Farmers' coping strategies to artisanal small-scale mining activities: welfare improvement or deterioration in Asutifi North District of Ghana?

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Abstract

Purpose – In Ghana, legal and illegal artisanal small-scale mining (ASM) activities have attracted the attention of the general populace and academia with varied opinions. This study examined how adopting the coping strategies for ASM operations affected the welfare of farm households.

Design/methodology/approach – Primary data were solicited from respondents using a semi-structured questionnaire. This paper used the endogenous treatment effect model to quantitatively estimate whether or not farmers who adopt coping strategies for activities of ASM have improved or deteriorated welfare.

Findings – The results revealed that households adopted coping strategies such as diversification, social networking, land reclamation, borrowing, dependence on the market for food and resettlement in other communities. The endogenous treatment effect model results show that households that adopted land reclamation and social networking had improved welfare regarding consumption expenditure and food security compared to non-adopters. Conversely, diversification was associated with lower consumption expenditures and high food insecurity among adopters.

Practical implications – This paper recommends that farm households in mining communities form cooperatives and farmer-based organizations to ensure improved access to joint resources for enhanced capacity to cope with ASM-induced shocks. There is a need for government and civil society organizations to encourage and support land reclamation measures.

Originality/value – This paper covers a broader perspective and deploys more than one welfare proxy, which has not been considered before in previous studies.

Keywords Artisanal small-scale mining, Adopters, Coping strategies, Welfare
Paper type Research paper

1. Introduction

Despite its long history of dispute and scholarly and political debate, artisanal small-scale mining (ASM) is yet to be given a universally accepted definition. Many researchers, groups and policymakers have defined ASM differently at different times and in different geographical areas worldwide. Despite the differences in definitions, there are some common characteristics: most artisanal miners are severely undercapitalized, rarely function as legitimate businesses and lack contemporary technology. Hinton (2006) defined ASM as a collection of mining activities ranging in scale from small to large that are distinguished from "formal" mining by a low degree of mechanization, high labour intensity, poor occupational and environmental health standards, a lack of capital investments and a lack of long-term planning. This definition identifies ASM as a generally unstructured and unorganized activity. ASM is usually classified into two groups: ASM with license and ASM without license.

ASM in Ghana presents both opportunities and threats to local economic development. On the one side, the contribution of ASM in Ghana to wealth creation, employment and the economy makes it one of the nation's most important livelihood activities, employing an estimated one million people and supporting approximately 4.5m more (Osei *et al.*, 2021; Hilson and Maconachie, 2020). On the other side, the informality associated with ASM in Ghana has resulted in several negative externalities such as pollution of waterbodies, degradation of arable agricultural lands and biodiversity as well as adverse health impacts on local residents (Isung *et al.*, 2021; Hilson, 2016; Osei *et al.*, 2021). In recent years, the negative externalities of ASM have overshadowed its economic gains, leading to increasing criticism from the public, the media, academic scholars and political actors likening the ASM scenario in Ghana to the "resource curse hypothesis," which provides compelling evidence that, natural resource extraction can be a barrier to local economic development (Zolnikov, 2020). Therefore, it is unsurprising that ASM operators, popularly called "galamsey operators" in Ghana, are seen by the public, policymakers and the media as a menace that must be eliminated.

According to Kusimi (2007), ASM activities in Ghana have contaminated significant portions of land previously used for agriculture, making it challenging to access viable farmlands for agricultural purposes. Farm households in many mining communities have utilized different coping strategies to help counter the negative implications of ASM activities on their livelihoods. Coping strategies are livelihood tactics utilized when a person's livelihood is threatened (De Haan, 2012). In the context of this study, coping strategies are adaptive and often community-driven approaches and actions taken to mitigate the adverse consequences and challenges associated with small-scale informal mining activities. These coping strategies aim to reduce the social, environmental and economic impacts of artisanal mining on farm households in mining communities. Much of the research on livelihood shocks and coping strategies starts with the underlying lifecycle model, which contends that households aim to smooth consumption to maintain their marginal benefit of consumption constant (Deaton, 2005). Coping strategies such as out-migration, diversification, borrowing from financial institutions, buying food from the market, selling livestock, engagement in off-farm employment, borrowing from relatives and doing nothing have been used in many research relating to environmental and livelihood shocks and household welfare across the globe.

Previous studies on ASM in Ghana, such as Hilson (2016), Banchirigah (2008), Aragon and Rud (2015), Onumah *et al.* (2013), Yankson and Gough (2019), Akabzaa (2000), Amoah (2003), Amponsah-Tawiah and Dartey-Baah (2011), Boateng (2017), Obeng and Appiah (2019) among others, which are primarily qualitative have focussed on the effect of ASM on the environment, ASM and agriculture as well as women's participation in ASM. Moreover, the previous studies on ASM in Ghana failed to identify the coping strategies that farm

households are using to deal with the adverse effects of ASM and how adopting these coping strategies affects the welfare of households. A better understanding of the relationship between the various coping strategies and welfare will help design policies to protect vulnerable farm households against the adverse effects of ASM in mining communities while providing an efficient pathway to exit poverty. Also, this study covers a broader perspective and deploys more than one welfare proxy (consumption expenditure and household food insecurity status) simultaneously, which has not been considered before in previous studies in Ghana. In conclusion, this research provides knowledge to the scant existing literature on how farmers cope with the negative impacts of ASM activities.

2. Methodology

2.1 The study area

The study was conducted in the Asutifi North District in the Ahafo region of Ghana (see Figure 1). Agriculture is the main economic activity in the district. The principal food crops are cassava, plantain, maize, cocoyam and vegetables such as cabbage, tomatoes, garden eggs, okro and pepper. Cocoa is the major cash crop produced in the area. Among the district's most significant development potentials are its large natural resources in the fields of timber and forestry products, rich soil with great agronomic value and mineral deposits, particularly gold. The prominent large-scale mining company in the district is Newmont Gold Ghana Limited (NGGL), with the Ahafo South concession (Tenkorang, 2021). According to Tenkorang (2021), this large-scale mining has increased the activities of legal small-scale mining and illegal small-scale mining in the district.

2.2 Data requirements

Cross-sectional research was employed in this study. A two-stage sampling technique was applied to select the sampled respondents from the mining communities in the district. In the first stage, ten communities were selected using a simple random sampling technique from a sampling frame of 20 mining communities. All the communities in the district share common demographic and socioeconomic characteristics. The ten mining communities were Ntotroso, Wamahinso, Gyedu, Kenyasi No. 1, Nkrankrom, Kenyasi No. 2, Ananekrom, Atwedee,

Figure 1.
Map of Ahafo region showing Asutifi North District

Source(s): Asutifi North District Assembly (2019)

Tutukwa and Attakrom. These communities are spread across the districts, with most inhabitants engaged in farming, while few are involved in ASM activities. In the second stage, 316 households were selected using proportionate probability sampling and systematic sampling techniques, which relied solely on the respective sizes of the communities as well as house numbers, respectively. A semi-structured questionnaire with both open-ended and closed-ended questions was used to collect data. The reliability of the research instrument was determined by doing a pilot study (pre-test) involving ten respondents in a mining community in the Savanna region. Lessons learned from the pre-test were used to make the necessary amendments to improve the questionnaire. The Cronbach's alpha of 89% shows that the survey instrument was reliable.

2.3 Theoretical and analytical framework
The random utility model (RUM) of the microeconomic consumer theory was used in this research. The RUM defines a choice resolution in which an individual i has a set of alternative coping strategies j from which to select (McFadden, 1978). As noted by Asfaw *et al.* (2012), a utility-maximizing farm household will choose to adopt a particular coping strategy or a combination of strategies if the expected utility is greater than that of non-adoption. This study assumes that a respondent's choice to adopt a coping strategy against the adverse effects of ASM is attributed to the respondent's inherent characteristics and other latent attributes. Therefore, the issue of selectivity bias needs to be dealt with if one wants to estimate the adoption effect on an outcome variable.

The linear endogenous treatment effect regression (ETR) model was used for a more robust approach and consistent estimation of the influence of coping strategy adoption on household welfare. The endogenous treatment effect model is a linear potential outcome model that provides for a specific correlation between unobservables that impact treatment and the potential outcome. The ETR model eliminates bias from observables and unobservables and permits the estimation of the determinants of coping strategy adoption and the direct impact of that adoption on welfare outcomes. This is accomplished by jointly estimating selection and outcome equations. As long as the treatment variable is binary, it can be utilized for continuous, binary, count, fractional and non-negative outcomes. It is also predicated on the notion that the factors influencing the outcome variable differ between the treated and control groups.

The selection model, which employs probit, is the model's initial stage. It states that certain socioeconomic factors influence farmers' adoption (t = 1) or non-adoption (t = 0) of coping strategies.

$$Prob(\text{t} = 1 \text{ or } 0|X) = f(X\alpha) = \alpha_0 + \sum_{j=1}^{j=J} \alpha_0 X_{ji} + \mu_i \qquad (1)$$

where

X represents a vector of explanatory variables, f represents standard normal cumulative distribution function, α represents a vector of unknown parameters, j represents jth socioeconomic factor, μ represents the error term and i represents the ith farmer.

Endogenous treatment effect models use an estimate that integrates residuals from the treatment model (probit model) in the outcome model to overcome the problem of sample selection bias and endogeneity of coping strategy adoption (Kassie *et al.*, 2011). The outcome models that estimate the direction and magnitude of the factors influencing welfare level for adopters and non-adopters of farm households are:

$$y_{i0} = E(y_{i0}|X_i) + \varepsilon_{i0} = \acute{x}\beta_0 + \varepsilon_0 \qquad (2a)$$

$$y_{i1} = E(y_{i1}|X_i) + \varepsilon_{i1} = \acute{x}\beta_1 + \varepsilon_1 \tag{2b}$$

where y_o and y_1 are the household welfare score for ith farmer who is a non-adopter and adopter of coping strategies, respectively; β_0 and β_1 are the vectors of coefficients; ε_0 and ε_1 are the error terms of regime one and two, respectively, and X represents the explanatory variables that can affect welfare level of farm households. Validating the null hypothesis that the treatment and outcome are uncorrelated is essential to determining whether endogeneity exists. From the above equations, a post-estimation was conducted, which estimated three treatment effect measures, namely, average treatment effect on the treated (ATET), average treatment effect (ATE) and potential outcome means (POMs) (Stata Manual, 2015) using the formulae below:

$$ATE = E(y_{1i} - y_{oi}/x_i) \tag{3}$$

$$POM_t = E(y_t) \tag{4}$$

$$ATET = E(y_{1i} - y_{oi}/x_i t_i = 1) \tag{5}$$

Empirically, the potential outcome of welfare for farmers who did not adopt coping strategies (y_{0i}) and farmers who adopted coping strategies (y_{1i}) are represented below:

$$y_{0i} = \beta_0 + \beta_1 AGE_i + \beta_2 SEX_i + \beta_3 EDU_{\cdot i} + \beta_4 HHSIZE_i + \beta_5 FMSIZE_i + \beta_6 FBO_i$$
$$+ \beta_7 CREDIT_i + \beta_8 FMYRS_i + \beta_9 HHINCOME_i + \beta_{10} ASMYRS_i$$
$$+ \beta_{11} DISSITE_i + \beta_{12} HHCONS_i + \beta_{13} EXTQTY_i + \varepsilon_0 \tag{6}$$

$$y_{1i} = \beta_0 + \beta_1 AGE_i + \beta_2 SEX_i + \beta_3 EDU_{\cdot i} + \beta_4 HHSIZE_i + \beta_5 FMSIZE_i + \beta_6 FBO_i$$
$$+ \beta_7 CREDIT_i + \beta_8 FMYRS_i + \beta_9 HHINCOME_i + \beta_{10} ASMYRS_i$$
$$+ \beta_{11} DISSITE_i + \beta_{12} HHCONS_i + \beta_{13} EXTQTY_i + \varepsilon_1 \tag{7}$$

An endogenous treatment effects (eteffects) model with a control approach was used to estimate the effects of coping strategies to ASM activities on welfare indicators. Table A1 in Appendix shows definitions, measurements and *a priori* expectations of variables in the models.

3. Results and discussions

3.1 Demographic characteristics of farmers

The demographic characteristics of the surveyed farm households are shown in Table 1. The mean age of the respondents was 51 years, which indicates the involvement of more elderly people in agricultural activities. In terms of sex distribution, the result reveals a significant prevalence of male-headed households (67.7%) compared to female-headed households (33.3%) and this corresponds to Ghana's statistics, which show that 65.3% of households have male heads while 34.7% have female heads (Ghana Statistical Service, 2019). The mean years of education of six years imply that most respondents in the study area have attained formal education up to the primary level. It can be argued that most of these people would be unable to engage in formal non-farm activities, increasing their likelihood of resorting to various activities along the ASM value chain.

From the results, the mean household size was of six persons. The findings are similar to those of Mabe *et al.* (2021), who discovered an average household size of 7.75 people in Ghanaian areas where small-scale mining is prevalent. For farming experience, the households have an average of 23.76 years of agricultural experience, indicating more than

Variable	Mean	Std. Dev	Min	Max
Age (Years)	51.013	13.49	28	76
Sex (1 = Male, 0 = Female)	0.677	0.468	0	1
Educational level (Years)	6.0380	5.231	0	17
Household size (Number of People)	6.165	1.734	3	11
Farming experience (Years)	23.7595	13.2738	2	54
Membership of FBO(1 = Yes, 0 = Otherwise)	0.5126	0.500	0	1
Access to credit facilities (1 = Yes, 0 = Otherwise)	0.601	0.49	0	1
Amount of credit received (Gh₵)	6717.708	4025.469	1200	18000
Access to ext. services (1 = Yes, 0 = Otherwise)	0.81	0.393	0	1
Farm size (Acres)	3.7879	2.1795	1	14
Total household income (Gh₵)	26198.35	19455.41	8000	99000
Years of ASM in the community (Years)	10.26	1.84	3.5	13
Distance to mining site (Km)	3.04	1.14	1	7
Total household expenditure (Gh₵)	13883.04	5839.015	6396	34944

Note(s): [Exchange rate in May 2021: $1 = Gh₵6.30]
Source(s): Field survey (2021)

Table 1.
Descriptive statistics of
key sociodemographic
characteristics of
respondents

two decades of farming experience in the research area, while 51.2% of the respondents indicated their membership with FBOs in the study area. The members of farmer-based organizations meet on average twice a month, showing that farmer-based organizations are moderately robust in the research area.

Many respondents (60.01%) received credit facilities, which came mainly from credit unions, microfinance institutions, family and friends. The findings of the survey further revealed that 81% of the respondents received agriculture extension services. The study discovered that the average farm size cultivated was 3.8 acres, with the largest farm size being 14 acres and the smallest being 1 acre. The average farm size of 3.8 acres falls within the range of the national farm holding of 1–5 acres (2 hectares). The average annual income in the study area was Gh₵26,198, with the minimum annual household income being Gh₵8,000 and the maximum annual household income of Gh₵99,000. The average annual household income in the study area falls below the Ghana Statistical Service (2019) national average of Gh₵ 33,937. It was revealed that household income in the study area flows from sales of cocoa, compensation from ASM operators, compensation from Newmont Ghana Gold Limited, remittances and non-farm activities. Also, households in the study area spent an average of GH₵13,883.04 each year, with a lowest of GH₵6,396 and a highest of GH₵34,944. The average household expenditure is slightly greater than the national average of GH12,857 and the national lowest and maximum of GH₵5,168 and GH₵19,421 per year, according to the Ghana Statistical Service (2019) estimates.

The average distance from the residence to the mine sites was about 3 km, with the closest and farthest distances from the residence to the mine sites being 1 –7 km, respectively. The proximity of communities to mine sites has profound health implications for households. Hinton (2006) observed that the distance between households and mining sites is positively related to exposure to household pollution. As a result, it is feasible to conclude that the study area's proximity to mine sites increases human exposure to ASM activities, leading to health problems and a decline in household food security.

3.2 Types of coping strategies adopted by farm households and intensity of adoption
The frequency distribution of coping strategies adopted by households against the negative consequences of ASM activities is shown in Table 2. Considering the responses from the

respondents, farmers relied on land reclamation, resettlement to a different community, diversification and dependence on the market for food, social networking and borrowing as coping strategies to deal with the negative effects of ASM on their welfare. These coping strategies were obtained from an extensive literature review and a reconnaissance survey in the district before they were presented to the farmers during the data collection. The results indicate that diversification forms the highest adopted strategy (36.08%), followed by social networking (34.18%), land reclamation and borrowing (31.01%), dependence on the food market (30.38%) and finally, resettlement to a different community (29.11%).

Diversification, for instance, refers to farm households venturing into other income-generating activities due to the ASM invasion. Social network refers to informal insurance in the form of cash or materials provided by family members, friends, neighbours and affiliated groups to farm household members in economic crises due to the destruction of their farmlands by ASM operators. Land reclamation refers to farm households restoring disturbed or altered land areas impacted by mining activities back to a functional state. ASM often activities can significantly change the landscape, topography, soil structure and vegetation, thereby requiring land reclamation. Dependence on the market refers to a situation where farm households who were previously self-sufficient in food production now rely on purchasing food from external sources, such as markets because the adverse effects of mining have disrupted their ability to produce food locally. Resettlement/out-migration refers to a household member moving out of their community affected by ASM to a different community for an enhanced livelihood opportunity.

The number of coping strategies adopted by the sample is shown in Table 3. From Table 3, most sampled households (32.28%) adopted two coping strategies, followed by 26.58% of the respondents who adopted three coping strategies. The results further reveal that 24.68% of the sampled households did not adopt any of the coping strategies, while 6.33% and 9.49% of the sample adopted only one of the coping strategies, and four of the coping strategies, respectively, with only 0.63% of the respondents adopting five of the coping strategies at the same time.

Coping strategies	Frequency	Percentage
Land reclamation	98	31.01
Resettlement/Out-migration	92	29.11
Diversification	114	36.08
Dependence on market	96	30.38
Social network	108	34.18
Borrowing	98	31.01
Source(s): Field survey (2021)		

Table 2.
Farm households' coping strategies against the negative effects of ASM

Number of coping strategies	Frequency	Percentage	Cumulative
0	78	24.68	24.68
1	20	6.33	31.01
2	102	32.28	63.29
3	84	26.58	89.87
4	30	9.49	99.37
5	02	0.63	100.00
Total	316	100.00	
Source(s): Field survey (2021)			

Table 3.
Intensity of adoption of coping strategies by farm households

3.3 Effects of the adoption of coping strategies on households welfare
Two outcome variables, household consumption expenditure and household food insecurity score (HFIS), were used as proxies for welfare. Consumption expenditure in this study refers to the measurement of goods and services consumed by a household during a calendar year. This study's primary components of consumption expenditure were food consumption, non-food items (e.g. health, education, rent and utilities) and consumer durables. On the other hand, HFIS refers to the assessment of a household's ability to consistently access an adequate and nutritious food supply during a calendar year. The HFIS in this study was based on a series of nine questions that focused on the quantity and quality of food consumed as well as the stability and predictability of access to food resources by households.

Tables 4 and 5 indicate the factors influencing the adoption of coping strategies for HFIS and household consumption expenditure, respectively. The TME1 model depicts the factors that influence adopting coping strategies on welfare. The OME0 and OME1 models look at the factors influencing household welfare for farm households who are not using and those who are using coping strategies, respectively. The household welfare indicators used for this analysis are consumption expenditure and household food insecurity score. Consumption expenditure was based on the indication that consumption is far less volatile compared to income. Unlike income affected by seasons, especially in the study area, which can lead to underestimation or exaggeration of real income, consumption expenditure is relatively stable. HFIS was also chosen because it provides a more direct and comprehensive perspective, especially in the study area where food insecurity is a significant concern due to ASM activities.

The null hypothesis of no endogeneity is rejected, as shown in Tables 4 and 5, because the chi-square values of 5.96 and 6.88 are statistically significant. This suggests that unobserved

Variables	TME1	OME0	OME1
AGE	0.0045 (0.0087)	−111.4096** (60.2204)	−361.7354*** (71.2312)
SEX	−0.5338*** (0.1307)	3044.6000*** (892.3288)	2673.2730*** (1029.4630)
EDU	0.0505** (0.0223)	128.4600 (100.9035)	65.9190 (90.6789)
HHSIZE	0.2366*** (0.0340)	1449.4400*** (349.6138)	1278.2070*** (383.6804)
CREDIT	0.9355*** (0.1630)	−1365.3260 (1709.9160)	−1517.4120 (2017.4870)
FMSIZE	−0.0350 (0.0224)	−269.7145 (144.6978)	214.0879 (201.6762)
FBO	0.0087 (0.1565)	3029.0830** (1085.5340)	1214.8800 (1108.3320)
FARM YRS	−0.0143 (0.0119)	78.0866 (49.8121)	204.0598*** (58.5025)
ASM YRS	−0.1445*** (0.0199)	240.2201 (252.6436)	−209.6648 (286.2724)
DIST TO SITE	0.3683*** (0.0309)	–	–
HH CONSU	2.18e-05*** (5.65e-06)	0.0450 (0.0443)	−0.0355 (0.0576)
EXT QTY	0.1805*** (0.0559)	–	–
CONSTANT	−1.0833* (0.4108)	1479.1520 (4032.3880)	18927.4700*** (3779.5250)
TEOM0_cons		−9796.2100** (4041.3700)	
TEOM1_cons			919.9240 (3220.6700)

Note(s): $\chi^2(2) = 5.96^*$; Prob $> \chi^2 = 0.0509$
OM0 = Outcome Model 0; OM1 = Outcome Model 1
OME0 = linear equation used to estimate the nontreated POM
OME1 = linear equation used to estimate the treated POM
TME1 = determinants of adoption of at least three coping strategies
OME0 = factors influencing household consumption expenditure for non-adopters
OME1 = factors influencing household consumption expenditure for adopters
[Exchange rate in May 2021: $1 = Gh₵6.30]
***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$
Source(s): Field survey (2021)

Table 4.
Determinants of adoption of coping strategies and household consumption expenditure

Variables	TME1	OME0	OME1
AGE	0.0045 (0.0087)	0.0365*** (0.0141)	0.0882*** (0.0222)
SEX	−0.5338*** (0.1307)	−0.6437*** (0.1662)	−0.3559 (0.2264)
EDU	0.0505** (0.0223)	−0.0119 (0.0275)	−0.0702*** (0.0273)
HHSIZE	0.2366*** (0.0340)	0.2363*** (0.0739)	−0.1427 (0.1080)
CREDIT	0.9355*** (0.1630)	−1.1005** (0.3692)	−1.2309** (0.4357)
FMSIZE	−0.0350 (0.0244)	0.0082 (0.0346)	0.0224 (0.0435)
FBO	0.0087 (0.1565)	−0.4010* (0.2423)	−0.3339 (0.2902)
FARM YRS	−0.0143 (0.0119)	−0.0130 (0.0099)	−0.0554** (0.0179)
ASM YRS	−0.1445*** (0.0199)	−0.0091 (0.0490)	0.3716*** (0.0823)
DIST TO SITE	0.3683*** (0.0309)	–	–
HH CONSU.	2.18e-05*** (5.65e-06)	16.8e-05** (6.89e-06)	2.94e-05* (1.11e-05)
EXT QTY	0.1805*** (0.0559)	–	–
CONSTANT	−1.0833* (0.4108)	7.3176*** (0.8510)	3.2425** (1.0495)
TEOM0_cons		0.3420 (0.9883)	
TEOM1_cons			−1.9916* (0.7659)

Note(s): $\chi^2(2) = 6.88$**; Prob $> \chi^2 = 0.0320$
OM0 = Outcome Model 0; OM1 = Outcome Model 1
OME0 = linear equation used to estimate the nontreated POM
OME1 = linear equation used to estimate the treated POM
TME1 = determinants of adoption of coping strategies to negative effects of ASM
OME0 = factors influencing HFIS for non-adopters of coping strategies
OME1 = factors influencing HFIS for adopters of coping strategies
***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$
Source(s): Field survey (2021)

Table 5.
Determinants of
adoption of coping
strategies and HFIS

factors influence both coping strategy adoption on the one hand and household consumption expenditure as well as HFIS on the other hand, and hence the justification for using an endogenous treatment effect estimator approach. As a result, the researcher could not have estimated the model using any OLS estimators. Due to endogeneity in the data, any analysis that ignores it will underestimate the true impact of coping strategies adoption on consumption expenditure and HFIS.

3.3.1 Determinants of adoption of coping strategies and household consumption expenditure. The likelihood of a farm household adopting coping strategies is highly influenced by sex, education, household size, access to credit, ASM years, distance to the mine site and several extension visits. At 1%, sex is statistically significant. The coefficient of sex is positive, indicating that being a man raises the likelihood of using coping strategies by 53%. This may be due to cultural attitudes and conventions favouring men over women regarding access to productive resources. This discovery is consistent with a study conducted in Kenya by Ngenoh *et al.* (2018). Regarding the years of education, the variable was discovered to be statistically significant at 5%, with a positive direction of the effects on the propensity to adopt coping strategies. This suggests that as the household head spends an additional year in school, the chances that a farm household will adopt coping strategies increase by 5.1%. For household size, the variable was found to be statistically significant at 1%. The positive coefficient implies that an increase in the membership of a farm household by one person increases the likelihood of using coping strategies by 23.7%. This finding aligns with Lawal (2016), who discovered a positive link between household size and the level of coping strategy used in a family by cocoa farmers in Nigeria.

Credit access significantly and positively influenced farm households' decisions to adopt coping strategies at 1%. This finding supports the assertion by Bryan *et al.* (2011) in Kenya that credit access allows farm households to build assets and spend on innovative

agricultural practices and other off-farm activities that give them a stable foundation for coping with livelihood shocks. Also, contact with extension agents was statistically significant at 1%, which implies that farmers who have contact with extension agents are more likely to employ coping strategies than those who do not have access to extension agents. According to Mabe *et al*. (2021), regular encounters between farmers and extension agents expose farmers to new farming technologies that can mitigate agricultural problems caused by ASM operations in Ghana. Distance to the ASM site was also statistically significant at 1%. The positive coefficient indicates that a 1 km increase in distance to the ASM site from residence increases the probability of adopting coping strategies by 36%. Contrary to the study's expectation, an increase in ASM activities by an additional year decreases the propensity of a farm household to adopt coping strategies by 14%.

Regarding OME0 and OME1 in Table 4, it is clear that age, sex and household size significantly affect the consumption expenditure of farm households who are both adopters and non-adopters of coping strategies. These variables (age, sex and household size) are statistically significant at 1% for users and non-users of coping strategies. While FBO membership is statistically significant at 5% in the outcome model explaining the determinants of consumption expenditure of farm households who are non-adopters, farming experience is statistically significant at a 1% level in influencing the consumption expenditure of adopters. The results in Table 4 show that sex and household size significantly and positively influences the consumption expenditure of both groups of farmers, while the reverse is true for age.

From Table 4, the coefficients for sex in OME0 and OME1 suggest that males who are non-adopters of coping strategies attain GH₵3044.60 consumption expenditure more than their counterpart females compared to male adopters who attain GH₵2673.27 more than female adopters. Secondly, the household size coefficients indicate that one person's increase in household size will increase the consumption expenditure of adopters and non-adopters by GH₵1,449 and GH₵1,278, respectively. Again, the coefficients for age imply that, as the age of the farm household increases by one year, the consumption expenditure of non-adopters decreases by GH₵111.41, whilst that of adopters decreases by GH₵361.74.

For non-adopter farm households, being a member of FBO increases consumption expenditure by GH₵1,085, but FBO membership has no significant effect on the consumption expenditure of adopters. Also, the farming experience only affects the consumption expenditure of adopters. The positive coefficient implies that engaging in farming activities by one more year increases the consumption expenditure of adopters by GH₵204.

3.3.2 Determinants of adoption of coping strategies and HFIS. Concerning OME0 and OME1 in Table 5, it can be seen that age, access to credit, and total household expenditure significantly affect the HFIS of farm households who are both users and non-users of coping strategies. The age is statistically significant at 1% for adopters and non-adopters, while access to credit is statistically significant at 5% for both adopters and non-adopters. For household total expenditure, it is significant at 5 and 10% for non-adopters and adopters, respectively. Whist sex and FBO are statistically significant at 1 and 10% levels in the outcome model explaining the determinants of HFIS of farm households who are non-adopters. Education and ASM years are statistically significant at 1% in influencing the HFIS of adopters. It is worth mentioning that the number of years in farming is statistically significant at a 5% level in influencing the HFIS level of only adopters.

The coefficients for age in OME0 and OME1 in Table 5 suggest that an increase in the age of a farm household by one year raises HFIS by 0.0365 points for non-adopters and 0.088 points for adopters. Access to credit improves the food security level of both adopters and non-adopters. Household total expenditure adversely affects the food security status of farm households who are adopters and non-adopters. Also, being a male and a member of FBO improves the food security of non-adopters of coping strategies by decreasing HFIS by 0.644

points and 0.401 points, respectively. Conversely, household size negatively affects the food security status of non-adopters by raising the HFIS by 0.236 points. On the other hand, education and farming experience improve the food security status of farm households who are adopters by decreasing HFIS by 0.070 points and 0.055 points, respectively. However, the years of ASM existence in the community worsens the food security of farm households by increasing the HFIS by 0.371 points.

3.3.3 Actual effects of coping strategies on households' welfare. Table 6 shows the actual effects of adoption of coping strategies on household consumption expenditure. The ATET for adopting at least two coping strategies reveals a substantial difference in consumption expenditure between adopters and non-adopters. The positive sign of the ATET aligns well with the study's expectations. According to the result, households that adopted at least two coping strategies have Gh₵7,989.01 higher consumption expenditure than their counterparts who did not adopt at least two coping strategies at a 5% significance level. This suggests that adopting at least two coping strategies improves the welfare level of adopters compared to non-adopters. This finding agrees with Alpizar (2007) and Martina et al. (2016), who found comparatively high per capita consumption among households that adopted coping strategies

Coping strategies	Treatment	Control	ATET	PO means	TEOM0_cons	TEOM1_cons
Household consumption expenditure						
At least two coping strategies	152	164	7989.0120** (3498.4850)	6852.1730** (3448.7760)	−9796.2100** (4041.3700)	919.9240 (3220.6700)
At least three coping strategies	50	266	2218.7910 (2871.2680)	11620.0700*** (2794.6000)	−4667.610 (2914.388)	−5957.0190 (4303.3430)
Only land reclamation	98	218	452.8376* (3045.7980)	15303.3100*** (3010.6970)	2427.8570 (3081.5980)	−9985.6720 (8520.2280)
Only resettlement	92	224	5271.4710 (3967.7710)	8949.6380** (3923.8920)	−7962.8340** (4005.9030)	−974.7140 (2277.2940)
Only diversification	114	202	−3762.3110* (2157.9530)	17891.5200* (2061.2480)	2447.0650 (2511.5210)	−4481.1150 (6539.4070)
Only dep. On Mkt for food	96	220	−9726.72*** (3297.0520)	25323.5300* (3135.1740)	11485.3400*** (3311.4280)	−3153.9530 (10275.2200)
Only social networking	108	208	1442.8280** (9673.5990)	13520.06* (7659.684)	−953.3328 (7833.6770)	−12438.6500 (11355.4700)
Only borrowing of food	98	218	325.7859 (4865.7060)	13365.8500*** (4856.9950)	−4170.4420 (5157.9480)	−2381.9760 (4899.8790)
Household food insecurity score (HFIS)						
At least two coping strategies	152	164	−0.5280** (0.9363)	7.5280*** (0.9300)	0.3420 (0.9883)	−1.9916*** (0.7659)
At least three coping strategies	50	266	2.3517* (1.2038)	5.3683*** (1.1573)	−1.5489 (1.2389)	1.4392 (1.0490)
Only land reclamation	98	218	−2.3887* (1.2332)	−5.4481*** (1.2195)	−2.1097* (1.2764)	−3.6750** (1.4361)
Only resettlement/ Out-migration	92	224	0.8455 (0.8459)	6.5458*** (0.8423)	−0.4543 (0.8756)	−0.6685 (0.7041)
Only diversification	114	202	2.8298*** (0.6853)	4.2930*** (0.6460)	−2.3775*** (0.7199)	−2.8009** (1.3061)
Only dep. On Mkt for food	96	220	−0.8424 (0.8869)	7.4674*** (0.8658)	0.5416 (0.9665)	8.7203*** (2.5914)
Only social networking	108	208	−6.5889*** (1.6108)	0.7630 (1.5211)	−6.7711*** (1.5294)	−14.8596* (4.1385)
Only borrowing of food	98	218	−4.6311*** (0.8453)	11.0189*** (0.7362)	4.2419*** (0.8086)	4.7381 (2.9026)

Table 6.
Effects of coping strategies adoption on household welfre

Note(s): [Exchange rate in May 2021: $1 = Gh₵6.30]
***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$
Source(s): Field survey (2021)

against livelihood shocks in El Salvador and Kenya, respectively. The potential outcome mean value of Gh₵6,852.17 implies that if all farmers adopt at least two coping strategies, they would have an average consumption expenditure of Gh₵6,852.17, *ceteris paribus*. Regarding adopting at least three coping strategies, the results reveal no significant difference in the consumption expenditure of households that adopted and their non-adopter counterparts, as indicated by the ATET. However, the potential outcome mean was significant at a 1% significant level. This suggests that if all farmers adopt at least three coping strategies, they would have a mean consumption expenditure of Gh₵11620.07.

Concerning the effects of individual coping strategies, the results reveal a significant difference in the consumption expenditure of households that adopted only land reclamation and social networking. The ATET and the POM for adopting only land reclamation are positive and significant at 10 and 1%, respectively. The implication is that households that adopted land reclamation obtained an average of Gh₵452.8376 higher than their counterparts who did not use land reclamation as a coping strategy. This revelation is intuitively apt as land reclamation can make once-degraded lands fertile. For the adoption of social networking, the ATET and POM are positively signed and significant at 5 and 10% levels, respectively. The ATET result suggests that households that relied on social networking obtained an average of Gh₵1442.8280 higher than their counterparts who did not use this strategy. The results for social networking are not surprising as this reflects the premise that many groups and other social supports are established to provide financial or other support for members in times of need.

Again, the results in Table 6 further reveal no significant difference in the consumption expenditure of households that adopted only borrowing and only resettlement and their counterparts who did not adopt any of these strategies, as indicated by the ATET. Notwithstanding this, the potential outcome of adopting each of these single strategies was found to be statistically significant. At a 1% significance level, if all households had adopted only borrowing, they would have attained an average consumption expenditure of Gh₵13,365.85. Furthermore, a significant negative ATET was obtained for adopting only diversification and dependence on the market for food. With regards to diversification, the negative value indicates that households that adopted income diversification strategies have significantly lower consumption expenditure and that non-adopters achieved an average of Gh₵3,762.31 higher than adopters, implying that non-adopters are better off than adopters in terms of welfare. This does not meet the apriori expectation. Regarding the potential outcome, the results indicate that at a 10% significance level, if all households had adopted only diversification, they would have achieved a consumption expenditure of Gh₵17,891.52.

Moreover, the results in Table 6 show that the ATET and POM for reliance on the market for food are negatively and positively signed, respectively. In the first place, the ATET shows that farmers who relied on the market for food have significantly lower consumption expenditure than adopters at a 1% significant level. Specifically, non-adopters of this strategy attained an average consumption expenditure of Gh₵9,726.7220 higher than adopters, suggesting a better welfare level for non-adopters than adopters, thereby being counterintuitive to researchers' expectations. Also, at a 10% significance level, the POM value indicates that if all farmers were to rely on the market for food, they would have obtained a consumption expenditure of Gh₵25,323.53.

For HFIS, the ATET was negative and significant at a 5% level regarding adopting at least two coping strategies. The implication is that households that adopted at least two coping strategies were less food insecure compared to non-adopters of at least two coping strategies. Technically, the adopters of at least two coping strategies are 0.5280 less food insecure than their counterparts who did not adopt at least two coping strategies. This finding is similar to the finding of Demeke *et al.* (2011), who reported improved food security for households who adopted coping strategies against rainfall shock in rural Ethiopia. Similarly, POM was found to be significant at a 1% level and positively signed. This suggests

that if all households adopted at least two coping strategies, they would have had an average HFIS of 7.53, ceteris paribus.

For adopting at least three coping strategies, the ATET and POM mean were positively signed and significant at 10 and 1%, respectively. The positive coefficient of the ATET implies that adopting at least three coping strategies increases the food insecurity level of adopters by 2.35, suggesting further that non-adopters of at least three coping strategies are better off in terms of food insecurity. With food insecurity level as a welfare indicator, this finding supports Guloba *et al.* (2014), who reported that the aggregated coping strategies used by households during livelihood shocks decrease welfare in Uganda by 31.3 and 15.9%, respectively. This may be attributed to the complexities faced by households in managing several strategies in times of shocks.

For land reclamation, the ATET value of −2.3887 implies that adopting only land reclamation as a coping strategy reduces the food insecurity level of households by 2.3887, which is an indication that adopters of this strategy are better off than non-adopters in terms of food insecurity. Intuitively, land reclamation ensures the availability of additional land for farming purposes, which can positively affect crop production and food availability for consumption. The POM of HFIS for land reclamation is −5.45, which is highly statistically significant at 1%. This POM value implies that if all farmers were to adopt only land reclamation, they would have obtained an HFIS of −5.45, suggesting improved food security status for all adopters. Also, the ATET is negative and highly significant at a 1% level for borrowing, suggesting that adopters of this strategy are −4.6311 less food insecure than non-adopters. Technically, this implies that borrowing improves the food security status of adopters. This can be attributed to the fact that borrowing enables households with food deficits to obtain food from friends, neighbours and relatives, thereby ensuring food availability for consumption. The POM, however, indicates that all households would have experienced deterioration in their food security if they had used borrowing as a strategy.

Again, the negative coefficient of ATET for adopting only social networking suggests that adopters of this strategy have significantly lower HFIS than their non-adopters of this strategy. In other words, the difference between the HFIS of adopters of only social networking and non-adopters is −6.59 6.59, which indicates that non-adopters are 6.59 more food insecure than adopters. This conforms to the initial hypothesis that social networks enable households to obtain cash and non-cash support from other people through social connections that they have established, increasing their chances of having access to food from the market or loved ones in times of crisis. Regarding the effect of the adoption of diversification on HFIS, the coefficients of the ATET and the potential outcome mean are positive and highly significant at a 1% level, respectively. This does not meet the *a priori* expectations of researchers and economic theory. This finding is not surprising because of the possibility of households diverting income that could be used to acquire more food for consumption into carrying out business activities with the hope of achieving stable income and consumption in the future.

There is no significant difference between ATET of adopters and non-adopters of only resettlement and dependence on the market for food as a coping strategy. However, the POM for these two single strategies is positive and significant at a 1% level but counterintuitive. The POM value for adopting only resettlement shows that if all farmers had adopted resettlement as a coping strategy, they would have had an HFIS of 6.55. By implication, there would be an increase in food insecurity levels if all households had adopted only resettlement. Similarly, the potential outcome mean value for adopting only dependence on the market for food implies that if all farmers were to resort to dependence on the market for their food, they would have obtained an HFIS of 7.47. To sum up, the adoption of only resettlement or the adoption of dependence on the market for food by households is associated with deterioration in the food insecurity level of households.

4. Conclusions and policy recommendations

4.1 Conclusions

The study aimed to identify the coping strategies adopted by farm households against the adverse effects of ASM and estimated the effects of adopting coping strategies on household welfare. From the results, the respondents adopted a mix of coping techniques to counteract the adverse effects of ASM. The most adopted strategy was diversification (36.08%), followed by social networking (34.18%), land reclamation and borrowing (31.01%), dependence on the food market (30.38%), and finally, resettlement to a different community (29.11%). Farm households in the study area used the above coping strategies as compliments or substitutes. Also, the majority of the respondents (32.28%) adopted two coping strategies. The ATET results show that adopting land reclamation and social networking improves household consumption expenditure and food security status, while resorting to diversification and relying on the market for food adversely affects the consumption expenditure and food security status. Additionally, using at least two coping strategies by farm households in the study area has a positive effect on welfare, while adopting at least three coping strategies by households has a negative effect on welfare due to the complexities and resources involved in managing several coping strategies simultaneously.

4.2 Recommendations

Based on these findings, it is recommended that farmers should be encouraged to form cooperatives and other groups to increase their social capital, which in turn can help to ensure easy access to joint resources that could be used to cope with ASM-induced shocks in mining areas. Also, civil society organizations and the government of Ghana, through the Ministry of Lands and Natural Resources, should consider programs that support and encourage land reclamation practices in mining areas to ensure sustainable food production and food security.

Aside from the contribution of this study, the welfare indicators used are only two. Further studies investigating the effects of coping strategies against ASM-induced shocks should consider other welfare indicators such as assets. In addition, future studies should apply the Monte Carlo Verification Test of Estimability to enhance the robustness of the research findings under varying conditions and assumptions. Also, unlike cross-sectional data used in the current study, panel data should be used in further studies to assess the long-term effects of the coping strategies adoption on welfare.

References

Akabzaa, T.M. (2000), *Boom and Dislocation : The Environmental and Social Impacts of Mining in the Wassa West District of Ghana*, Third World Network-Africa, Accra.

Alpizar, C.A. (2007), "Risk coping strategies and rural household production efficiency: quasi-experimental evidence from El Salvador", Doctoral dissertation, Ohio State University, OhioLINK Electronic Theses and Dissertation Center, available at: http://rave.ohiolink.edu/etdc/view?acc_num=osu1180206697

Amoah, B.A. (2003), "Proliferation of surface mining in Ghana: a threat or a blessing to the poor in the mining areas? A case study of Tarkwa mining area", An MSc. Thesis, Lund, available at: https://www.lumes.lu.se/sites/lumes.lu.se/files/amoah_antwi-boasiako.pdf (accessed 20 June 2021).

Amponsah-Tawiah, K. and Dartey-Baah, K. (2011), "The mining industry in Ghana: a blessing or a curse", *An International Journal of Business and Social Science*, Vol. 2 No. 12, pp. 62-69.

Aragon, F.M. and Rud, J.P. (2015), "Polluting industries and agricultural productivity: evidence from mining in Ghana", *The Economic Journal*, Vol. 126 No. 597, pp. 1980-2011, doi: 10.1111/ecoj.12244.

Asfaw, S., Shiferaw, B., Simtowe, F. and Lipper, L. (2012), "Impact of modern agricultural technologies on smallholder welfare: evidence from Tanzania and Ethiopia", *Food Policy*, Vol. 37 No. 3, pp. 283-295, doi: 10.1016/j.foodpol.2012.02.013.

Banchirigah, S.M. (2008), "Challenges with eradicating illegal mining in Ghana: a perspective from the grassroot", *Resources Policy*, Vol. 33 No. 2008, pp. 29-38, doi: 10.1016/j.resourpol.2007.11.001.

Boateng, A. (2017), "Rethinking alternative livelihood projects for women of the pits: the case of Atiwa", *Academic Journal of Interdisciplinary Studies*, Vol. 6 No. 2, pp. 17-25, doi: 10.1515/ajis-2017-0002.

Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S. and Herrero, M. (2011), "Coping with livelihood shocks in Kenya: household and community strategies and determinants", *Journal of Agricultural Sciences*, Vol. 9 No. 7, pp. 804-823.

De Haan, L.J. (2012), "The livelihood approach: a critical exploration", *Erdkunde*, Vol. 66 No. 4, pp. 345-357, doi: 10.3112/erdkunde.2012.04.05.

Deaton, A. (2005), "Franco Modigliani and the life-cycle theory of consumption", *Banca Nazionale del Lavoro Quarterly Review*, Vol. 58 No. 233, pp. 91-107.

Demeke, A.B., Keil, A. and Zeller, M. (2011), "Using panel data to estimate the effect of rainfall shocks on smallholder's food security and vulnerability in rural Ethiopia", *Climatic Change*, Vol. 108 No. 2, pp. 185-206, doi: 10.1007/s10584-010-9994-3.

Ghana Statistical Service (2019), *Ghana Living Standards Survey Round 6 (GLSS 6)*, Main Report, Ghana Statistical Service (GSS), Accra.

Guloba, M., Lokina, R. and Hisali, E. (2014), "Impact of adaptation to covariate shocks on household welfare: evidence from panel survey data in Uganda", *Tanzania Economic Review*, Vol. 11 No. 1, pp. 90-114.

Hilson, G. (2016), "Farming, small-scale mining and rural livelihoods in Sub-Saharan Africa: a critical overview", *Extractive Industries Society*, Vol. 3 No. 2, pp. 547-563, doi: 10.1016/j.exis.2016.02.003.

Hilson, G. and Maconachie, R. (2020), "Entrepreneurship and innovation in Africa's artisanal and small-scale mining sector: developments and trajectories", *Journal of Rural Studies*, Vol. 78 No. 2020, pp. 149-162, doi: 10.1016/j.jrurstud.2020.06.004.

Hinton, J. (2006), *Communities and Small-Scale Mining: An Integrated Review for Development Planning*, Communities and Small-scale Mining (CASM), Washington, DC.

Isung, C.B., Salifu, Y. and Agana, T.A. (2021), "The socio-economic implications of artisanal and small scale mining on mining communities in Northern Ghana", *Open Access Library Journal*, Vol. 8 No. 3, pp. 1-17, doi: 10.4236/oalib.1107010.

Kassie, M., Shiferaw, B. and Muricho, G. (2011), "Agricultural technology, crop income and poverty alleviation in Uganda", *World Development*, Vol. 39 No. 2, pp. 75-90, doi: 10.1016/j.worlddev.2011.04.023.

Kusimi, J. (2007), *Groundwater Hydro-Geochemistry and Land Cover Change in the Wassa West District of Ghana*, Royal Institute of Technology.

Lawal, J.O. (2016), "Shocks and welfare transitions among cocoa farming households in South-West, Nigeria", A PhD thesis submitted to the Department of Agricultural Economics in-partial fulfilment of requirement for the award of PhD Degree at University of Ibadan.

Mabe, F.N., Owusu-Sekyere, E. and Adeosun, O.T. (2021), "Livelihood coping strategies among displaced small scale miners in Ghana", *Resources Policy*, Vol. 74 No. 2020, pp. 1-9, doi: 10.1016/j.resourpol.2021.102291.

Martina, B., Smale, M. and Di Falco, S. (2016), "Climate, shocks, weather and maize intensification decisions in rural Kenya", FOODSECURE Working Paper No. 39.

McFadden, D.L. (1978), "Econometric analysis of qualitative response models", *Mapping Small-Scale Mineral Production Handbook of Econometrics*, Vol. 2 No. 2, pp. 1395-1457.

Ngenoh, E., Kebede, S.W., Bett, H.K. and Bokelmann, W. (2018), "Coping with shocks and determinants among indigenous vegetable smallholder farmers in Kenya", *Agricultural Sciences*, Vol. 9 No. 12, pp. 804-823, doi: 10.4236/as.2018.97057.

Obeng, E.A. and Appiah, M. (2019), "Impact of illegal mining activities on forest ecosystem services : local communities' attitudes and willingness to participate in restoration activities in Ghana", *Heliyon*, Vol. 5 No. 10, pp. 27-47.

Onumah, J., Leeuwis, C., Boamah, P.O. and Salifu, T. (2013), "Operations and frames of illegal small-scale mining in Ghana", *International Journal of Agriculture Innovations and Research*, Vol. 2 No. 3, pp. 307-312.

Osei, L., Yeboah, T., Kumi, E. and Antoh, E.F. (2021), "Government's ban on Artisanal and Small-Scale Mining, youth livelihoods and imagined futures in Ghana", *Resources Policy*, Vol. 71 No. 202, pp. 1-10, doi: 10.1016/j.resourpol.2021.102008.

Stata Manual (2015), *Stata Treatment Effects Reference Manual: Potential Outcomes/Counterfactual Outcomes*, Stata Press, TX, Release 14.

Tenkorang, E.Y. (2021), "Illegal small-scale mining in Asutifi North District, Ghana: traditional authority's tacit support for an illegality", *African Social Science Review*, Vol. 11 No. 1, pp. 74-100.

Yankson, P.W.K. and Gough, K.V. (2019), "Gold in Ghana: the effects of changes in large-scale mining on artisanal and small-scale mining (ASM)", *The Extractive Industries and Society*, Vol. 6 No. 1, pp. 120-128, doi: 10.1016/j.exis.2018.09.009.

Zolnikov, T.R. (2020), "Effects of the government's ban in Ghana on women in artisanal and small-scale gold mining", *Resources Policy*, Vol. 65 No. 2020, pp. 1-6, doi: 10.1016/j.resourpol.2019.101561.

Further reading

Asutifi North District Assembly (2019), "Composite budget for 2019 – 2022: a programme-based budget estimates for 2019", Districts in Ghana.

Barreto, M.L. and Pact (2016), "Understanding the economic contribution of small-scale mining in East Africa", Project Inception Report, Pact and ARM on behalf of DFID, Westcombe and Envigado (CO).

Franks, D.M., Ngonze, C., Pakoun, L. and Hailu, D. (2020), "Voices of artisanal and small-scale mining, visions of the future: report from the international conference on artisanal and small-scale mining and quarrying", *The Extractive Industries and Society*, Vol. 7 No. 2, pp. 1-7, doi: 10.1016/j.exis.2020.01.011.

Hilson, G. (2019), "Why is there a large-scale mining 'bias' in sub-Saharan Africa?", *Land Use Policy*, Vol. 81 No. 26, pp. 852-861, doi: 10.1016/j.landusepol.2017.02.013.

Hilson, G. and Garforth, C. (2012), "Agricultural poverty and the expansion of artisanal mining in sub-Saharan Africa: experiences from South West Mali and South East Ghana", *Population Research and Policy Review*, Vol. 31 No. 3, pp. 435-464, doi: 10.1007/s11113-012-9229-6.

Hilson, G. and Garforth, C. (2013), "Everyone now is concentrating on the mining: drivers and implications of rural economic transition in the Eastern Region of Ghana", *Journal of Development Studies*, Vol. 49 No. 3, pp. 348-364, doi: 10.1080/00220388.2012.713469.

McQuilken, J. and Hilson, G. (2018), "Mapping small-scale mineral production networks: the case of alluvial diamonds in Ghana", *Development and Change*, Vol. 49 No. 4, pp. 978-1009, doi: 10.1111/dech.12403.

OECD (2019), "OECD regional well-being. OECD regional well-being (database)", available at: https://www.oecdregionalwellbeing.org/ (accessed 27 May 2021).

Tenkorang, E.Y. (2023), "Environmental governance in gold mining: the role of traditional institutions in Asutifi North District of Ghana", *SAGE Open*, Vol. 13 No. 2, pp. 1-11, doi: 10.1177/21582440231178175.

Tenkorang, E.Y. and Osei-Kufuor, P. (2013), "The impact of gold mining on local farming communities in Ghana", *Journal of Global Initiatives, Policy, Pedagogy and Perspective*, Vol. 8 No. 1, pp. 25-44.

Appendix

	Definition and measurements	Endogenous TE model: expected sign	
		Adoption	Welfare
AGE	Age of farmer (years)	+/−	+
SEX	Sex of the respondent (1 = male, 0 = otherwise)	+	+
EDU	Educational level of the household head (years)	+	−
HHSIZE	People in the house eating from same pot (number)	+	+
FMSIZE	Total land for cultivation (acres)	+	+
HH INCOME	Total money earned by the households (GH₵)	+	+
MFBO	Membership of an FBO (1 if member, 0 otherwise)	+	+
ACCRE	Households' access to credit (1 if Yes, 0 otherwise)	+	+
FMYRS	Farming Experience (years)	+	+
ASM YRS	ASM existence in the community (years)	+	−
DISTSITE	Distance from residence to ASM site (Km)	+	NA
HHCONS	Household expenditure on Consumption (GH₵)	NA	NA
EXT QTY	Access to extension service (1 if Yes, 0 otherwise)	+	+

Table A1.
Definitions, measurements and *a priori* expectations of variables in the models

Source(s): Authors' own work

Stata command for endogenous treatment effects with control function approach
eteffects (CE AGE SEX EDU HHSIZE CREDIT FMSIZE FBO FARMYRS ASMYRS HHCONSU) (ADOPTION AGE SEX EDU HHSIZE CREDIT FMSIZE FBO FARMYRS ASMYRS DISTTOSITE HHCONSU EXTQTY)
  eteffects (HFIS AGE SEX EDU HHSIZE CREDIT FMSIZE FBO FARMYRS ASMYRS HHCONSU) (ADOPTION AGE SEX EDU HHSIZE CREDIT FMSIZE FBO FARMYRS ASMYRS DISTTOSITE HHCONSU EXTQTY)

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