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Review Article

Implications of Artisanal Mining on Food Security: A Survey of Selected Counties in Kenya

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Abstract *- Artisanal Mining (ASM) has emerged as one of the economic activities in a number of counties in Kenya. The majority of artisanal miners have abandoned other economic enterprises, such as agriculture, to improve their living standards. Given the ecological and socio-economic challenges that characterize the artisanal mining sector, several questions have been raised regarding its capacity to meet the miners' economic needs, such as food security. This study sought to establish the influence of ASM practices on food security in selected counties in Kenya. A participatory cross-sectional survey research design was employed in executing this study. The study was confined to the five selected counties (Migori, Kakamega, Kisii, Kajiado, and Kitui), where artisanal mining (ASM) activities occur. Both qualitative and quantitative data collection methods were utilized. Stakeholders of interest for purposes of this study included relevant county government departments, farmers, miners, and local leaders. Primary data was gathered through FGDs, KII, and the use of structured questionnaires. Indicators of food security were borrowed from various instruments such as SDGs, WHO, and WFO. Study findings revealed that the level of agricultural produce is quite low and barely meets the household's basic food requirements in ASM areas. Overall the study revealed that ASM activities lead to food insecurity within the mining households in the selected counties.*

Further, the study results indicated that underground mining results in a decrease in food security by 38% holding other factors constant, open surface mining practices leads to a decrease in food security by 48 percent holding other factors constant, placer mining practices result in a decrease in food security by 27.03 percent holding all other factors constant and solution mining activities result to a decrease in food security by 3.13 percent. The negative influence on food security by underground, open surface, and placer mining practices was found to be significant, resulting in lower incomes to support artisanal miners' socio-economic needs. Towards improving food security and income in ASM counties, the study recommends that the government and other sector players should embrace strategies such as agro-artisanal mining (AASM) policy, awareness programs on social evils of mining activities and health hazards associated with mining activities, and formalization of artisanal mining operations, regulation of marketing, pricing and mining processes.

Keywords *— Artisanal Mining, Food Security, Kenya.*

I. INTRODUCTION

A. Background of the Study

In most developing countries, artisanal mining remains a largely informal and unregulated activity [16]. As a result, artisanal miners rely largely on cheap, old-fashioned, and polluting technologies and chemicals, such as mercury [26]. This is injurious to community wellbeing, the environment, and possible negative consequences on food production and access (Hinton 2011:29). Given these concerns, Hentschel and Hruschka (2002) had pointed out that researchers had begun to examine the impact of artisanal and small-scale mining on food security. Artisanal or small-scale mining refers to mining by individuals, groups, families, or cooperatives with minimal or no mechanization, often in the informal (illegal) sector of the market [26].

ASM in sub-Saharan Africa is often believed to be a “rush-type” activity, characterized as chaotic and entrepreneurial-driven, where miners are “fortune-seekers” [15]. It is also often seen as a “distress-push” type of activity where miners are looking to alleviate their poverty and work in ASM to complement revenues from farming [15]. Thousands of local communities in sub-Sahara Africa depend on this labor-intensive, disorganized, and unlicensed mining practice to sustain their livelihoods. Though the informal nature and the whole un-mechanized operation generally result in low productivity, the sector represents an important livelihood and income source for the poverty affected the local population in the mining regions. It ensures the existence of millions of families in rural areas of sub-Saharan Africa. However, a large proportion of artisan miners are women and children who need to contribute to a sustainable livelihood. Their extensive involvement in informal mining operations affects other livelihood interventions where they hold key roles [17].

Even though ASM ensures the existence of millions of families in the rural areas, especially in the developing

world, it has been associated with environmental destruction, criminality, the unsustainable plundering of resources, destruction of private property, destruction of farmlands, child labor, the inter-communal conflicts, and general social degradation [17]. It has been hypothesized that communities characterized by these features are likely to experience food insecurity [15]. Food insecurity exists when all people have no or insufficient access to safe, nutritious food to maintain a healthy and active life [22]. Circumstantial evidence indicates that ASM activities around developing countries have impacted farm produce and supply. For example, low agricultural activities in Amansie West District and Kyebi in the Eastern Region in Ghana due to land degradation and pollution of water bodies as a result of placer mining [16], starvation of farming communities surrounding Nyamongo gold mine in Tarime district in Tanzania [13], low farm produce in small-scale mining areas of Katni and Chatanagpur in India [14], stalled agro-activities in mercury and gold mining areas of Mexico [5] and reduced food production operations in Manila mining areas of Philippines due to land degradation, pollution of water bodies, deforestation and shortage of active laborers [8]. Therefore, the study sets out to explore the implications of artisanal mining on food security in Kenya's selected counties. The aim is to propose best-practice strategies for sustainable exploitation and to highlight other necessary policy interventions to improve food security in the ASM-prone counties in Kenya.

B. Artisanal mining in Kenya

Kenya, famous for its natural beauty and wildlife, is a country that experiences limited commercial exploitation of its wealth in minerals. Historically the county had focused on developing farming, tourism, manufacturing, and service industries [3]. Until recent years, mining exports only amounted to around 1 percent of the GDP [3]. The country's mining industry is governed by the Mining Act, 2016 [7]. According to the Act, every mineral is the Republic of Kenya's property and is vested in the national government in trust for the people of Kenya (G0K, 2016). The Act provides prospecting, mining, processing, refining, treatment, transportation, and any dealings in minerals and related purposes (GoK, 2016).

Most of Kenya’s commercial mining and mineral processing operations are privately owned, including the diatomite, fluorspar, gemstone, salt, and soda ash mines; the lime plants; and the steel mills except for Numerical Machining Complex Ltd. All cement plants except for East Africa Portland Cement Company Ltd (EAPC) is privately owned [4]. However, the country has an undocumented number of artisanal miners mining gold, gemstones, copper, quarry, sand, and other minerals spread across the country and mostly in the rural areas where food production is expected to occur [22]. In Kenya, artisanal mining is defined as mining by individuals, groups, and families with minimal or no mechanization, often in the informal (illegal) sector of the market [22]. Some of the counties in Kenya where artisanal mining takes place are Kakamega County, Migori County, Homa Bay County, Kwale County, Machakos County, Kitui County, Kajiado County, and Kisii County [21], where underground mining and open surface mining are the dominant ASM practices (Arasa, Achuora & Okello, 2020).

ASM practices in Kenya are undertaken mainly by poor persons struggling to earn a living to support their basic needs. Further, the practices are characterized by environmental degradation, health risks, landscape interference, accidents, interfering with the quality of soil, water siltation, and surface topography [21]. However, since ASM does not operate within the formal setup and is not documented by the regulatory authority, it is hard to control or regulate with consequential impact on land, rivers, lake, ocean, vegetation, and air [2]. Hence there is a need to empirically establish its impact on general farming and, in particular, food production.

C. Food security in Kenya

Kenya has the largest, most diversified economy in East Africa, with agriculture being the backbone of the economy and central to its development strategy [22]. More than 75 percent of Kenyans make some part of their living in agriculture, and the sector accounts for more than a fourth of Kenya’s Gross Domestic Product (GDP) [1]. However, agricultural productivity has gradually stagnated in recent years, despite continued population growth. This has resulted in a gradual decline in food security nationally. However, the achievement of national food security is the key objective of the agricultural sector in line with the country’s Vision 2030 [1] and the government's Big Four Agendas [1].

Food security is defined as “ a situation in which all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life” [22]. In recent years, and especially starting from 2008, the country has been facing severe food security problems [6]. These are depicted by a high proportion of the population having no access to food in the right amounts and quality [22]. Official estimates indicate that over 10 million people in Kenya are food insecure, with most of them living on food relief [22]. The 2007 Economic Review of Agriculture indicates that 51 percent (%) of the Kenyan population lacks adequate food [22]. Food security is closely linked to poverty, which is estimated at 46 percent (%) nationally [22]. Moreover, only about 20 percent of the land is suitable for farming. In these areas, not all land is used for agricultural activities [4], raising doubt on the sector's ability to effectively contribute to the realization of Vision 30 goals and the government Big Four Agendas [20], [1].

D. Study Goals and Objectives

Starting in 2008, Kenya has been facing severe food security problems [6]. These are depicted by a high proportion of the population having no access to food in the right amounts and quality [22]. Official estimates

indicate that over 10 million people in Kenya are food insecure, with the majority of them living on food relief [22]. The 2007 Economic Review of Agriculture indicates that 51percent (%) of the Kenyan population lack access to adequate food [22]. Food security is closely linked to poverty, which is estimated at 46 % nationally [22]. Moreover, only about 20 percent of the land is suitable for farming. In these areas, not all land is used for agricultural activities, raising doubt on the sector's ability to effectively contribute to the realization of Vision 2030 goals [20] and the government's Big Four Agendas [1].

As a result, the country has tried a number of methods through policy interventions in an attempt to increase food production. Policies such as subsidy on farm inputs, especially fertilizers, through the involvement of the National Cereals and Produce Board (NCPB) in importing and distributing the inputs, improvement of research and extension services and improving their linkages, provision of rural credit for farming such as the Kilimo Biashara Initiative, development of rural agricultural markets and agri-business skills, allowing for imports of tax-free maize and ban on exports and providing farmers with planting materials and seeds with limited success [22] due corruption or and the inability to increase agricultural land size and participants in farm produce [4]. The situation is worsened in some Counties in Kenya, such as Kakamega, Migori, Homa Bay, Kwale, Machakos, Kitui, and Kisii, where artisanal mining takes place [2]. Further, Kenya is ranked among the countries most vulnerable to food insecurity caused by drought, climate change, and uncontrolled human activities cite the source of this.

Therefore, the main goal of this study was to contribute to the enhancement of food and nutrition security for all and, in particular, those in mining regions. Thus, the general research objective was to establish the effect of artisanal mining practices on food security in Kenya's selected counties. Specifically, the study sought to:

- Establish the effect of underground mining on food security
- Assess the influence of open surface (pit) mining on food security
- Evaluate the effect of placer mining on food security
- Determine the influence of solution mining on food security

E. Rationale and Scope of the Study

Food security issue within ASM communities in counties in Kenya requires exigent consideration in order to find practical, sustainable strategies which can guarantee an improvement in food production. Therefore, this study was necessitated by the need to develop mechanisms that could be used to address food insecurity in ASM-prone counties in Kenya. Food security is one of the goals of the Big4 agenda, the short-term socio-economic development program for the Jubilee government. The study was limited to the counties of Kakamega, Migori, Homa Bay, Kwale, Machakos, Kitui, and Kisii because they account for the bulk of ASM activities in Kenya. Miners, farmers, professionals, administrators, and county officials were interviewed. ASM practices such as underground mining, open surface mining, placer mining, and solution mining were considered.

II. THEORETICAL AND CONCEPTUAL FRAMEWORK

Reference [9] broadly defined artisanal or small-scale mining as mining by individuals, groups, families, or cooperatives with minimal or no mechanization, often in the informal (illegal) sector of the market. Reference [13] defined an artisanal miner or small-scale miner (ASM) as a subsistence miner who is not officially employed by a mining company but works independently, mining or panning for minerals using their resources. In Kenya, artisanal mining is defined as mining by individuals, groups, and families with minimal or no mechanization, often in the informal (illegal) sector of the market [22].

Empirical research into the impact of ASM mining on food security has produced mixed results [9]; [10]. Reference [15] content that mining affects farming in different ways, including loss of farmlands, competition for limited farm labor; increased the cost of other farm inputs, and environmental pollution, which adversely affect the quality of farming in the mining area; for example Reference [10] revealed that the Ahafo Mining Project of Newmont Ghana Gold Limited occupied 16 square kilometers which is currently just about 2.1% of the overall mining lease area of 774 square kilometers of land which resulted in the clearing of large tracks of land and forest for mineral extraction and is expected to continue for at least 30 years of the mine life [11]. Reference [18] established that mining activities such as underground mining, open surface, placer, and solution mining limit people from engaging in agricultural activities in a given community.

Reference [10] looked at the influence of surface mining on food production in the western region of Ghana. The study revealed that the practice leads to the reduction of farmland by converting the land into minor pits, mine waste dumps, settlement area, and roads" [17]. This indicates that mining practices modify the land use patterns in mining areas, which eventually limit farmers' ability to access farmland for farming purposes [12]. Reference [18] noted that since ASM projects are "located in rural areas where agriculture is the main economic activity, expansion in mining activities such as placer, open surface, and underground leads to increase pollution of air, water and land" that seriously affect farmers ability to produce- leading to significant impacts on yield reductions ranging from 30 to 60% depending on the type of crop [17]. A similar study by Reference [16] noted that small-scale mining activities destroy vast tracks of forest, which exposes fertile lands to erosion and other forms of degradations. Eventually, farmers lose their farmlands to these mining activities, which can hamper the development

of agriculture in the long run [16]. It is therefore hypothesized that as more and more households gain employment with the mines coupled with the continuing loss of farmlands to the mines, farming activities will reduce in the long run in communities located in mining areas.

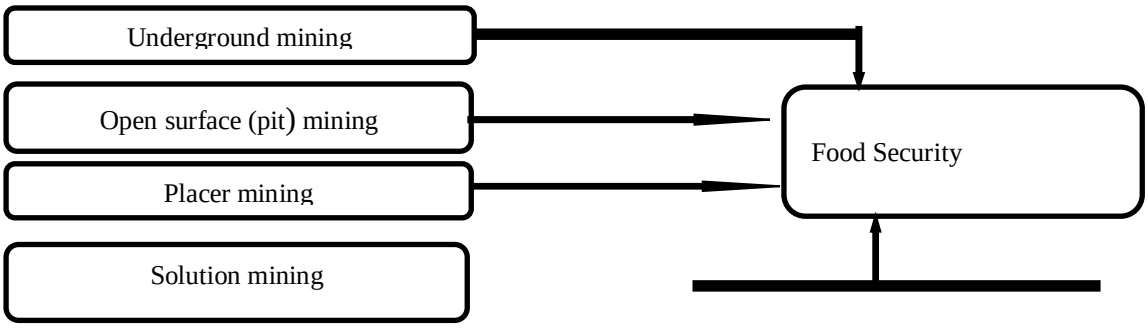

Fig. 1 Conceptual Framework

However, some studies contend that ASM mining activities play a crucial role in poverty alleviation and rural development; thus, rural people can regularly access food [16]. This is supported by Reference [15], who indicated that the livelihoods of mining communities in developing countries are "structured around an assortment of agrarian activities and complementary subsistence occupations" whose impact on the environment is negligible compared to mining operations. Reference [16] added that ASM practices diversify the local people's economy, which is often unsuccessful because of the lack of requisite capacity among the indigenous people to take advantage of the formal employment opportunities resulting from the mining operations. Despite this, Reference [16] noted that even though ASM practices do contribute tremendously to the economic gains of the indigenous communities involved, they cause serious environmental problems such as “land degradation, contamination, and chemical pollution. Due to this mixed contentions on the effect of ASM on food security, the subject is now on the agenda of many national governments, bilateral and multilateral donor organizations, and researchers [18]. This has led to a continuing discussion in the literature regarding whether ASM influences food security [17]. Therefore, this study set out to move this debate forward in the Kenyan context by providing empirical data from ASM communities in Kenya that can be used for an in-depth understanding of the topic. Based on the existing literature, the following hypotheses were tested as conceptualized in Figure1:

H01. Underground mining has no significant effect on food security.

H02. Open surface (pit) mining has no significant effect on food security.

H03. Placer mining has no significant effect on food security.

H04. Solution mining has no significant effect on food security.

III. RESEARCH PROCEDURE AND ACTIVITIES

A. Research Approach and Design

The study was executed through the involvement and participation of various stakeholders, namely administrators, farmers, miners, county officials, and community leaders. The approach has enabled the study to collect comprehensive and diverse data that was useful in addressing the study objectives. Further, a descriptive cross-sectional research design was employed in this study. This design was selected for the study because it allowed the study to observe the phenomenon in a completely natural and unchanged natural environment at appoint in time and afforded the study an opportunity to integrate the qualitative and quantitative methods of data collection [28].

The study used structured face interviews of both individuals and groups and focused group discussions on collecting qualitative data [29]. The collection of qualitative data in this study involved the collection of first-hand information through respondents’ own words and interpretation of the same [28]. Observation, individual, and group interviews were used to collect quantitative data. Therefore the study used both interview and observation as the main approaches to data collection. The two approaches offered the opportunity to appreciate the natural and unchanged environment of the phenomena under the study [29].

Further, the study used both methods, triangulation and sources triangulation, to check the consistency of findings. Under methods triangulation, different data collection methods (unstructured interviews, observation, discussions, questionnaires, and structured interviews) were used to check the consistency of the data. On the other hand, information was derived at different times and from different people for cross-checking of consistency of the data under sources triangulation [29]. The object of the

exercise was to attain the validity and reliability of the data in the study [28].

B. Study Area and Target Population

The study covered ASM-prone counties in Kenya, namely: Kajiado, Kitui, Migori, Kakamega, and Kisii. The target population of this study was farmers, miners in the respective study sites, staff from the selected counties, and opinion leaders in the selected counties where artisanal mining takes place. Various categories of the population were targeted in order to get in-depth information on the study subject.

C. Sample and Sampling Technique

Random and purposive sampling procedures were employed in selecting the target respondents. Purposive sampling was used to identify individuals and groups who were participants in ASM activities, who are farmers, opinion leaders, individuals or groups with knowledge of food security in the respective counties, or those with knowledge of land tenure in the respective study areas. Simple random sampling was used to select respondents from the clusters identified through purposive sampling. Sampling afforded the study with a reasonable number of respondents who were economical in terms of cost and time to study and at the same time were representative enough for generalization of the findings [28].

D. Pilot Testing of Research Instruments

The study pretested both the questionnaire and the interview guide on a small sample of five farmers, five miners from one county, two officials from one county government, two opinion leaders. This is in line with the recommendations by Reference [25], who noted that a small number as ten participants for pilot testing is adequate. The purpose of pre-testing was to ensure that items in the questionnaire and on the interview guide were stated clearly and held the same meaning to all participants. This provided a trial run for the data collection.

Further pre-testing acts as a check for the validity and reliability of the instruments. Validity can be viewed as an integrated evaluative judgment of the degree to which empirical evidence and theoretical rationales support the adequacy and appropriateness of inferences and actions based on modes of measurement [25]. It gives a measure of the degree to which an instrument measures what it claims to measure [28]. Adequate consultation amongst the expert evaluation team members was done to check on content, construct and face validity, among others in helping to examine the items in the questionnaires, interview guides, and document analysis guide to ascertain the adequacy and appropriateness of the items for the study. Further, this ensured that the items and questions were meaningful, clear, and precise.

E. Data Collection Method, instrument, and Procedure

A concurrent mixed-method data collection strategy was employed in this study. This approach helped validate the study data through the comparison of one form of data with the other form [29]. Therefore the study used questionnaires, interview guides for key informants interviews (KII), focus group discussions, and observations to collect both quantitative and qualitative data. The quantizing method was then applied to transform qualitative data into quantitative data to facilitate analysis and comparison of the data set [28].

The questionnaire was both structured and unstructured. Structured part aimed at standardizing information gathered for ease of comparison and analysis. The unstructured section allowed the respondents to air their in-depth thoughts about the study subject [29] freely. The questionnaire was self-administered by the research assistants who were pre-trained on data capturing and reporting. This method was selected for this study because a number of targeted respondents were semi-illiterate who required help; there was also the need to observe activities and conditions of the miners and farmers. Through help from local administrators, key informants were identified, organized, and appoint scheduled at their convenience for interviewing them. The same approach was used for focus group discussion.

F. Data Collection Method, instrument, and Procedure

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G. Pilot Data processing, analysis, and presentation

The survey responses were analyzed and reported using descriptive statistics (use of frequency, means, and standard deviation). Descriptive statistics provide simple summaries about the sample and the measures. Data processing entailed data cleaning, coding, definitions of variables, data entry, analyses, and interpretations, in that order. Data analysis and interpretation were done with the

aid of the STATA and MS Excel platforms. Structural Equation Modeling (SEM) was employed to aid in addressing the objectives and testing of the formulated hypotheses (mainly the effect of artisanal mining practices on food security within the selected counties). The structural Equation Model (SEM) technique is considered a very powerful multivariate method.

SEM makes use of a conceptual model, as well as a path diagram and system of connected regression-style equations to explore multifaceted and vibrant relationships within a network of observed and non-observed variables. Path diagrams are best placed to present SEM equations and output. Despite being comparable in appearance, SEM is fundamentally dissimilar from regression as it incorporates both structural endogenous and exogenous factors. This approach was desired for this study since the equations model both the causal relationships between dependent and explanatory factors, which are structural in nature and the causal links among endogenous factors without necessarily using averages, as is the case with regression.

IV. SEM RESULTS AND DISCUSSIONS

The study sought to establish the influence of ASM practices on food security in the selected counties in Kenya. Consequently, the following four specific objectives were formulated to guide the study: to establish the influences of underground mining, open surface mining, placer mining, and solution mining on food security. In order to address these objectives, the ensuing null hypotheses were developed and tested using Structural Equation Modeling (SEM):

HO1. Underground mining has no significant effect on food security

HO2. Open surface (pit) mining has no significant effect on food security

HO3. Placer mining has no significant effect on food security

HO4. Solution mining has no significant effect on food security

The SEM results from each hypothesis test are presented in Table 4.1 and are discussed in the section to follow:

A. HO1. Underground mining has no significant effect on food security

The test results established that underground mining activities lead to a decrease in food security by 38% holding other factors constant. The coefficient of underground mining (t value 2.52, p-value 0.012) was significant at 0.05 level and hence the hypothesis HO1. "Underground mining has no significant effect on food security" was rejected, as the study findings indicate the existence of a significant negative effect on food security by engaging in underground mining activities.

This result confirms revelations from FGDs and key informant interviews reports. For instance, FGDs and key informant interviews revealed that artisanal mining activities deplete the available arable land of its quality which is expected to trigger higher levels of productivity. Sculptures mining implies removing surface soil, thus affecting the level of yield from agricultural activities, taking away labor that could participate in fostering farming activities, and reducing the land available for farming.

Further, of the miners and small scale farmers who responded to the questionnaire interviews, 58.6 percent indicated that underground mining reduces the active labor force available for farming, 62 percent indicated that it causes pollution and changes topography, thus affecting farming activities, 55 percent indicated that it affects water resource for farming, 59 percent reported that it reduces the land available for farming, 61 percent reported that it affects the quality of soil for agricultural activities while 37 percent indicated that it leads to displacement or relocation of people. The responses imply that the labor force for farming and soil degradation were the two most affected by the practice of underground mining.

B. HO2. Open surface (pit) mining has no significant effect on food security

The SEM test results reveal that open surface mining practices course a decrease in food security by 48 percent, holding other factors constant. The coefficient of open surface mining (t-value 2.76, p-value 0.0021) was found to be statistically significant at 0.05 level. Hence the hypothesis HO2 "Open surface (pit) mining has no significant effect on food security" was rejected, as the study findings indicate the existence of a negative influence on food security by engaging in open surface mining activities.

This finding was supported by FGDs and key informant interviews responses/reports. Of the miners and farmers who responded to the questionnaire interviews, 76 percent indicated that open surface mining reduces the active labor force available for farming, 80 percent indicated that it causes pollution and changes topography, thus affecting farming activities, 62 percent indicated that it negatively affects water resource for farming, 77 percent revealed that it reduces the land available for farming, 75 percent reported that it affects the quality of soil for agricultural activities and 50 percent indicated that it leads to displacement or relocation of people. Environment (pollution, topography), labor available for farming, and soil quality for supporting agriculture were notably the areas that suffered most due to open surface mining activities.

C. HO3. Placer mining has no significant effect on food security

The study test results revealed that placer mining practices result in a decrease in food security by 27.03 percent, holding all other factors constant. The coefficient of placer mining (t-value 1.97, p-value 0.049) was found to

be statistically significant at 0.05 level. Hence the hypothesis HO3, "Placer mining has no significant effect on food security," was rejected, as the study findings reveal that engaging in placer mining activities leads to a decrease in food security.

Findings from FGDs and key informant interviews echoed the above SEM results. Further, of the miners and farmers who responded, 78 percent indicated that placer mining reduces the active labor force available for farming, 83 percent indicated that it causes pollution and changes topography, thus affecting farming activities, 64 percent indicated that it negatively affects water resource for farming, 50 percent revealed that it reduces the land available for farming, 55 percent reported that it affects the quality of soil for agricultural activities and 22 percent indicated that it leads to displacement or relocation of people. Hence the availability of labor and environment were the most hit areas as a result of engagement in placer mining activities.

D. HO4. Solution mining has no significant effect on food security

The SEM results from the hypothesis test showed that solution mining activities result in a decrease in food security by 3.13 percent. However, the solution mining coefficient (t-value 0.20, p-value 0.844) was found to be statistically not significant at 0.05 level. Hence the hypothesis HO4 "Solution mining has no significant effect on food security" was accepted. Yes, solution mining activities do influence food security status, but that influence is not significant.

Findings from the FGDs and key informant interviews supported the empirical statistical results that, indeed, solution mining does affect food security status in the respective areas. Of the miners and farmers who responded, 49 percent indicated that placer mining reduces the active labor force available for farming, 54 percent indicated that it affects the environment by causing pollution and changes topography, thus affecting farming activities, 36 percent indicated that it negatively affects water resource for farming, 35 percent revealed that it reduces the land available for farming while 36 percent reported that it affects the quality of soil for agricultural activities. However, interviewees indicated that solution mining activities are not popular within the areas selected for this study and, therefore, to a large extent, have no felt consequences on food security status.

The deterioration in food security as a result of the increase in underground mining, open surface mining, placer mining, and solution mining can be attributed to deterioration of the environment, diverting much of the labor available to ASM, and declining quality of soil as a result of the practices.

Table 1. Structural Equation Model (Dependent Variable: Food Security Status)

Structural equation model Number of Observation = 59 Estimation method = Maximum Likelihood(ML)			
Standardized Structural Model	Coefficient	t	P value
Underground Mining	-0.3800321	2.52	0.012
Open Surface Mining	-0.482351	2.76	0.0021
Placer Mining	-0.2703088	1.97	0.049
Solution Mining	-0.0313475	0.20	0.844

V. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

Artisanal mining has emerged as one of the popular economic activities that many rural people in developing countries are embracing with the expectation of improving their socio-economic status. This is specifically the case in ASM-prone counties in Kenya, where it is embraced as a substitute economic activity, chiefly as a means to address increasing poverty and livelihood concerns. However, the practice's perceived value is dwarfed by its negative impact on the environment and livelihood of persons involved, as evidenced by the study findings.

The findings of the study highlight a strong relationship between the ASM practices and food security (artisanal mining and food security). This was determined using a structural equation model at 95% confidence intervals; statistically significant test result ($P \leqslant 0.05$). This established that communities on mining sites have severe food security problems, as well as lower household incomes. Additionally, it was observed that the miners live in deplorable sanitary conditions and use toxic chemicals like mercury for the gold extraction process. Further, ecosystems and agricultural land, which should support their livelihoods, are severely degraded by ASM practices, which impairs food production activities.

Involvement of energetic youths and women in ASM activities, alterations of land use, widespread use of chemicals, and physical destruction of the land surface were found to affect the different levels of food production, availability, and access. As corroborated by other studies [16], [15], communities involved in ASM are bewildered with various challenges ranging from but not limited to poor access to financial services, lack of market information, pricing challenges, weak or non-existent government policies, segregation of certain demographic groups, persistent structural barriers like conflict over land-use and access, and technology, poor productivity, unsafe working conditions, uncontrolled migration, low entry barriers to illegal activities, environmental damage, child labor, lack of education and high transmission of communicable diseases.

B. Recommendation

Undisputable, the above-established challenges affect artisanal mining communities' livelihoods, poverty level, and food security situation in the selected counties in Kenya. Thus, this study put forth strategies aimed at mitigating the challenges to maximize the economic benefits of artisanal mining and improve miners' food security and livelihoods as follows:

a) Agro-artisanal mining (AASM) policy

Since communities in the selected counties view ASM practices as critical sources of their livelihood, the governments in both levels (county and national) should formulate a well-resourced policy that streamlines ASM activities and at the same time encourages participants to actively take part in agricultural activities as a way of supplementing and securing their mining earnings. The policy should focus on making the miners appreciate and reorganize the value of agro-activities in their lives and how significant it can augment their mining incomes. Within the policy, there should be incentives to incentivize artisanal miners to convert old minefields into farms (minefields reclamation) through provision of resources for reclamation, farm inputs, and training of miners on sustainable farming practices as a way of increasing the size of farmlands, arm the miners with right farming skills and resources thus boosting food production and addressing food insecurity

b) Creation of awareness among the miners on the social evils of mining activities and health hazards associated with mining activities

Advocacy programs should be developed and implemented by the county governments to expose the miners to the social dangers their families face as a result of mining activities within their communities and educate them on ways to mitigate the negative social impacts mining has on them. Further, public health awareness programs should be instituted to make the miners appreciate the health dangers they are exposed to as a result of participating in mining activities. These will enable miners to take personal responsibility for their actions towards the social health and physical health of their communities and may lead to environmentally and socially friendly actions by miners. Consequently, such actions may reduce the degradation of farmlands through miners' actions, thus improving the environment for farming activities.

c) Formalizing artisanal mining operations, regulation of marketing, pricing, and mining processes.

sBoth the national and county governments should work to create a framework for formalizing ASM activities through registration and recognition. These will enable the national government to develop some kind of affirmative action geared towards empowering miners, for example, special financing vehicles and provision of infrastructures.

Based on formalization and registration data, the county governments should organize miners into co-operatives to give them a voice to negotiate marketing and pricing terms for miners as a way of removing cartels from the minerals supply chain, thus improving miners' unit value of a given mineral. With improved unit value, the income of miners will improve, which in turn will improve food security as a result of better purchasing power.

Controlling mining processes will be easy when dealing with an organized group. The governments will be able to prescribe best mining practices that will be mindful of land degradation, water pollution, air pollution, and the social wellbeing of the mining communities. These will provide a supportive environment for farming activities which will go a long way to improve food security in the affected counties.

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