
Article:
Adranyi, Enoch, Stringer, Lindsay Carman orcid.org/0000-0003-0017-1654 and Altink, Henrice orcid.org/0000-0001-9123-0722 (2023) Impacts of artisanal and small-scale gold mining on rural livelihoods trajectories:insights from Ghana. The Extractive Industries ands society. 101273. ISSN 2214-7918

https://doi.org/10.1016/j.exis.2023.101273

The Extractive Industries and Society 14 (2023) 101273

Contents lists available at ScienceDirect

The Extractive Industries and Society

journal homepage: www.elsevier.com/locate/exis

Original article

The impacts of artisanal and small-scale gold mining on rural livelihood trajectories: Insights from Ghana

Enoch Adranyi [a,*], Lindsay C. Stringer [b], Henrice Altink [c]

[a] Department of Politics, Interdisciplinary Global Development Centre (IGDC), University of York, York YO10 5DD, UK
[b] Department of Environment and Geography, York Environmental Sustainability Institute, University of York, Wentworth Way, York YO10 5NG, UK
[c] Department of History, Interdisciplinary Global Development Centre (IGDC), University of York, York YO10 5DD, UK

ARTICLE INFO

Keywords:
Artisanal and small-scale mining
Gold
Agriculture
Livelihood trajectories
Ghana

ABSTRACT

Rising gold prices, together with other challenges faced by smallholders, mean rural people in sub-Saharan Africa are increasingly taking advantage of ASGM's low barriers to entry and engage in artisanal and small-scale gold mining (ASGM) to make money on a regular basis. Yet, adequate knowledge on the impact of ASGM's emergence on rural livelihood trajectories is lacking, particularly for emerging ASGM communities. Understanding the long-term dynamics of community livelihoods as small-scale mining emerges is important to inform the design of appropriate sustainable rural livelihood policies. Existing scholarship has predominantly examined livelihood snapshots rather than exploring how present livelihood outcomes have emerged over time, and for whom. Guided by the sustainable livelihood framework, this paper uses a household questionnaire survey, oral history interviews, focus group discussions and transect walks to investigate livelihood trajectories in three farming communities engaged in ASGM in Atiwa West district, Ghana, from the early 1990s up to 2021, focussing particularly on changes since the rise of ASGM in 2010. Three distinct livelihood trajectories emerge — consolidation, fluctuation, and marginalisation — reflecting the different pathways followed by rural households. In this constrained, yet shared resource space, ASGM's emergence has benefitted the farmers turned miners and enhanced their livelihood outcomes. But it has had damaging consequences for livelihoods dominated by subsistence farming so that more rural people find themselves locked into poverty, due to competition for arable farmlands with ASGM appealing as a more lucrative option in the short term. Findings evidence the differential and unintended consequences of livelihood adjustments. They highlight the urgent need for well-targeted policies and sustainable livelihood strategies in farming communities where ASGM is emerging to provide effective linkages between rural livelihoods, agriculture, and mining, and address growing inequalities in livelihood trajectories posed by ASGM's emergence.

1. Introduction

Rural livelihoods are closely linked to the landscapes in which people live and the natural resources present. Across sub-Saharan Africa, increasing pressures from environmental and socio-economic changes – e.g., population increase and migration, climate change, global market demand for resources, and changes in land use – influence the livelihood strategies rural people adopt (Shackleton et al., 2019). Multiple cross-scale stressors such as high levels of poverty, food insecurity, health concerns, low levels of development, rapid urbanization, weak governance and natural resource management systems, ecosystem degradation shape the possible livelihood activities people can pursue.

A livelihood comprises the capabilities, material and social assets, and activities required to make a living (Chambers Conway, 1992). A livelihood is deemed sustainable when "it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (Scoones, 1998: p.5). The Sustainable Livelihood Approach (SLA) recognises that people compose complex, dynamic livelihood portfolios influenced by socio-economic, political, and climatic uncertainties and variabilities (Ellis, 2000). The SLA focuses on the income-generating, cultural and social activities that people engage in, the assets that enable those activities to make a living, and what people gain as a result (livelihood outcomes) (Scoones, 1998; 2009). In

* Corresponding author.
E-mail address: esa524@york.ac.uk (E. Adranyi).

https://doi.org/10.1016/j.exis.2023.101273
Received 13 February 2023; Received in revised form 15 May 2023; Accepted 16 May 2023
Available online 22 May 2023

pursuing a livelihood, both access to natural, physical, financial, human, and social assets and those that are subsequently used, are mediated by transforming structures and processes (e.g., laws, policies, and institutions). Livelihoods are also affected by external factors, referred to as the 'vulnerability context' (Allison and Ellis, 2001). The SLA provides insights into livelihood vulnerability and inequalities that confront households (van Dijk, 2011)

Combining the SLA with the concept of livelihood trajectories, i.e., the directions that livelihoods follow over time (Bagchi et al., 1998; Sallu et al., 2010), enables the dynamics of livelihoods to be captured and analyzed across multiple scales, and can help account for social, political and environmental variability over time (de Haan and Zoomers, 2005; Scoones, 2009). Consideration of livelihood trajectories allows exploration of the life histories of individual households regarding how the present conditions have emerged and evolved over time, and for whom, as well as the strategic behaviors that underpin those changing livelihoods (de Haan and Zoomers, 2005). It helps identify change processes and barriers to change, as well as the differential and potentially unequal effects of new livelihood strategies and people's capacity for action and decision making (Sallu et al., 2010; Orchard et al., 2016; Trung Thanh et al., 2021).

By using the SLA as its underlying framework alongside the concept of livelihood trajectories, this paper examines the impact of the emergence of new livelihood activities on the livelihood trajectories of rural people engaged in farming in Ghana. In particular, it focusses on the emergence of artisanal and small-scale gold mining (ASGM) and considers its livelihood trajectory impacts in a study area previously dominated by agricultural livelihoods, focusing on multiple scales – households and community – over the period 1992 – 2021.

The main occupation across sub-Saharan Africa is smallholder agriculture ($\leq$ 2 ha), chiefly organised as a family enterprise. Almost all agronomic activities (e.g., weeding, sowing and harvesting) use family labor, with rudimentary equipment for farming (Stringer et al., 2020). In Ghana, agriculture plays a key economic role, contributing 20% of GDP and is a significant employer (Ofosu et al., 2020). Smallholder farming is nevertheless fraught with challenges, with some areas consequently experiencing deagrarianisation (Pritchard et al., 2017). Decades of insufficient government budgetary allocations have resulted in minimal support for agriculture. Subsidies for innovative technologies and crucial inputs such as fertilizers are lacking. Farmers have to pay exorbitant prices for their inputs due to high inflation and currency fluctuation (Okoh and Hilson, 2011). Smallholders also face poor access to markets and low prices for their produce. These and other factors, such as changing climatic conditions, mean that smallholder farming is losing its viability, causing diminished farm productivity, high levels of poverty (Hilson, 2016) and in some cases exit from agriculture altogether (Stringer et al., 2020). Available land for smallholders has declined, largely because of growing rural populations and inheritance-based land fragmentation over decades (Pritchard et al., 2017). Many farmers consequently find themselves in unstable situations, struggling to produce sufficient yields for the market on their undersized plots (Hilson and Garforth, 2012). Farming households increasingly experience continued hardships linked with over-dependency on unprofitable agricultural activities for survival. When rural people encounter such 'agricultural poverty' (Hilson and Garforth, 2012), they tend to consider other possibilities and potentially pursue other undertakings to secure a livelihood and supplement their incomes. Such livelihood diversification or 'branching out' is common across sub-Saharan Africa (Sabates-Wheeler et al., 2018) as rural people with access to mineral rich lands reorient to engage in artisanal and small-scale gold mining (ASGM) (Hilson and Garforth, 2012; Banchirigah and Hilson, 2010).

Artisanal and small-scale mining of minerals and metals (mostly informal and labor-intensive, low capital, low-tech, and a risky form of mining) (ASM) has become a vital livelihood activity and one of the main non-agricultural rural livelihood activities in the Global South due to its low entry level (Hilson and Osei, 2014). Rises in gold prices since the early 2000s – US$ 8652/kg in Nov 2000 rising to US$60,688/kg in Dec 2020 (World Gold Council, 2021) – mean artisanal and small-scale gold mining (ASGM) is very lucrative in Ghana (Osumanu, 2020). Together with the promise of rapid returns, this has encouraged many rural people to engage in it. It has also changed ASGM's operation and reach, with the use of more sophisticated methods and rapid expansion into traditional farming areas (Ofosu et al., 2020).

ASGM is seen by many African governments, development partners, and donor organisations like the World Bank, as a means to create jobs, generate wealth, boost rural livelihoods and offer greater distributional benefits to mining communities (Amankwah and Anim-Sackey, 2004). Studies have shown that ASGM serves as a viable source of income, for rural inhabitants in the developing world (Banchirigah, 2008; Tschakert, 2009; Teschner, 2014). It can enable improved standards of living, as reflected in asset acquisition, provide for the family and can increase abilities to afford education and healthcare (Hilson and Osei, 2014; Arthur et al., 2016; Osei et al., 2021). Recent studies indicate that ASM is now a platform for wealth creation for its participants (Hilson and Hu, 2022). Various reasons have been provided for the widespread prevalence of artisanal and small-scale gold mining (ASGM) as a way of branching out of agriculture in sub-Saharan Africa including: ease of entry (no prior special skillset required) (Hilson and Potter, 2003); proven extensive distributional benefits (Banchirigah, 2008); failure of the IMF/World Bank's Structural Adjustment Programmes to improve rural livelihoods more generally (Hilson and Potter, 2005; Banchirigah, 2006) and because ASGM is seen as a way to escape poverty (Hilson and Osei, 2014).

ASGM creates employment, promotes improved livelihoods (IGF, 2017; Hilson and Hu, 2022) and contributes to national economies (Osei et al., 2022), yet itself is fraught with many challenges. Many studies have shown that ASGM activities come with high environmental costs (Ncube-Phiri et al., 2015; Bansah et al., 2018; Ofosu et al., 2020). Osei et al. (2022) found in Ghana that most youth ASGM operators lacked considerable knowledge on the long-term impact of their activities on the environment and prioritised their financial needs for survival over any environmental costs. Studies have also highlighted how existing customary land tenure practices largely dictate miners' access to lands, enforcing informality of the ASGM sector (Nyame and Blocher, 2010) and how the intersection of state-based mining titling systems with customary land tenure arrangements impacts ASM formalisation efforts (Mensah, 2021).

ASM sector dovetails subsistence agriculture, in many instances generating finance used to support farming including to purchase essential farm inputs such as fertilisers, improved seeds, and tools (Pijpers, 2014; Brugger and Zanetti, 2020; Hilson and Hu, 2022). However, ASGM's informal nature and environmentally-unfriendly methods have the potential to adversely impact other livelihood options, both in host communities and beyond (Baffour-Kyei et al., 2021). Despite these complexities, scholars have paid scant attention to how ASGM activities impact other rural livelihoods. The existing literature on ASGM's impact on livelihoods, mostly treats the participants in the sector as a homogenous group or, at best, shows evidence of gendered impacts (Yakovleva, 2007; Arthur-Holmes and Abrefa Busia, 2022) and highlights ASGM as an opportunity for youth employment in rural areas (Osei et al., 2021, 2022; Arthur-Holmes et al., 2022). Some ASGM-related livelihood studies have been undertaken in Ghana (e.g., Ontoyin and Agyemang 2014; Arthur et al. 2016; Osumanu 2020) but they have not fully provided evidence of aspects of livelihoods that have improved and those that become more vulnerable due to ASGM development. When ASGM emerges in established farming settings, it remains unclear if it benefits everyone in those spaces. It is unclear which groups benefit most, which ones are most affected, and what factors shape this livelihood differentiation (if any). Although published studies provide some useful insights for livelihoods, significantly less attention has been paid to how the expansion of ASGM has affected livelihood dynamics in

new rural mining communities (new frontiers) and what this means for overall livelihood trajectories. Also, little attention has been given to historical perspectives to trace livelihood dynamics and trajectories linked to ASGM, which is particularly important given households' differing capabilities that enable, constrain and shape their livelihood decisions and outcomes (Antwi-Agyei, 2012; Hilson and Hu, 2022). Similarly, it remains unclear how different groups in rural communities benefit from or are constrained by ASGM's emergence.

This paper aims to identify and analyze livelihood trajectories linked to ASGM in new frontier communities, with a view to informing policy interventions that support the development of sustainable rural livelihoods. It improves knowledge on the complex interactions between multiple drivers of livelihood change, and the impacts of, and responses to these changes, exploring the outcomes of different local responses, external interventions, and policy actions, that purport to enhance sustainable rural livelihoods. It asks:

Q1: What household livelihood portfolios existed prior to and after the rise of ASGM, and what key factors have influenced changes in livelihood activities?
Q2: What are the impacts of ASGM emergence on livelihoods?
Q3: What opportunities and barriers have evolved for different livelihood trajectory groups since ASGM emergence and how do these interact to shape overall livelihood trajectories?

2. Methods and data

2.1. Study area

Atiwa West District in Ghana's Eastern region is located in the semi-deciduous forest agro-ecological zone and is highly suitable for agriculture. The district is predominantly rural and cocoa production is the main economic activity. It is part of the Atiwa enclave that produces the region's highest annual cocoa yields (Codjoe et al., 2013; MOFEP, 2021). Since 2010, artisanal and small-scale gold miners (both legally and illegally operating) have been exploring and mining gold in the district with sophisticated machinery, triggered by commercial discovery of huge gold deposits (7.4 million oz) in nearby Birim North District by Newmont Mining Inc. in 2010 (Mining-technology.com, 2014).

2.2. Data collection methods and analysis

Fieldwork was undertaken from October to December 2021 in three farming communities involved in ASGM operations: Akwabuoso, Ekorso and Pameng. These communities were chosen following review of online news publications (e.g., Thecocoapost.com 2020), use of Google Earth imagery to observe recent mining activities, and communications with a district agricultural extension officer. The communities cover the three Area Councils (Kwabeng, Abomosu and Akropong) ensuring data was gathered across the district. They were accessible by road; and residents were willing to participate in the study. Qualitative and quantitative methods were applied to gather empirical data (Table 1).

A questionnaire survey was firstly administered among residents across the three communities ($n = 360$) seeking information on livelihood portfolios and how they were impacted by ASGM. Respondents identified the positive and negative impacts of ASGM on their households. Quantitative demographic, economic and social data, including opportunities and barriers that emerged, were also collected. The questionnaire was piloted with 30 households to ensure content was contextually relevant, but the sample was excluded in the final data set. Some farmers who took part in the main questionnaire later participated in focus group discussions (FGDs) following preliminary descriptive statistical analysis of the survey data. They were selected based on their experiences and interest to participate, ensuring representation across gender and age groups. FGDs were used for clarification, validation of survey findings and to provide forward-looking insights. FGDs focussed on the community rather than individual level to enable those raising sensitive issues, such as illegal mining activities, to do so generally. Oral history interviews were conducted among 30 purposively selected residents who had participated in the survey (Table 1). Oral histories explored household accounts of livelihood changes and responses to livelihood disruptions over the period 1992–2021. The year 1992 was selected as a starting point because up to then, Ghana faced considerable political instability, including coups. The 1992 presidential and parliamentary election was the first election since 1979. Interviewees were of different age, gender, and capabilities, and engaged in varied livelihood activities including farming, ASGM, trading, and artisanship.

Key informant interviews were also conducted with five purposively selected officials in the district (one district agricultural officer; one Atiwa West District Assembly official, one cocoa purchasing officer; one educationalist; and one chairman of the farmers' cooperative). Informants were selected based on their knowledge and experience and interviews continued until we reached saturation, with no new information being received (Bowen, 2008). Transect walks were conducted in each community with three community leaders, who were purposively selected based on recommendations from the chief farmers and associated leaders. This exercise observed the distribution of resources, infrastructure, land use patterns and different activities taking place within the three communities. Data collection tools were developed in English and translated into Twi. Three research assistants fluent in both languages assisted with data collection. All data collection was conducted in Twi, with data translated into English for analysis, and in accordance with ethical approval. Interviews and FGD recordings were transcribed and translated. By means of manual coding, themes were

Table 1
Research methods and sampling techniques.

Method	Sampling method	Sampling size	Data capture Tools	Data analysis
Face-to-face household survey with semi-structured questionnaire	Simple random sampling	360* (117-Akwabuoso; 121-Ekorso; 122-Pameng) c.30 min each	Questionnaire; Qualtrics Offline Surveys; Tablets;	Descriptive statistics, using SPSS v27+
Transect walk with 3 community leaders	Across community	1 per community	Field notebook Voice recorder; notebook; Smartphone camera	Data transcribed & translated; Thematic analysis by manual coding
Focus group discussions (FGDs) with farmers	Purposive sampling	1 FGD per community; 10 members each (7 men, 3 women); 1 h each	Voice recorder; Smartphone camera; FGD schedule	Data transcribed & translated; Thematic analysis by manual coding
Oral history Interviews	Purposive sampling	10 per community (7 men 3 women); 30 min each	Voice recorder; field notebook; Interview schedule	Data transcribed & translated; Thematic analysis by manual coding
Key informant/stakeholder interviews	Purposive sampling	5 actors/officials; 30 min each	Voice recorder; field notebook; Interview schedule	Data transcribed & translated; Thematic analysis by manual coding

* Information from District agricultural officers indicated ASGM was present in several communities, so the study assumed 1/3 of the district population was experiencing ASGM (61,219/3 = 20,406) (GSS 2021). Our sample population was 5102 (20,406/4) households (GSS 2021, p. 83) and sample size determined at 360 based on a statistical confidence level of 95%; margin of error of 5% as well as time, and cost (Bryman and Bell, 2007; Qualtrics.com, 2021). Estimate of community population obtained through discussion with district agricultural officers: Akwabuoso – 3000; Ekorso – 3000; and Pameng – 4000.
+ Statistical Package for Social Sciences software (SPSS) version 27.

identified from recurring ideas and described. Primary results regarding cocoa farming and productivity were triangulated with data on annual cocoa bean production (Ghana Cocoa Board, Ghana Cocoa Board, 2022) obtained from their online portal of Ghana Cocoa Board (https://cocobod.gh/cocoa-purchases).

Analysis of livelihood activities of households between 1992 and 2021 following oral history interviews, together with indicators from – financial, physical, natural, human, and social livelihood capitals (Appendix A), identified livelihood trajectory groups and their outcomes. Indicators were developed, ($n = 12$; adapted from Carrie et al. (2022) and Antwi-Agyei et al. (2013) and used to group households based on data collected during household surveys (Appendix A). Due to data type and distribution (see test for normality in SPSS, Appendix B), a Kruskal-Wallis H test with Dunn-Bonferroni nonparametric post hoc comparison test was used to analyze differences in mean rank values between groups.

3. Results

3.1. Household livelihood portfolios before and after the rise of ASGM, and factors influencing changes in the livelihood activities

Findings from FGDs and oral history interviews revealed six main livelihood activities in the study communities before the rise of ASGM (Table 2).

Oral history interviews and FGDs, revealed less human pressure and more forested areas during the 1990s, which enabled the provision of food, land for agriculture, fuel, timber, potable water sources, palm wine tapping, and animal hunting. Cocoa was considered to yield well due to fertile lands coupled with adequate and predictable rainfall patterns, while cocoa farmers were respected and influential in their communities. Arable crops were mainly maize, cassava, plantain and vegetables. Oral histories further revealed that during the 1990s, young adults would either move to cities to search for jobs or learn a trade (e.g., tailoring), or stay in the village and go into arable crop farming, before later moving into cocoa farming. At this time, residents lacked electricity access and mobile telecommunications. Roads were not tarred, making motoring difficult, and affecting transport of farm produce to markets, while fewer vehicles were available to transport goods and people.

Farmers mentioned in the oral histories and FGDs that in the 2000s, cocoa farming was still vibrant, and they had expanded their cultivated land. More migrants arrived to undertake cocoa farming as they accessed farmlands without capital. Migrants farmed, either as tenants (where they shared half the proceeds with the landowner) or as caretakers (who managed existing farms for a one-third share). Ghana Cocoa Board's data reflects this, showing a steady rise in annual cocoa beans production from 1990s – 2010s in the Eastern region (26,196 tonnes in 1992 to 79,842 tonnes in 2010, Fig. 1).

Interviews revealed that even though farming faced many constraints, limited government interventions in the 2000s had facilitated continuing involvement and investment in the sector by cocoa farmers. Interventions included annual free mass spraying of cocoa farms to control pests and diseases, and a fertilizer subsidy program, alongside increased access to extension officers. Gradual introduction of electricity, tarred roads, and mobile telecommunications in the 2000s allowed locals to venture into linked livelihood options (e.g., trading, communication services, driving).

3.1.1. Livelihood portfolios after the rise of ASGM (2010 – 2021)

Table 3 shows the livelihood portfolios across the three communities and their percentage income contributions according to the analysis of quantitative data from household surveys. Across the three communities since 2010, ASGM on average contributed 76% of total household income for those engaged in mining. Agriculture remained dominant while trading in agricultural produce increased, alongside increased participation in goods and service sectors, and a boost in local markets. Interviews revealed that ASGM drew migrants into the study communities and miners made enough money to purchase items helping local businesses to thrive. Alongside ASGM's emergence, electricity, tarred roads, and mobile telecommunications enabled livelihood diversification. Questionnaire findings nevertheless show that ASGM practices were not always carried out responsibly. Community transect walks confirmed this, with local rivers and streams polluted and brown due to liquid waste discharges from mine sites. Mine pits were left uncovered, and most mine sites were unreclaimed, with deforestation and degradation in and around the communities. This caused livelihood activities such as fishing, and forest resource exploitation to decline considerably.

Table 2
Main livelihood activities prior to ASGM emergence in the study area, obtained through oral interviews ($n = 30$).

	1992-2000			2001-2010			Livelihood change (2001-2010) - (1992-2000)		
Main livelihood activities	Akwabuoso %	Ekorso %	Pameng %	Akwabuoso %	Ekorso %	Pameng %	Akwabuoso %	Ekorso %	Pameng %
Cocoa farming	19	23	35	40	42	39	21	19	4
Arable farming	25	46	53	40	37	44	15	-9	-9
Forest resource exploitation	6	15	0	0	11	6	-6	-4	6
Waged labour	13	8	6	7	0	6	-6	-8	-1
Trading in agricultural produce	0	0	0	0	5	0	0	5	0
Service – e.g., tailoring/sewing	38	8	6	13	5	11	-25	-3	5
Total count of livelihood sources	16	13	17	15	19	18			

Legend: Increase in livelihood source; No change in livelihood source; Decrease in livelihood source.

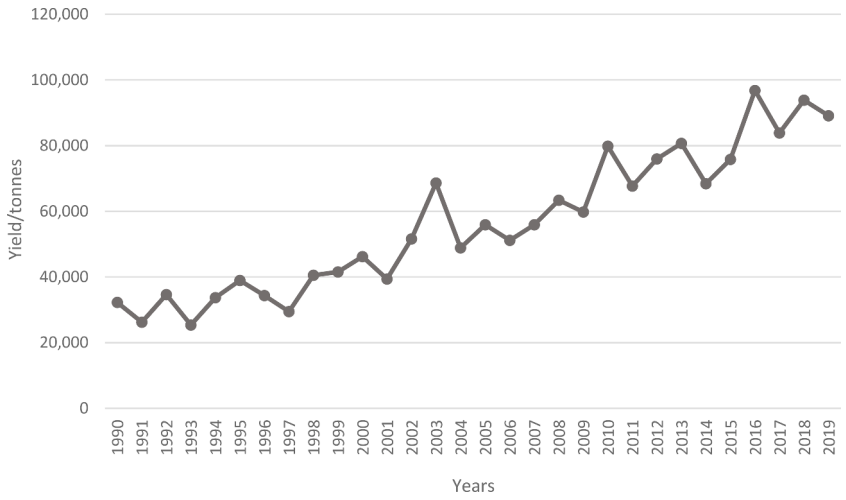

Fig. 1. Annual cocoa bean yield in Eastern region, Ghana. Data source: Ghana Cocoa Board website - https://cocobod.gh/cocoa-purchases.

Table 3
Household livelihood sources and their percentage income contributions after ASGM's rise from 2010, based on questionnaire survey.

Source of livelihood	Akwabuoso, $n = 117$		Ekorso, $n = 121$		Pameng, $n = 122$	
	Participants (%)	Income contribution (%)	Participants (%)	Income contribution (%)	Participants (%)	Income contribution (%)
Cash crop cultivation	63	62	47	63	47	65
Arable crop cultivation	67	31	49	29	34	29
Livestock	23	11	17	11	5	26
Fishing	0.9	5	0	0	0	0
Forest resource use	0.9	5	0.8	100	0	0
ASGM	13	79	17	83	34	71
Professional	0	0	2	70	4	58
Waged labor	3	70	4	44	4	57
Industry/Manufacturing	0.9	100	3	38	3	70
Agribusiness	10	47	16	48	9	51
Service	21	74	29	78	28	69
Retiree on pension	0	0	2	100	3	49
Remittances	3	100	3	27	2	65

3.1.2. Factors that influenced changes in livelihood activities since ASGM's emergence from 2010

FGD, oral histories and questionnaires revealed three sets of factors that influenced households' livelihood decisions since the arrival of mining enabling, or constraining movement along a productivity-enhancing pathway (Table 4).

Household-level characteristics. Age was a significant factor influencing households' decision to change livelihoods. Questionnaires revealed most household heads were aged 35–54. The youngest, most energetic household heads had greater opportunity to shift into ASGM or linked livelihoods e.g., driving. Households with more working-age members were likely to be more productive, while those with more dependents were less able to convert resources such as cash into productive opportunities and investments. There were schools in the communities and interviews indicated that household heads who had attained higher education levels were better able to negotiate involvement in ASGM. Similarly, households' capability to change livelihoods depends on good health, as it provides flexibility. Primary health care is free and universal in Ghana, but inequitable resource distribution meant residents were forced to pay for major treatments in the district. Residents indicated that ASGM's revenue was more decent and regular than from farming and so enabled them better to handle health challenges.

Household's available resources. Interviews indicated customary land tenure predominated and influenced households' abilities to change livelihoods. Those who owned land or had rights of access due to cultural norms could decide to undertake ASGM themselves on their land or lease portions of land for ASGM. Funds raised enabled livelihood change/enhancement. Those without secure tenure rights were sometimes forced to change their livelihoods e.g., shift into ASGM if their farmlands were taken back by landowners. Similarly, households' financial assets influenced livelihood change. Prior to ASGM's arrival, access to affordable formal loans was lacking, restricting capabilities to change or enhance livelihoods. Lenders did not accept farms as collateral considering farming high-risk due to variable weather patterns, pests, and price fluctuations and lack of formally defined property and land-use rights. Even though cocoa bean prices are regulated by the government, there was no government-led credit scheme for cocoa farmers, forcing some to take high interest informal loans from middlemen along the cocoa supply chain. Arrival of ASGM was therefore perceived by residents as an opportunity to generate funds.

External circumstances. The communities had access to key infrastructure such as tarred roads, electricity, and communication networks. Hence, households with means were able to own and use technologies such as a television, radio, and mobile phone, which they considered relevant for their livelihoods. The presence of such key infrastructure empowered residents to shift easily into the provision of ASM support services. For instance, some residents ran taxi services and motorcycle rentals with ease due to the presence of good roads; others were able to run electricity-dependant services like restaurants, bars, and hair salons, catering for miners as well as local residents. Other services that saw an increase in sales following ASGM emergence include the sale of water, machine maintenance, general shop/petty trading, shoe repairs, masonry (house construction), tailoring, carpentry, and house rentals. The

Table 4
Key factors that influenced changes in livelihood activities since ASGM's emergence from 2010 in the study area, based on FGDs and questionnaire survey of residents.

Factors	Akwabuoso (%), $n = 117$	Ekorso (%), $n = 121$	Pameng (%), $n = 122$
Land tenure rights (those who own lands)	59	38	39
Education/awareness (highest education level completed - Junior high school)	60	56	64
Finance (No access to credit)	77	88	53
Age (age group with highest frequency)	35–44 & 45–54 (21.4%)	35–44 (24%)	35–44 (25.4%)
Infrastructure (Households that own the following items)	TV – 66 Radio – 64 Mobile phone – 90 Car/truck – 7 Motorbike – 7 Crop sprayer – 33	TV - 59 Radio – 66 Mobile phone – 97 Car/truck – 3 Motorbike – 12 Crop sprayer – 36	TV – 78 Radio – 87 Mobile phone – 89 Car/truck – 3 Motorbike – 10 Crop sprayer – 25
Health (households' ability to handle health issues/hospital treatment; options grouped: easy, somewhat easy, moderate)	38	47	50
Miners' ease of access to land for ASGM (options grouped: very easy, somewhat easy, moderate)	77	52	71
Access to market*	–	–	–
National policy*	–	–	–
Weather variability*	–	–	–

* These additional factors were revealed during FGDs but not in the questionnaire, so no percentages are assigned.

presence of communication network services meant residents could easily use mobile phones, facilitating the running of their businesses. Poor prices for farm produce and increasing input prices, drove farmers into ASGM when opportunities arose. There was a demand for gold and miners had direct access to gold markets. No policy protected cocoa farms from competition for arable farmlands with ASGM, and tenant farmers struggled, facing landowners who leased cocoa farms to miners against their will. Artisanal miners perceived the ASGM registration process as expensive and complicated, so operated informally. Farmers also stated that rainfall patterns in the past decade have become increasingly erratic and unpredictable, with cocoa trees producing lower yields. This too encouraged livelihood diversification.

3.2. The impacts of ASGM emergence on livelihoods

Analysis of household livelihood activities 1992–2021, together with the 12 livelihood capitals indicators based on oral histories, FGD and questionnaires, revealed individual households have pursued various strategies, influenced by multiple interacting factors, resulting in different livelihood outcomes. Households used diverse strategies to respond to interruptions, including ASGM's emergence, drawing on savings, bank loans, social and kinship networks, and use or sale of assets and labor. Three distinct livelihood trajectories emerged: consolidating, fluctuating, and marginalised (Fig. 2). In all communities, the fluctuating group was largest, followed by the marginalised, and finally the consolidating group (Fig. 2). Further analysis (see Kruskal-Wallis results in Appendix B) revealed that observed differences in household frequency among the livelihood trajectory groupings were significant ($p < 0.05$).

A Kruskal-Wallis test provided very strong evidence of a difference ($p < 0.05$) between the mean ranks of at least one pair of groups. Dunn's pairwise tests were carried out for the three pairs of groups. There was very strong evidence ($p < 0.05$, adjusted using the Bonferroni correction) of a difference between the three groups (Appendix B).

3.2.1. Consolidating

This trajectory is followed by households that exert power and social influence in their communities. They are characterized by relatively high incomes, middle-aged male heads, (45–64 years) or elderly men (65 years and over), and low livelihood diversity. They have access to large tracts of farmland, inherited from their ancestors or acquired over time, with secure land-use rights and/or owning functional businesses. They have access to and benefit from limited government agricultural interventions, especially regarding cocoa farming, easily accessing extension officers who advise on farm management, and can secure more productive cocoa plant varieties. They prosper through a combination of access to emerging external markets, capital, social networks, and progressive farming knowledge. Challenges and constraints faced by those on a consolidating trajectory include continuing increases in farm input prices and labor, meaning profits remain limited. They are industrious, proactive, risk takers and willing to utilize any perceived opportunities to accumulate assets. The impact of ASGM emergence on this group has been generally positive. They reinforced this trajectory of prosperity by leveraging assets, social influence, and networks to their

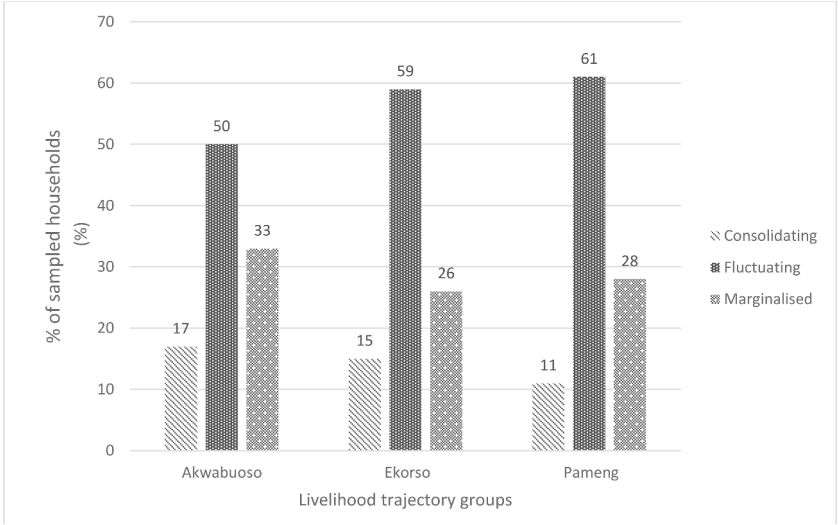

Fig. 2. Household occurrence across livelihood trajectory groups in the three communities, based on indicator scores from questionnaire surveys.

advantage, e.g., interested landowners engaged with miners, leasing out lands to them for well-negotiated fees. Younger residents ran their own ASGM operations alongside farming, while others rented-out mining equipment/accessories or became gold traders.

3.2.2. Fluctuating

Households on this trajectory tend to own small farmlands/trade or are caretaker farmers or waged laborers in agriculture or service sectors. They have limited access to communal community resources such as family lands and forest products. Households are characterized by mid- to low-level incomes, male/female heads, young to middle-aged adults (18–44 years), with mid to low livelihood diversity and some land-use rights. Although farm-based livelihoods have continued to play an important role, past, and current limited agricultural interventions have not yielded appreciable improvements. Households on this trajectory proactively shifted into ASGM because of the high, quick financial returns. Some households also entered ASGM because their farmlands were being mined and left unreclaimed. These households access informal loans or pool resources with family or friends to engage in ASGM. This increased their incomes and enabled acquisition of assets such as houses and motorcycles. These households improved their livelihood trajectory through a combination of human capital, social networks, and forging reputations as good workers. The local economy provides an adequate living for them, and they can overcome livelihood disturbances and further fluctuations by seeking alternative employment opportunities elsewhere within their communities because of their human capital and assets acquired through ASGM. Many of these households still engage in farming for consumption, to supplement income, or to address potential livelihood shocks and stresses.

3.2.3. Marginalised

Households on this trajectory are typically from poor backgrounds and are marginalised due to severely limited access to livelihood resources (e.g., land, networks, funds) and a lack of power and influence. These households are struggling to survive and are characterized by low incomes, young female/male heads, the aged, and widows, with high livelihood diversity and insecure land-use rights. These households rely heavily on farming for income and subsistence. Increased degradation of farmlands and waterbodies due to ASGM disproportionately negatively affects this group, who are least able to defend their livelihoods or harness other opportunities. Some households shifted from the fluctuating trajectory to this one following sickness/death of household members, or forceful mining of their farms without reclamation, or when mine waste polluted their farms increasing their susceptibility to poverty. Migrants lacking social networks, local knowledge and secure access to natural resources also constituted a large proportion of this group. To cope with shocks, these households increased livelihood diversity, engaging in waged labor activities in agriculture, artisanship, or construction or taking informal loans from community members. Some have pre-existing debt from failed ventures and sometimes resort to asset selling. ASGM-linked deforestation has reduced forests normally available for this group to harvest products for sale. They are likely to experience trajectory lock-ins due to limited access to natural capital, networks, and support from local authorities. Households whose farmlands have been mined without reclamation and who have few other options lose the capacity to respond to future changes. Those who have the capability to do ASGM reluctantly engage, with no clear future plans.

Three distinct life-stories selected from 30 interviewed households, with respective factors contributing to poverty or development over time, are illustrated in Table 5. These three lived experiences illustrate the three livelihood trajectories - consolidating, fluctuating, and marginalised - that are clearly traceable throughout the three farming communities. At community level, our findings showed that informal mining caused degradation of farms, land, waterbodies, and forests in all three communities. However, ASGM companies undertook development work in Pameng (public toilet, boreholes, renovation of chief's palace

Table 5
Livelihood trajectories of households most reflective of the impact of ASGM emergence.

Case study household	Limiting (L) and Enabling (E) factors leading to poverty or development
Consolidating trajectory Case 1 – male, 55 years, Pameng *He has always loved to work for himself, and prior to ASGM he owned shops trading in household goods as a businessman. When ASGM emerged, he ventured into it alongside his business. He sought permission from local landowners, negotiated and compensated them before mining starts. Mining business has been profitable. Presently, he has secured a deal with a large-scale mining company, and mine portions of their concessions that the company considers uneconomical to mine. He mines using his own machinery and shares the gold proceeds with them. He finds it profitable and has good relations with the large-scale mining company, including helping him to negotiate with difficult landowners during land acquisition. He was able to secure bank loans to grow the mining business and now he uses sophisticated machinery such as excavators and trommel to mine. Presently he has 86 employees. His-mining work also draws self-employed artisanal miners who search for residual gold (kuli-kuli). He often permits them because they do it to survive. He ensures that water bodies and forest reserve near his site are protected and not degraded (mine site visit confirmed efforts made in this regard). The profits obtained from the mining has enabled him to expand his trading business as well. He takes steps to link well with the village people and their leaders. There is a percentage of his mining proceeds he gives to the chief and elders to support the chieftaincy. Due to limited government support, he has provided bore hole, and two KVIP toilets based on community demands, and has donated ambulance to the Atiwa West district assembly.*	E1. Human and financial capital/ productive capacity E2. New livelihood opportunity E3. Access to land E4. Financial accumulation E5. Access to business support networks E6. Access to financial credit E7. Possession of new assets E8. ASGM employment option E9. Ease of entry for artisanal miners E10. Financial accumulation E11. Community benefits L1. Limited state support E12. Benefits to society
Case study household	Limiting (L) and Enabling (E) factors leading to poverty or development
Fluctuating trajectory Case 2 - Female, 42 years, Akwabuoso *She has lived in Akwabuoso all her life. In the* 1990s*, her mum operated a traditional eatery business. She took over in the late* 1990s *whilst her mum helped. She did this for 14 years, worked on weekdays and farmed on Saturdays. The business helped look after two younger siblings in secondary school. During difficult times, the business and her mum helped. Later she stopped the eatery when her mum became ill. In the* 2000s*, she switched to selling rice and beans (waakye) and fried yam, which was less intensive but profitable. Afterwards, she shifted into selling corn porridge and meat pie due to inadequate time for the waakye. She did this till ASGM arrived. Hearing how lucrative ASGM was, she joined in 2010. Initially she faced resistance from male colleagues who insisted it was a man's/tough job, but she prevailed. Later, she was made a gang leader* [a *gang constitutes 10 - 12 members, including about 2 ladies*]. *Sometimes the manager took her to do gold prospecting in nearby communities. She participated until mining wound up, as most miners moved to Pameng (a more productive deposit found). ASGM enabled her to build a*	E1. Diversification of income E2. Good quality land for farming E3. Social support networks E4. Livelihood diversification L1. Lack of time E5. New livelihood opportunity L2. Cultural aspects barriers E6. Enhanced human capital E7. Possession of new assets E8. Financial accumulation E9. Empowered livelihood diversification E10 Enhance human capital L3. Lack of financial capital E11. Rising market demand

(*continued on next page*)

Table 5 (*continued*)

Case study household	Limiting (L) and Enabling (E) factors leading to poverty or development
3-bedroom house, cared for her ill mum for 3 years ($40/week for the treatment); and later cared for her sick husband for a year. After mining declined, she went into meat barbecuing at social events, which supports her children's education. Future mining is possible in the community because not all deposits were mined. However, miners now need license from the government to freely operate, but it is expensive. Hence, they do not see a lot of miners back in the community. Presently, the meat barbecuing is profitable. There is opportunity for growth because there is demand for it.	
Case study household	Limiting (L) and Enabling (E) factors leading to poverty or development
Marginalised trajectory	L1. Inadequate family support
Case 3 - migrant, male, 40 years, Ekorso	L2. Lack of access to farmland
He was born in the northern part of Ghana. As an adult, due to difficulties between him and his dad and lack of access to adequate farmland, he moved to Ekorso in 2009 with the intent to go into cocoa farming. He got farmland and cultivated a 9-acre cocoa farm. When the miners arrived, they mined his farm, even though he disagreed. He is a tenant farmer, and the landowner agreed to the mining, so he was helpless. He had to look for other farmland far from the village and start the cocoa farm all over again setting his plans back. The compensation given to him and the landowner was $2000, of which he was given one-third. This was regrettably inadequate. Presently, ASGM activities have made his farm roads unmotorable, especially when it rains. He is a member of a cooperative, which helps him to access the agro-chemicals to do the annual spraying of the cocoa farm, but once a year is not enough. He wants the government to protect cocoa farmers enacting a regulation that does not permit miners to mine in areas where there are cocoa farms. He plans to trade in goods alongside the cocoa farming if he manages to access some funding. He would want the government to provide loans to cocoa farmers at a moderate interest rate, to support him so the money is paid at the end of the cocoa season.	E1. Access to farmland E2. ASGM emergence/new livelihood opportunity L3. Unsecured land under customary land tenure system L4. Inadequate compensation L5. ASGM degraded farm roads E3. Access to social network L6. Limited government support L7. Lack of state support for cocoa farmers against miners L8. Lack of access to financial credit.

and regular cash donation) as demanded by community leaders. No development projects happened in Ekorso and Akwabuoso, as leadership did not press for them. Yet, presence of community infrastructure can impact livelihood trajectories of households.

3.3. Opportunities and barriers for different livelihood trajectory groups since ASGM emergence

Oral histories, key informant interviews, FGDs and questionnaires revealed a number of opportunities and barriers to people's capabilities to shape their livelihood trajectories resulting from ASGM's emergence (Table 6). Households on a consolidating trajectory had access to most of the available opportunities, while those on the marginalised trajectory had the least. Consolidators leveraged available household assets and utilized opportunities to set up businesses, diversify and accumulate more assets. ASGM has become an important source of income and employment for households on a fluctuating trajectory. These households were generally making greater financial gains since the arrival of ASGM. Conversely, the marginalised faced most of the barriers identified, followed by households on fluctuating trajectory with the consolidating group facing the least of the identified barriers (Table 6). Findings revealed that local miners lacked access to affordable credit, limiting their capabilities to become self-employed artisanal miners using sophisticated mining equipment and employing several workers. In Akwabuoso, mining activities had slowed because most migrant ASGM companies had moved out due to new gold discoveries elsewhere. Local miners were unable to fill the gap due to lack of access to finance and complications with acquiring ASGM licence. Fig. 3 demonstrates the different livelihood trajectories – consolidating, fluctuating and marginalised – that households followed after ASGM's emergence.

Table 6
Opportunities and barriers that evolved for the different livelihood trajectory groups upon ASGM emergence.

Opportunities/Barriers	Livelihood trajectory groups		
Opportunities	Consolidating	Fluctuating	Marginalised
Livelihood diversification or change/employment prospects in ASGM	x	x	x
Leveraging prospects	x		
Increased access to business/social networks	x	x	
Sale/lease of natural assets, including land	x		
Rental of mining implements	x		
Acquisition of new knowledge and skills	x	x	x
Boost to local economy (increased access to market and finance, increased purchasing power of locals)	x	x	
High levels of human capital (influx of mine workforce)	x	x	x
Barriers			
Land and water degradation due to irresponsible ASGM	x	x	x
Inadequate support from local assembly and Police to resolve ASGM related complaints	x	x	x
Lack of or limited access to financial credits		x	x
Insecure land tenure rights (customary systems)			x
Social-cultural barriers affecting employment			x
Limited state support for farmers and miners	x	x	x
Ineffective implementation of mining regulation	x	x	x
Increased prices for food items			x
Limited access to farmlands		x	x
Decrease in farming labor	x	x	x
Decreased school attendance affecting quality of future labor		x	x

4. Discussion

4.1. Impact of ASGM adoption on livelihood trajectories

ASGM is expanding in Ghana, like in many other sub-Saharan African countries (Hilson and Maconachie, 2020), and the future exploitation of minerals in farming areas will likely intensify due to soaring demand for minerals and metals to manufacture devices that promote the carbon net zero agenda. Combining the Sustainable Livelihood Approach (SLA) with livelihood trajectories, this study analyzed livelihoods dynamics of residents in cocoa farming areas experiencing ASGM across multiple scales – households and community. It explored how their present conditions have emerged over time, and the strategic decisions and behaviors underpinning those changing livelihoods. Residents demonstrated complex, dynamic livelihood portfolios, depending on household capabilities and level of access to livelihood assets but

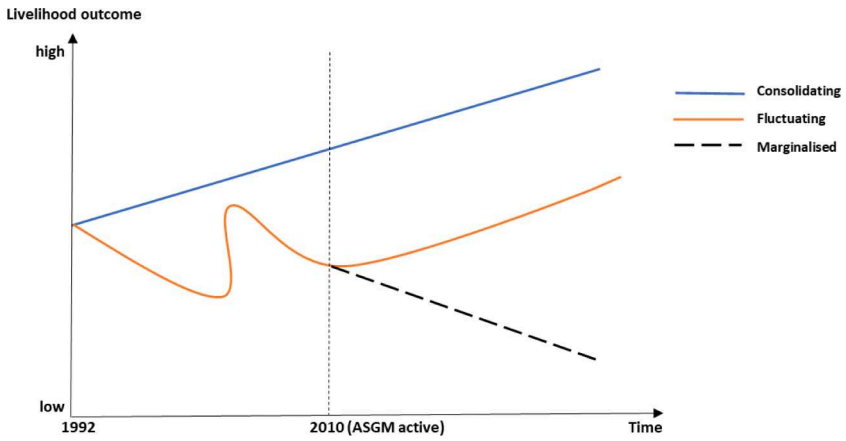

Fig. 3. Illustrative representation of livelihood trajectories of households following ASGM emergence.
Source: Authors' construct.

livelihood outcomes were influenced by structures and external factors relating to socio-cultural, economic, political, and biophysical variabilities. Both access to natural, physical, financial, human, and social assets and those that are subsequently used, were mediated mainly by customary norms and traditional institutions but also affected by statutory laws and policies. Our findings revealed that prior to ASGM emergence in the communities, households who had acquired or had access to more assets and generally had improved livelihood outcomes, were better positioned to take advantage of the opportunities that ASGM presented, compared with households who had little assets and household capabilities. This study has shown that ASGM will not fully replace agricultural livelihoods because new frontier communities will continue to rely on farming for food and livelihoods, and identities will likely remain linked to agriculture. The study helped identified opportunities and barriers to change processes, as well as the differential and unequal effects of ASGM emergence that confront households, and showcased people's capacity for action and decision making and livelihood trajectories that evolved.

This study highlighted that the ASGM sector comprises both poverty-driven and profit-driven actors with widely different opportunities and resources (see also: Hilson and Maconachie 2020). Due to its wealth creation potential, individuals, and entrepreneurs with access to financial, socio-political and/or natural capitals, notably mineral rich lands, ventured into and operated ASGM companies for profit-generating purposes, employing community members as casual ASGM workers. However, most residents shifted into ASGM simply because of the opportunity to get employment or diversify and generate funds to improve their living conditions. Thus, constraints associated to farming, limited rural employment opportunities and the pressing need of local households to generate cash income opportunities as well as chance to generate wealth were the primary drivers of local people's entry into ASGM. These findings are similar to other studies across sub-Saharan Africa (Hilson, 2002; Okoh and Hilson, 2011; Pokorny et al., 2019). Our findings have shown that ASGM development can create livelihood alternatives and income opportunities to households and be an incubator for local economic development because of the ASGM support services that emerge because of mining operations (see also Hilson and Maconachie 2020). ASGM managers are inclined to support local development if community leaders negotiate such demands, because ASGM productivity depends on the goodwill of local workers and their host communities.

Yet the expansion of ASGM was one of the underlying drivers of income inequality in the communities. Because of differences in access to and use of livelihood assets, there are power asymmetries in the ASGM sector (see also: Maconachie and Conteh 2021; Van Bockstael 2019) such that ASGM impacts households unequally. Consolidating and fluctuating livelihood trajectories moved towards development, whilst those of the marginalised moved towards poverty. Benefits from ASGM were largely driven by market forces that served the interests of a small number of households (consolidating group) with abundant resources (e.g., land and other physical assets, funds, skills and labor, business and social networks). Consolidators encountered more opportunities than barriers and accumulated further assets. Households on a fluctuating trajectory were generally making more financial gains since ASGM's arrival, due to increased opportunities for mining and provision of ASGM support services. However, this group faced difficulty shifting into the consolidating trajectory. They lacked access to credit to boost their enterprises. While the government has enacted laws to regulate the ASGM sector, our findings found no deliberate attempt to support local artisanal miners to extend their undertaking. Some households on the fluctuating trajectory could drift into the marginalised when faced with ASGM-linked external shocks/stresses e.g., tenant farmers losing farms to mining. Marginalised households faced reduced access to resources due to degradation from ASGM. This potentially increases the vulnerability of marginalised households as it reduces their options for livelihood diversification in response to internal and external disturbances and shocks. For instance, some female-headed households who had lost farms and become artisanal miners (*kuli-kuli)* did not have free access to mine sites as accessibility was closely controlled by ASGM managers, affecting how much revenue they could generate. The restriction of access to assets such as land, loans, equipment, and networks hinder movement in the sector for the more marginalized households and signals the propensity of the marginalised having little chance to escape poverty. However, the ASGM livelihood trajectory of the marginalised was better than that from farming. Farming households on marginalised livelihood trajectories faced the worst situation and mostly, out of desperation, opted to join ASGM as casual workers, becoming caretakers of other peoples' farms, looking for new farmland elsewhere to restart farming or simply becoming dependant on families in order to cope. Our results are similar to those of Pokorny et al. (2019) and Brugger and Zanetti (2020), for Burkina Faso where the distribution of income from ASGM was also highly unequal, reflecting the disproportionate concentration of resources among a small number of high-income households. Likewise, in Zimbabwe ASGM has brought economic benefits to high- and middle-income households but significantly compromised the livelihoods of low-income and landless farmers (Mkodzongi and Spiegel, 2019).

These consequences of ASGM expansion in new frontier communities should be viewed in light of wider socio-economic developments in Ghana and in sub-Saharan Africa, and its impacts on long-standing livelihoods among farming communities. Although non-farming employment encouraged by the gradual introduction of key

infrastructure such as electricity, mobile network and good roads has opened new livelihood options and facilitated livelihood diversification and mobility, these pathways have not been accessible to all. Some elite households and groups with more capital and flexible endowments have benefitted more than less affluent and less privileged farmers. Such uneven uptake and differential flourishing and struggles linked to ASGM emergence further exacerbate power asymmetries that put disadvantaged farmers at even higher risk. Despite the multiple factors that affect livelihood trajectories of farming communities, evidence from this study suggests that ASGM expansion plays a fundamental role in uneven development pathways. It intersects with and reinforces other drivers (e.g., limited access to finance, soil fertility decline, lack of markets) to significantly alter farming livelihoods. Despite long-term constraints affecting productivity, most households continue to rely on farming as their main livelihood source. Hence, the experiences, and aspirations of farming-dependant households need to be reflected in pro-poor rural development programmes, especially given the continuous growth of farming in forested areas and its complex role in the political economy of the sub-Saharan Africa region. Customary norms e.g., land tenure rights and other regulations that govern mineral resource access for various social groups and shape the prospects for mining as a viable livelihood strategy, need to be understood and reviewed so they offer benefits for local people and migrants in mining areas (Brottem and Ba, 2019). Asset acquisition at household level alone cannot enable rural households to become non-poor. Structural transformation of the context/environment to support such a transition is needed. Several factors affect whether a household will improve their position (in relation to a specific indicator), if at all, and the pace at which they do so. Thus, livelihood trajectories are shaped by household characteristics and access to resources as well as wider social, economic, environmental, and institutional factors.

4.2. Future outlook for rural people in new frontier communities

This study highlights the need to design policies to effectively target and appropriately support different livelihood trajectory groups and to lessen undesirable and unequal livelihood trajectories. This suggestion was strongly endorsed by the communities. In Ghana, presently there are policies that would be beneficial for the three groups, (e.g., The Investing for Food and Jobs (IFJ) initiative has been designed to provide investment to develop infrastructure to modernise the agri-food system) but are not reaching them and better implementation measures are needed. Sub-Saharan African governments should liaise with donors and create opportunities such as affordable finance to those on consolidatory trajectory to enable them to expand their enterprises or create new ones such as agro processing units. Policies regarding the fluctuating trajectory group, should support rural people in either moving up to profitable mining/farming systems or moving out of agriculture to engage in other viable non-farm employment opportunities. Interventions could include better training, improved land rights and enhanced access to financial as well as non-financial services such as access to regulated markets and guaranteed good prices. Farmers and miners should be assisted to form functional community cooperatives so that government support for them is better targeted and supervised, for instance enhancing the capacities of qualified miners to scale-up production and move from fluctuating trajectory onto desired consolidatory trajectory. In Ghana, the government has launched a community mining scheme. However, the success of cooperative approach will depend on political will and effective coordination among stakeholders to monitor and to improve processes.

The government of Ghana and other sub-Saharan African governments should provide marginalised trajectory households with opportunities to build productive livelihood strategies and cushion against shocks. Social protection interventions could include in-kind and food transfers, conditional (and unconditional) cash transfers, fee waivers, and subsidized inputs/tools for agriculture and mining. Safety net schemes should be designed to ensure a minimum level of food consumption, protection, and assets building/income generation boosting when shocks hit.

5. Conclusion

ASGM is expanding across mineral rich farming areas in Ghana and many parts of sub-Saharan Africa. This study provides important insights into livelihood trajectories that emerge following ASGM emergence in these new frontier communities, the opportunities and barriers various livelihood trajectory groups have encountered and how they have managed these changes in pursuit of their livelihoods. Findings show that ASGM can provide broad positive livelihood outcomes and increased livelihood options. However, differential household capacities to respond to associated changes linked to ASGM's emergence result in differential trajectories — consolidating, fluctuating, and marginalised – with some households able to improve their livelihood trajectory but less desirable consequences for others, which can amplify over time with interactions with concurrent developments and external factors. Differences in the distribution of ASGM-linked benefits depends on people's access to, control and use of resources in pursuing their livelihoods and fulfilling their capabilities. ASGM's expansion thus plays a fundamental role in uneven development pathways. It intersects with and reinforces other drivers (e.g., limited access to finance, soil fertility decline, lack of markets) to significantly alter farming livelihoods for both those who engage in ASGM and those who do not. ASGM is dynamic and connected to broader land-uses that are likely to experience increasing change. Careful consideration is needed about how interventions might modify the impact of such maximum changes. Additionally, to ensure sustainable livelihood development, socio-economic support should be orientated towards the needs of different groups in new frontier communities, depending on their movement towards poverty or development.

Funding

The data collection part of this work was partly supported by the University of York.

Declaration of Competing Interest

None.

Acknowledgements

The authors would like to thank all study participants, chiefs, and local agricultural officials in the Atiwa West district for their contributions. The authors would also like to thank Musah Seidu, Jeffery Amoah, and Sylvester Adranyi, without whose assistance this research would not have been possible. Informed consent was obtained from all participants prior to data collection.

Appendix A. Indicators used to group households based on data collected during household surveys

Component	Indicators	Description	Data range or categories
Financial capital	Gross annual agricultural income (number of bags of cocoa harvested; number of bags of cassava harvested)	Financial assets enable households to respond to change, acquire physical assets and strategize to develop	Item
Physical capital	Number of transportation assets	Different transportation assets provide livelihood options when opportunities materialize and can be sold in times of need.	Item
	Number of communication assets	Having communication gadgets enables easier and quicker access to vital information relevant to their livelihoods	Item
	Ownership of house	Allow households to consolidate income, due to not needing to pay rents, plus generate more income if able to rent	1. owner, 2. renting, 3. family home
Natural capital	Tenure arrangement held over agricultural land	Type of land tenure enables livelihood planning, loans to be secured or land sold/leased if desiredneeded.	1. owner (inherited); 2. owner (private purchase); 3. owner (gifted); 4. Rented. 5. share cropping; 6. caretaker;7. other
	Size of agricultural land held	The size of agricultural field is related to the amount of financial assets that can be generated (AS). The larger the area, the better.	1. < 5, 2. 5 – 10, 3. 11 – 15, 4. 16–20, 5. >20 acres (2.5 acre=1 ha)
Human capital	Highest educational level achieved	Education level attained provides an indication of human capital (L), increasing capacity to exploit a broader range of opportunities.	1.none, 2. primary 3. Junior secondary/ middle school, 4. senior secondary
	Able to afford children's education	Level of capacity to pay education related fees of wards indicates the level of financial assets a household wield	1.very easy, 2. easy, 3. moderate, 4. difficult, 5. very difficult
	Able to afford health check	To afford treatment of illness shows household ability to restore/maintain its human capital, which is necessary for engagements in livelihood options	1.very easy, 2. easy, 3. moderate, 4. difficult, 5. very difficult.
Social capital	Membership of social groups (No. of associations households belong to)	Membership of groups provides social safety nets and access to information. Membership of a higher number of groups enriches social networks and information sources.	1. None, 2. 1–2, 3. 3–5, 4. 5–7, 5. 8 and above
Livelihood diversification	Number of livelihood activities undertaken (subsistence and income)	Livelihood diversification provides an indication of flexibility or resilience when change impacts income sources or household resources	1–16 [item]

Appendix B

B1. Akwabuoso

Preliminary test: The Shapiro-Wilk test statistic is significant, meaning the number of households is not normally distributed in the population (data is nonparametric). Therefore Kruskal-Wallis test (not ANOVA) was applied to test for any significance in differences in number of households observed among the livelihood trajectory groups.

Tests of Normality

	Livelihood trajectory group	Shapiro-Wilk		
		Statistic	df	Sig.
Number of households	Consolidating	0.351	20	0.000
	Fluctuating	0.865	59	0.000
	Marginalised	0.786	38	0.000

Test for significant difference:
Kruskal-Wallis Test

	Ranks		
	Livelihood trajectory group	N	Mean Rank
Number of households	Consolidating	20	107.50
	Fluctuating	59	68.00
	Marginalised	38	19.50
	Total	117	

Test Statistics[a,b]

	Number of households
Kruskal-Wallis H	98.138
df	2
Asymp. Sig.	0.000

aKruskal Wallis Test.
bGrouping Variable: Livelihood_trajectory_group.

Dunn-Bonferroni nonparametric post hoc comparison test following a significant Kruskal-Wallis test.
Pairwise Comparisons of Livelihood_trajectory_group

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig[a]
Marginalised-Fluctuating	48.500	6.999	6.930	0.000	0.000
Marginalised-Consolidating	88.000	9.295	9.467	0.000	0.000
Fluctuating-Consolidating	39.500	8.706	4.537	0.000	0.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is 0.050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

B2. EKORSO

Preliminary checks for data analysis:
Tests of Normality

	Livelihood trajectory group	Shapiro-Wilk		
		Statistic	df	Sig.
Number of households	Consolidating	0.726	18	0.000
	Fluctuating	0.825	71	0.000
	Marginalised	0.777	32	0.000

Test for significant difference:
Kruskal-Wallis Test

	Ranks		
	Livelihood trajectory group	N	Mean Rank
Number of households	Consolidating	18	112.50
	Fluctuating	71	68.00
	Marginalised	32	16.50
	Total	121	

Test Statistics[a,b]

	Number of households
Kruskal-Wallis H	94.989
df	2
Asymp. Sig.	0.000

[a]Kruskal Wallis Test
[b]Grouping Variable: Livelihood_trajectory_group
Dunn-Bonferroni nonparametric post hoc comparison test following a significant Kruskal-Wallis test.
Pairwise Comparisons of Livelihood_trajectory_group

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig[a]
Marginalised-Fluctuating	51.500	7.395	6.964	0.000	0.000
Marginalised-Consolidating	96.000	10.233	9.381	0.000	0.000
Fluctuating-Consolidating	44.500	9.166	4.855	0.000	0.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is 0.050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

B3. PAMENG

Preliminary checks for data analysis:
Tests of Normality

	Livelihood trajectory group	Shapiro-Wilk		
		Statistic	df	Sig.
Number of households	Consolidating	0.790	13	0.005
	Fluctuating	0.889	75	0.000
	Marginalised	0.647	34	0.000

Test for significant difference:
Kruskal-Wallis Test

	Ranks Livelihood trajectory group	N	Mean Rank
Number of households	Consolidating	13	116.00
	Fluctuating	75	71.85
	Marginalised	34	17.84
	Total	122	

Test Statistics[a,b]

	Number of households
Kruskal-Wallis H	94.989
df	2
Asymp. Sig.	0.000

aKruskal Wallis Test.
bGrouping Variable: Livelihood_trajectory_group.

Dunn-Bonferroni nonparametric post hoc comparison test following a significant Kruskal-Wallis test.
Pairwise Comparisons of Livelihood_trajectory_group

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig[a]
Marginalised-Fluctuating	54.008	7.220	7.480	0.000	0.000
Marginalised-Consolidating	98.162	11.388	8.620	0.000	0.000
Fluctuating-Consolidating	44.153	10.492	4.208	0.000	0.000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is 0.050.
a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

References

Allison, E.H., Ellis, F., 2001. The livelihoods approach and management of small-scale fisheries. Mar. Policy 25 (5), 377–388. https://doi.org/10.1016/S0308-597X(01)00023-9.

Amankwah, R.K., Anim-Sackey, C., 2004. Strategies for sustainable development of the small-scale gold and diamond mining industry of Ghana. Resour. Policy 29 (3–4), 131–138. https://doi.org/10.1016/j.resourpol.2004.07.002.

Antwi-Agyei, P., 2012. Vulnerability and adaptation of Ghana's food production systems and rural livelihoods to climate variability. Environ. Dev. Sustain. 15 (4), 903–926. http://www.see.leeds.ac.uk/fileadmin/Documents/research/.

Antwi-Agyei, P., Dougill, A.D., Fraser, E.D.G., Stringer, L.C., 2013. Characterising the nature of household vulnerability to climate variability: empirical evidence from two regions of Ghana. Environ. Dev. Sustain. 15, 903–926. https://doi.org/10.1007/s10668-012-9418-9.

Arthur, F., Agyemang-Duah, W., Gyasi, R.M., Yeboah, J.Y., Otieku, E., 2016. Nexus between artisanal and small-scale gold mining and livelihood in prestea mining region, Ghana. Geogr. J. 2016, 1–18. https://doi.org/10.1155/2016/1605427.

Arthur-Holmes, F., Abrefa Busia, K., 2022. Women, North-South migration and artisanal and small-scale mining in Ghana: motivations, drivers and socio-economic implications. Extract. Ind. Soc. 10, 101076 https://doi.org/10.1016/J.EXIS.2022.101076.

Arthur-Holmes, F., Abrefa Busia, K., Vazquez-Brust, D.A., Yakovleva, N., 2022. Graduate unemployment, artisanal and small-scale mining, and rural transformation in Ghana: what does the 'educated' youth involvement offer? J. Rural Stud. 95, 125–139. https://doi.org/10.1016/J.JRURSTUD.2022.08.002.

Baffour-Kyei, V., Mensah, A., Owusu, V., Horlu, G.S.A.K., 2021. Artisanal small-scale mining and livelihood assets in rural southern Ghana. Resour. Policy 71. https://doi.org/10.1016/j.resourpol.2021.101988. January.

Bagchi, D.K., Blaikie, P., Cameron, J., Chattopadhyay, M., Gyawali, N., Seddon, D., 1998. Conceptual and methodological challenges in the study of livelihood trajectories: case-studies in eastern India and western Nepal. J. Int. Dev. 10 (4), 453–468. https://doi.org/10.1002/(SICI)1099-1328(199806)10:4<453::AID−JID538>3.0.CO;2-Q.

Banchirigah, S.M., 2006. How have reforms fuelled the expansion of artisanal mining? Evidence from sub-Saharan Africa. Resour. Policy 31 (3), 165–171. https://doi.org/10.1016/j.resourpol.2006.12.001.

Banchirigah, S.M., 2008. Challenges with eradicating illegal mining in Ghana: a perspective from the grassroots. Resour. Policy 33 (1), 29–38. https://doi.org/10.1016/j.resourpol.2007.11.001.

Banchirigah, S.M., Hilson, G., 2010. De-agrarianization, re-agrarianization and local economic development: re-orientating livelihoods in African artisanal mining communities. Policy Sci. 43 (2), 157–180. https://doi.org/10.1007/s11077-009-9091-5.

Bansah, K.J., Dumakor-Dupey, N.K., Kansake, B.A., Assan, E., Bekui, P., 2018. Socioeconomic and environmental assessment of informal artisanal and small-scale mining in Ghana. J. Clean. Prod. 202, 465–475. https://doi.org/10.1016/j.jclepro.2018.08.150.

Bowen, G.A., 2008. Naturalistic inquiry and the saturation concept: a research note. Qual. Res. 8 (1), 137–152.

Brottem L, V., Ba, L, 2019. Gendered livelihoods and land tenure The case of artisanal gold miners in Mali. Geoforum 105, 54–62.

Brugger, F., Zanetti, J., 2020. In my village, everyone uses the tractor": gold mining, agriculture and social transformation in rural Burkina Faso. Extract. Ind. Soc. 7 (3) https://doi.org/10.1016/j.exis.2020.06.003.

Bryman, A., Bell, E., 2007. Business Research Methods. Oxford University Press, Oxford.

Carrie, R.H., Stringer, L.C., Van Hue, L.T., Hong Quang, N., Van Tan, D., Hackney, C.R., Thanh Nga, P.T., Quinn, C.H., 2022. Social differences in spatial perspectives about local benefits from rehabilitated mangroves: insights from Vietnam. Ecosyst. People 18 (1), 378–396. https://doi.org/10.1080/26395916.2022.2083237.

Chambers, R., Conway, G., 1992. Sustainable rural livelihoods: practical concepts for the 21st century. In: Ids Discussion Paper, 29. Institute of Development Studies, University of Sussex, Brighton, 296ISBN 0 903715 58 9.

Codjoe, F.N.Y., Auming-Brempong, S., Mabe, F.N., 2013. Analysis of cocoa-based agricultural knowledge and information systems in the eastern region of Ghana. Russ. J. Agric. Socio Econ. Sci. 2 (14).
de Haan, L., Zoomers, A., 2005. Exploring the frontier of livelihoods research. Dev. Chang. 36 (1), 27–47. https://doi.org/10.1111/j.0012-155X.2005.00401.x.
van Dijk, T., 2011. Livelihoods, capitals and livelihood trajectories: a more sociological conceptualisation. Prog. Dev. Stud. 2, 101–117.
Ellis, F., 2000. The determinants of rural livelihood diversification in developing countries. J. Agric. Econ. 51 (2), 289–302. https://doi.org/10.1111/j.1477-9552.2000.tb01229.x.
Ghana Cocoa Board (2022). Regional cocoa purchases [online]. Accessed from https://cocobod.gh/cocoa.purchases, on 25/10/2022.
Ghana Statistical Service, 2021. Ghana 2021 population and housing census. Gen. Rep. 3A.
Hilson, G., 2016. Farming, small-scale mining and rural livelihoods in Sub-Saharan Africa: a critical overview. Extract. Ind. Soc. 3 (2), 547–563. https://doi.org/10.1016/j.exis.2016.02.003.
Hilson, G., Garforth, C., 2012. Agricultural poverty" and the expansion of artisanal mining in Sub-Saharan Africa: experiences from Southwest Mali and Southeast Ghana. Popul. Res. Policy Rev. 31 (3), 435–464. https://doi.org/10.1007/s11113-012-9229-6.
Hilson, G., Hu, Y., 2022. Changing priorities, shifting narratives: remapping rural livelihoods in Africa's artisanal and small-scale mining sector. J. Rural Stud. 92, 93–108. https://doi.org/10.1016/J.JRURSTUD.2022.03.010.
Hilson, G., Maconachie, R., 2020. Artisanal and small-scale mining and the sustainable development goals: opportunities and new directions for sub-Saharan Africa. Geoforum 111, 125–141. https://doi.org/10.1016/j.geoforum.2019.09.006. October 2019.
Hilson, G., Osei, L., 2014. Tackling youth unemployment in sub-Saharan Africa: is there a role for artisanal and small-scale mining? Futures 62 (2014), 83–94. https://doi.org/10.1016/j.futures.2014.05.004.
Hilson, G., Potter, C., 2003. Why is illegal gold mining activity so ubiquitous in Rural Ghana? Afr. Dev. Rev. 15 (2–3), 237–270. https://doi.org/10.1111/j.1467-8268.2003.00073.x. Issues.
Hilson, G., Potter, C., 2005. Structural adjustment and subsistence industry: artisanal gold mining in Ghana. Dev. Chang. 36 (1), 103–131. https://doi.org/10.1111/j.0012-155X.2005.00404.x.
Intergovernmental Forum on Mining, Minerals, Metals and Sustainable Development (IGF), 2017. Global Trends in Artisanal and Small-Scale Mining (ASM): A Review of Key Numbers and Issues. IISD, Winnipeg, MB, Canada.
Maconachie, R., Conteh, F., 2021. Artisanal mining policy reforms, informality and challenges to the sustainable development goals in Sierra Leone. Environ. Sci. Policy 116, 38–46. https://doi.org/10.1016/j.envsci.2020.10.011.
Mensah, L., 2021. Legal pluralism in practice: critical reflections on the formalisation of artisanal and small-scale mining (ASM) and customary land tenure in Ghana. Extract. Ind. Soc. 8 (4), 100973 https://doi.org/10.1016/J.EXIS.2021.100973.
Mining-technology.com, (2014). Akyem gold mine. https://www.mining-technology.com/projects/akyem-gold-mine/. Published 5 Feb 2014. Accessed 25.5.2021.
Ministry of Finance and Economic Planning, Ghana (2021). MOFEP budget report for Atiwa West District Assembly, 2021.
Mkodzongi, G., Spiegel, S., 2019. Artisanal gold mining and farming: livelihood linkages and labour dynamics after land reforms in Zimbabwe. J. Dev. Stud. 55 (10), 2145–2161. https://doi.org/10.1080/00220388.2018.1516867.
Ncube-Phiri, S., Ncube, A., Mucherera, B., Ncube, M., 2015. Artisanal small-scale mining: potential ecological disaster in Mzingwane District. Jàmbá J. Disaster Risk Stud. 7 (1) https://doi.org/10.4102/jamba.v7i1.158.
Nyame, F.K., Blocher, J., 2010. Influence of land tenure practices on artisanal mining activity in Ghana. Resour. Policy 35 (1), 47–53. https://doi.org/10.1016/j.resourpol.2009.11.001.
Ofosu, G., Dittmann, A., Sarpong, D., Botchie, D., 2020. Socio-economic and environmental implications of artisanal and small-scale mining (ASM) on agriculture and livelihoods. Environ. Sci. Policy 106, 210–220. https://doi.org/10.1016/j.envsci.2020.02.005. April 2019.
Okoh, G., Hilson, G., 2011. Poverty and livelihood diversification: exploring the linkages between smallholder farming and artisanal mining in rural Ghana. J. Int. Dev. 23 (8) https://doi.org/10.1002/jid.1834.
Ontoyin, J., Agyemang, I., 2014. Environmental and rural livelihoods implications of small-scale gold mining in Talensi-Nabdam Districts in Northern Ghana. J. Geogr. Reg. Plann. 7 (8), 150–159. https://doi.org/10.5897/jgrp2014.0447.
Orchard, S.E., Stringer, L.C., Quinn, C.H., 2016. Mangrove system dynamics in Southeast Asia: linking livelihoods and ecosystem services in Vietnam. Reg. Environ. Chang. 16 (3), 865–879. https://doi.org/10.1007/s10113-015-0802-5.
Osei, L., Arku, G., Luginaah, I., 2022. We have done nothing wrong": youth miners' perceptions of the environmental consequences of artisanal and small-scale mining (ASM) in Ghana. Extract. Ind. Soc. 12 https://doi.org/10.1016/j.exis.2022.101179.
Osei, L., Yeboah, T., Kumi, E., Antoh, E.F., 2021. Government's ban on Artisanal and Small-Scale Mining, youth livelihoods and imagined futures in Ghana. Resour. Policy 71, 102008. https://doi.org/10.1016/j.resourpol.2021.102008. January.
Osumanu, I.K., 2020. Small-scale mining and livelihood dynamics in North-eastern Ghana: sustaining rural livelihoods in a changing environment. Prog. Dev. Stud. 20 (3), 208–222. https://doi.org/10.1177/1464993420934223.
Pijpers, R., 2014. Crops and carats: exploring the interconnectedness of mining and agriculture in Sub-Saharan Africa. Futures 62, 32–39. https://doi.org/10.1016/j.futures.2014.01.012.
Pokorny, B., von Lübke, C., Dayamba, S.D., Dickow, H., 2019. All the gold for nothing? Impacts of mining on rural livelihoods in Northern Burkina Faso. World Dev. 119, 23–39. https://doi.org/10.1016/j.worlddev.2019.03.003.
Pritchard, B., Vicol, M., Jones, R., 2017. How does the ownership of land affect household livelihood pathways under conditions of deagrarianization? 'Hanging in', 'stepping up' and 'stepping out' in two north Indian villages. Singap. J. Trop. Geogr. 38 (1), 41–57. https://doi.org/10.1111/SJTG.12180.
Qualtrics.com (2021). Determining sample size: how to make sure you get the correct sample size. https://www.qualtrics.com/uk/experience-management/research/determine-sample-size/. Accessed 30.7.2021.
Sabates-Wheeler, R., Sabates, R., & Devereux, S. (2018). Enabling graduation for whom? Identifying and explaining heterogeneity in livelihood trajectories post-cash transfer exposure. 10.1002/jid.3369.
Sallu, S.M., Twyman, C., Stringer, L.C., 2010. Resilient or vulnerable livelihoods? assessing livelihood dynamics and trajectories in rural Botswana. Ecol. Soc. 15 (4) https://doi.org/10.5751/ES-03505-150403.
Scoones, I. (1998). Sustainable rural livelihoods: a framework for analysis. IDS Working Paper, 72.
Scoones, I., 2009. Livelihoods perspectives and rural development. J. Peasant Stud. 36 (1), 171–196. https://doi.org/10.1080/03066150902820503.
Shackleton, S., Masterson, V., Hebinck, P., Speranza, C.I., Spear, D., Tengö, M., 2019. Editorial for special issue: "Livelihood and landscape change in Africa: future trajectories for improved well-being under a changing climate. Land 8 (8). https://doi.org/10.3390/land8080114 (Basel).
Stringer, L.C., Fraser, E.D.G., Harris, D., Lyon, C., Pereira, L., Ward, C.F.M., Simelton, E., 2020. Adaptation and development pathways for different types of farmers. Environ. Sci. Policy 104, 174–189. https://doi.org/10.1016/j.envsci.2019.10.007. April 2019.
Teschner, B.A., 2014. Orpaillage pays for everything": how artisanal mining supported rural institutions following Mali's coup d'état. Futures 62, 140–150. https://doi.org/10.1016/J.FUTURES.2014.04.016.
Thecocoapost.com (2020). Cocoa farmers petition COCOBOD to assist clamp down illegal mining. https://thecocoapost.com/cocoa-farmers-petition-cocobod-to-assist-clamp-down-illegal-mining/. Accessed 25.5.2020.
Trung Thanh, H., Tschakert, P., Hipsey, M.R., 2021. Moving up or going under? Differential livelihood trajectories in coastal communities in Vietnam. World Dev. 138 https://doi.org/10.1016/j.worlddev.2020.105219.
Tschakert, P., 2009. Recognizing and nurturing artisanal mining as a viable livelihood. Resour. Policy 34 (1–2), 24–31. https://doi.org/10.1016/j.resourpol.2008.05.007.
Van Bockstael, S., 2019. Land grabbing "from below"? Illicit artisanal gold mining and access to land in post-conflict Côte d'Ivoire. Land Use Policy 81, 904–914. https://doi.org/10.1016/j.landusepol.2018.04.045.
Yakovleva, N., 2007. Perspectives on female participation in artisanal and small-scale mining: a case study of Birim North District of Ghana. Resour. Policy 32 (1–2), 29–41. https://doi.org/10.1016/j.resourpol.2007.03.002.
World Gold Council (2021). Gold spot prices. https://www.gold.org/goldhub/data/gold-prices Accessed 27.7.2021.