study recommends that the current compensation should be revised to a level that such money could be more useful and rewarding to the affected farmers. This could be done through consensus between representatives of the affected farmers and the mining giant (NGGL), including government intervention. Also, even as little as the compensation may be, farmers should be educated and equipped with business and entrepreneurial skills to always invest money in small-scale enterprises. This would help them to make a living even in the long run while also reducing their participation in illegal mining. It would also ensure that the environment is protected going forward as fewer farmers would engage in illegal mining.

Credit authorship

Adator Stephanie Worlanyo[a]; Conceptualization, Writing an original draft, Methodology; Writing review and editing. **Sikpaam Issaka Alhassan[b];** Conceptualization; Writing the original draft, Methodology, Data curation, Formal analysis, and Writing review & editing; **Jiangfeng Li[a]*;** Funding acquisition, Supervision, Validation and Project administration.

Declaration of competing interest

The authors of this study give their consent that, there is no known competing interest either financially or otherwise among them which could potentially jeopardize the publication of this manuscript.

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