Impact of Surface Mining on Food Security in Amansie West and South Districts of Ghana

Godfred Owusu AMOAKO, Ghana
Emmanuel Offei AKROFI, Ghana

Keywords: Food security, Land use land cover changes, Landsat

SUMMARY

In mining communities in the developing world, agricultural livelihoods are gradually being lost in terms of labour and farmlands. The operations of the miners coincide with other land use activities and cause conflicts between people who also have an interest in the land. The aim of this research is to assess land use changes caused by surface mining in Amansie West and South Districts and the effects they have on food security. The integration of Remote Sensing and Geographic Information System (GIS) techniques were used to create a land use and land cover classification scheme to analyze the trend, rate, and extent of land use and land cover changes. A modified random sampling technique was employed for data collection. Statistical analysis revealed that there has been a decrease in vegetation lands and forest reserves, contrary to the mass increase in mining areas and a considerable increase in settlements and bare lands. Statistical analysis revealed that there has been a decrease of 11.67% in vegetation lands, and forest reserves have also decreased by 5.95% from 2007 to 2020. Contrary to that, mining areas and settlement/bare land increased by 12.12% and 5.51%, respectively. The research revealed that the people living in the mining communities encounter several difficulties, such as water pollution and land degradation caused by mining activities. Although productivity has not necessarily been affected, there are still concerns about food security in terms of utility and accessibility.

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1. INTRODUCTION

Food security exists when everyone has safe, nutritious and sufficient access to preferred food at all times without any physical, social or economic interference for a healthy life (Pinstrup-andersen, 2009). Availability, access, utilization and stability stand out as the major components of food security (Mbow et al, 2019).

The capacity of agriculture to hold on to the demands of the increasing population of the world continues to be at the top of the concerns of world leaders although the United Nations Millennium Development Goals in 2000 included the elimination of poverty and hunger as one of their objectives to be accomplished by 2015 (Rosegrant & Cline, 2003). Studies on food security over the years express a level of urgency regarding the capability of agricultural production to meet the demands of food around the world. Other studies rely on the new technologies and techniques implemented in farming to improve productivity and cater for the increasing population (Rosegrant & Cline, 2003).

Providing enough food for an increasing population while addressing poverty and hunger is a struggle for Africa's agriculture in the next generation (Garrity et al., 2010). Notwithstanding rapid globalization, the majority of developing nations' food security is dependent on domestic food production (Funk & Brown, 2009). Agriculture employs the majority of the rural population and the quantity of food produced is mostly consumed locally therefore, agricultural productivity locally is crucial for food security.

In Ghana, big farms and plantations mostly indulge in rubber, oil palm, and coconut plantation as well as rice, maize and pineapple to a limited proportion (Darfour & Rosentrater, 2016). According to (FAO & FAPDA, 2015; Funk & Brown, 2009) Ghana produces 51% of the cereals it consumes, 60% of fish consumed and 50% of meat. Small-scale farmers are predominant in Ghana's agricultural industry, which employs a greater percentage of the country's workforce. Food insecurity remains a problem for the agriculture industry because about 5% of Ghanaians are faced with food insecurity and an estimated two million people are likely to be faced with food insecurity.

Remote sensing and Geographical Information Systems (GIS) are utilized globally in observing and assessing the state of the environment associated with sustainable development and food security. FAO uses geospatial techniques to observe the changes in land, water and natural resources to support their assessment of food security (Thenkabail et al., 2009). Different ways to provide insight and understanding of food security have been explored using GIS and remote sensing tools. These tools are used in processes like examining the local food environment and assessing the changes in land use and land cover which make them important for ensuring the sustainability of the food supply.

Remote sensing and GIS have also been integrated into food security analysis such as mapping, modeling and predictions. Remote sensing and GIS were used for food security mapping in Gunungkidul Regency, Daerah Istimewa Yogyakarta (Murti, 2018). Remote sensing data and GIS were applied in spatial modeling for food vulnerability in Klungkung Regency, Bali (Ratnasari & Kusumawardani, 2015). Remote sensing has also been used as a tool to enhance food security in Anambra, Nigeria (EJikeme et al., 2017). This study is carried out to analyze the changes in land use and land cover in Amansie West and South districts and aims to assess the impact of mining on land use in the districts and investigate on impacts it has on food security.

2. MATERIALS AND METHODOLOGY

2.1 Study Area

The Amansie West and South districts were selected as the study area for their mineral deposits and are part of the districts that are highly engaged in both legal and illegal mining (Galemsey) operations in Ghana and they are also great contributors to Ghana's food basket. They lie within longitude 1º40'W - 2º20'W and latitude 6º41'N - 6º10'N. The districts cover an area of about 1231.9 square kilometers. With a considerably large proportion of its people in the rural area, agriculture has been their major source of livelihood. The area has a rainforest type of vegetation with fertile lands that are very recommendable for agricultural investments. Food crops such as maize, cassava, rice, yam, cocoyam and plantain are very common in the two districts. Again, the area is equipped with several natural resources including four forest reserves; Oda River Forest Reserve, Apanprama Forest Reserve, Jimira Forest Reserve and Gyeni River Forest Reserve. However, recent activities of Artisanal Small-Scale Mining (ASM) have taken a major hit at the agricultural dominance of the districts' economic sector. The large mineral deposits have subjected a percentage of people to engage in gold mining activities. Figure 1 below shows the position of the study area in Ghana.

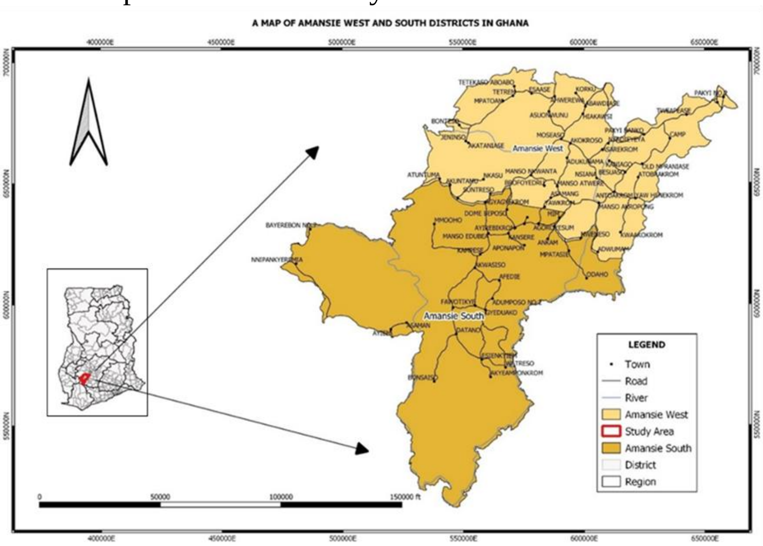


Figure 1. Map of Amansie West and South Districts in Ghana

2.2 Data Source

The study uses remotely sensed satellite image data and questionnaires to assess the effects of mining on food security within the Amansie West and South districts. Landsat images were used to assess the changes in land cover over the period of the study and the questionnaires were used to investigate the impact mining activities have had on the communities' agriculture and food security.

Landsat images of the study area were acquired from the United States Geological Survey achieves. For this research, the years downloaded were 2007, 2015, and 2020 and they were used to analyze the changes in land cover in the study area. Landsat was chosen based on the availability and the years needed for the research. Radiometric correction is done to correct or reduce the differences between the pixel values produced by the sensors and the spectral reflectance and radiation brightness of the object. The haze reduction and noise reduction tools were used on the images to clean the images for classification. The study area was clipped out of the land Landsat images and NDVI and LULC maps were generated out of the images. Table 1 below is a list of Landsat dataset sets used in this study.

Tabel 1. List of Landsat Dataset utilized for land cover change assessment

Date Acquired	Spacecraft	Sensor	Pixel Size
13/01/2007	Landsat 7	ETM+	30m
29/12/2015	Landsat 8	OLI	30m
09/01/2020	Landsat 8	OLI	30m

Interviews and questionnaires were administered at some selected mining communities in the study area. They were targeted at the inhabitants of the communities to gather their knowledge and to answer some specific questions regarding this research. The interviews were done to acquire knowledge of the land acquisition processes and how the mining firms acquired their land from the communities. The inhabitants also express their views on how mining activities are affecting food security in the communities through the questionnaire.

2.3 Image Processing and Classification

For a more accurate analysis of the changes, the Landsat multi-temporal image is pre-processed to remove the errors in the images and make them ready for classification. The types of corrections made are geometric corrections and radiometric corrections and they are caused by the sensors, the atmosphere and the earth's curvature. Pre-processing is carried out using QGIS version 3.10 for georeferencing and image clipping for the Area of Interest (AOI).

The study area was categorized into mining areas, settlement/ bare land, vegetation and forest with RStudio using the random forest classification package. The training data used for the classification was acquired from google earth and saved as a shapefile to perform a supervised classification. The classification was done for the years 2007, 2015 and 2020. The classification is used to analyze the changes that occurred within those periods.

The images were stacked and clipped to prepare the study area for classification. A visual inspection and classification were done using the rgdal package in RStudio. Following the completion of the image classification, the accuracy of the supervised classification was evaluated. The Confusion matrix which is one of the most common ways of expressing classification accuracy was used.

2.4 Accuracy Assessment

Accuracy assessments were performed on the Landsat images from 2007, 2015, and 2020 to verify the quality of information obtained from the data. If the data are to be used for change detection analysis, individual classification accuracy must be assessed (Behera et al., 2012). Kappa tests are used to evaluate classification accuracy because they can account for all elements in a confusion matrix, together with diagonal elements (Halmy et al., 2015). The Kappa test is a measure of the difference between a predetermined producer grading system and a user-assigned grading system.

2.5 Change Detection

Change detection requires correct and precise multi-temporal images because if pixels of the images are not assigned to their respective classes, a wrong classification is produced. Therefore, the validity of the analysis depends on how good the images are. Assigning the classes can only be done after the bands of the satellite images are stacked together as one image.

In IDRISI Selva environment v.17, the post-classification detection approach is used to identify LULC changes, which involves comparing two classified images to generate change information depending on the pixel. In other words, the interpretation of two images will come up with "-from, -to" information. Cross-tabulation is used to compare classified images from two different data sets to determine qualitative and quantitative aspects of change from 2007 to 2020. Mahmud & Achide (2012) used, a simple formula to calculate the extent of change and the rate of change:

$$K=F-I \quad (1)$$

$$A=((F-I))/I*100 \quad (2)$$

Where K = extent of change
A = rate of change
F = first data
I = second data

2.6 Questionnaire

For people who could read and write, they answered the questionnaires by themselves but the necessary guidance was given in case of any challenges or any misunderstanding. For the respondents who could not read and write, the questionnaires were self-administered by the researcher and a group of three field assistants who had been well briefed about the research

and the questionnaire. The purpose of the questionnaire was made open to the respondents and they were allowed to ask questions in case there were certain explanations to be made. The questionnaires were administered within four days.
The software used for the analysis of the questionnaire is IBM SPSS Statistics version 26. To analyze the severity of the food security, the respondents were asked to scale from 1 to 5 the impact of mining activities on the availability, access, utilization and stability of food. With 1 being the least and 5 being the highest, the respondents were tasked to evaluate the effects of surface mining on the four components of food security and their frequencies were calculated. The true value for each grade was calculated by multiplying the frequency of each grade under each component by the grade and the total grade for a component was calculated by adding the true values for each grade for that component. The total grade reflects the severity of the impact mining had on the components. The degree of damage is directly proportional to the total grade therefore the higher the total grade, the greater the impact.

3. RESULTS AND DISCUSSION

3.1 Land Use and Land Cover Changes

The changes in the land use and land cover classification maps for 2007, 2015 and 2020 are shown in figure 2 to figure 4 respectively. The respective change in land use for the different classes of Landsat images is presented in a histogram chart in figure 5. The analysis shows that Forest in the study area depleted from 13.1% of the cover in 2007 to 11.03% in 2015 and 13.07% in 2020. Vegetation land which had 83.68% of the total cover in 2007 also reduced to 76.12% by 2015 and 72.01% by 2020. The vegetation lost between 2007 and 2020 is 11.67% of the study area. The cover class that had a major increment was the mining areas. With only 0.95% of the land cover in 2007, the mining areas increase to 4.68% of the land cover by 2015 and 13.07% in 2020. There have also been changes in the settlement/bare land with 2.27% to 8.17% from 2007 to 2015 and 7.78% by 2020.
Overall, the mining areas and the settlement/bare land cover increased by 12.12% and 5.51% of the study area respectively from 2007 to 2020. The land cover which was affected most was the forest area with 45.42% of its cover in 2007 lost in 2020. For vegetation land, 16.21% of the land cover was lost between 2007 to 2020. Figure 6 show a summary of the temporal changes from 2007 to 2020 in the study area.

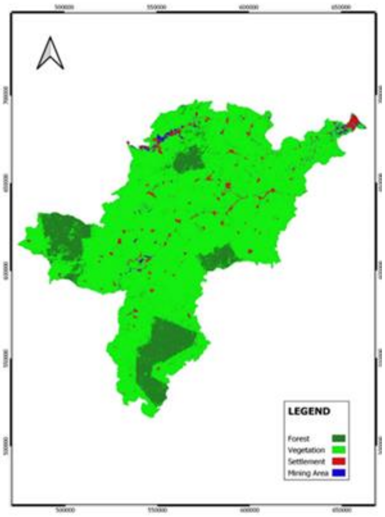


Figure 2. Land use land cover (LULC) map of Amansie West and South districts in 2007

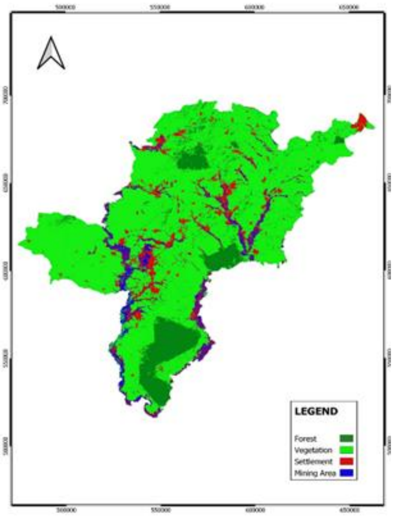


Figure 3. Land use land cover (LULC) map of Amansie West and South districts in 2015

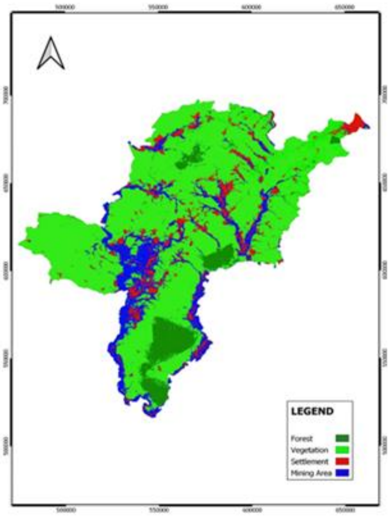


Figure 4. Land use land cover (LULC) map of Amansie West and South districts in 2020

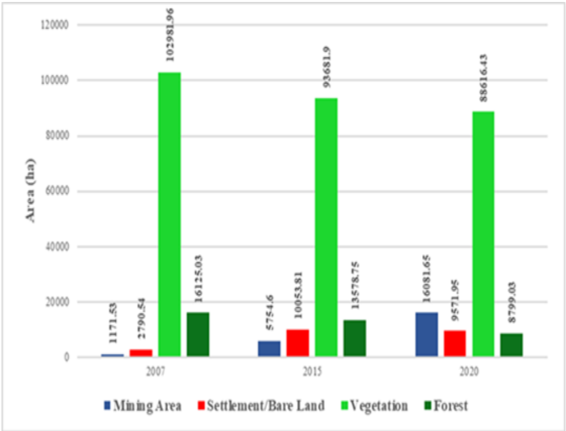


Figure 5. Histogram chart temporal changes of Amansie West and South districts for benchmark period 2007-2020

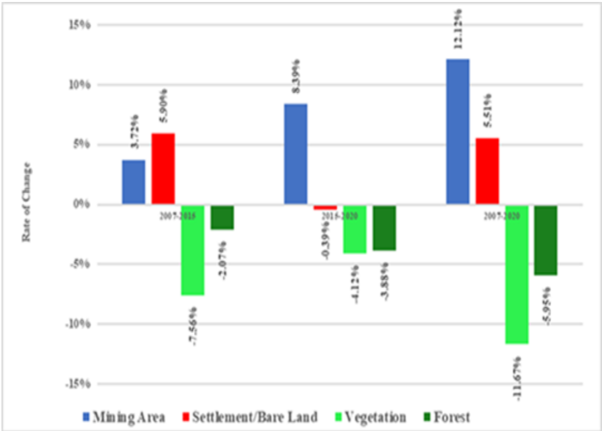


Figure 6. Bar chart of rate of change of area for the various LULC classes

3.2 Result on Accuracy Assessment

The supervised image classification method was used to extract thematic information on land covers from satellite images taken in 2007, 2015, and 2020, resulting in the creation of four (4) land use and cover classes. An important step in image classification is assessing the accuracy of the classified image. The accuracy of a thematic map created from a satellite image determines its quality. An accuracy assessment was performed after the classification and the overall accuracies obtained were 94.04%, 98.58% and 99.77% for 2007, 2015 and 2020 Landsat images respectively. Tables 2 to 4 represent the confusion matrix of the classifications. The

Kappa of the classifications were 90.66%, 97.59% and 99.46% for the 2007, 2015 and 2020 satellite images respectively.

Tabel 2. Accuracy assessment of the classification confusion matrix of the 2007 image classification

Class	Vegetation	Mining Area	Forest	Settlement	Total	Producer Accuracy	User Accuracy
Vegetation	2455	59	12	186	2712	90.5236	98.2
Mining Area	5	376	0	24	405	92.83951	81.03448
Forest	37	0	2423	0	2460	98.49593	99.50719
Settlement	3	29	0	395	427	92.50585	65.28926
Total	2500	464	2435	605	6004		
Error of Omission	1.8	18.96552	0.492813	34.71074			
Error of Commission	9.476401	7.160494	1.504065	7.494145			

Tabel 3. Accuracy assessment of the classification confusion matrix of the 2015 image classification

Class	Vegetation	Mining Area	Forest	Settlement	Total	Producer Accuracy	User Accuracy
Vegetation	2338	0	11	4	2353	99.36252	99.61653
Mining Area	0	211	0	3	214	98.59813	84.4
Forest	9	0	1779	0	1788	99.49664	99.38547
Settlement	0	39	0	246	285	86.31579	97.2332
Total	2347	250	1790	253	4640		
Error of Omission	0.383468	15.6	0.614525	2.766798			
Error of Commission	0.637484	1.401869	0.503356	13.68421			

Tabel 4. Accuracy assessment of the classification confusion matrix of the 2020 image classification

Class	Vegetation	Mining Area	Forest	Settlement	Total	Producer Accuracy	User Accuracy
Vegetation	3868	0	8	0	3876	99.7936	99.89669
Mining Area	0	192	0	0	192	100	100
Forest	4	0	714	0	718	99.4429	98.89197
Settlement	0	0	0	459	459	100	100
Total	3872	192	722	459	5245		
Error of Omission	0.103306	0	1.108033	0			
Error of Commission	0.206398	0	0.557103	0			

3.3 Change Detection

The changes in the land use land cover for the districts were done by overlaying the class cover of the corresponding years. For the location of the changes, much emphasis was placed on the mining area. Figure 7 shows the difference in land cover for mining for 2007 and 2015 and it shows the extensive spread of mining over the period. The path of the mining activities is along with the river bodies. For the period between 2015 and 2020, figure 8 shows the mining activities continue to spread and the overlay continues to show the expansion of the mining areas. There is a drastic increase in mining activities by widening their coverage in 2020 as compared to 2015. Overall, Figure 9 shows the changes the mining activities have brought to the Amansie West and South district over the period of this study and it is overwhelming.

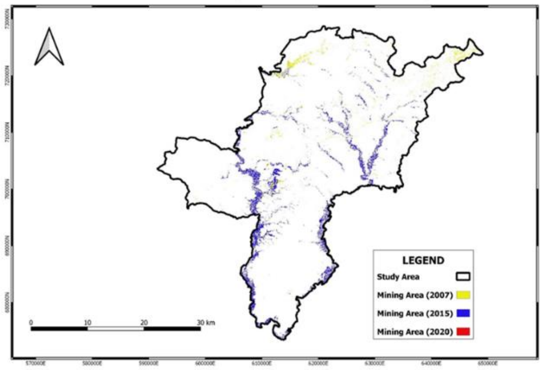
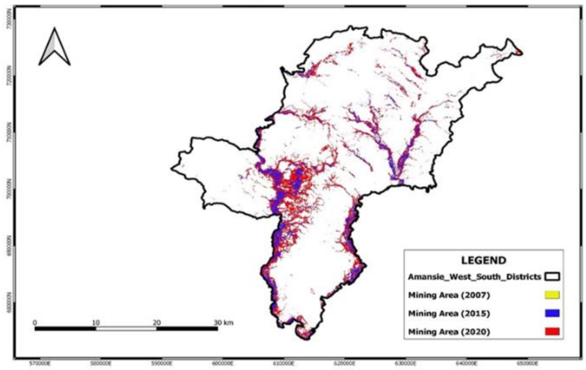


Figure 7. Derivative from the overlay of 2007 and 2015 land use and cover map



Figur 8. Derivative from the overlay of 2015 and 2020 land use and cover map

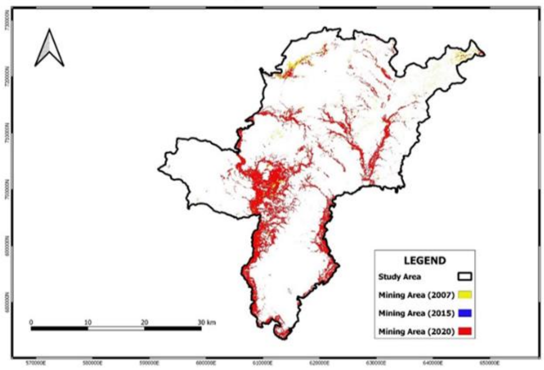


Figure 9. Derivative from the overlay of 2007 and 2020 land use and cover map

3.4 Effects of Surface Mining on Crop Production

Mining sites are typically cleared of their vegetation before all mining activities commence. Surface miners use procedures that include clearing vast areas of forest cover and vegetation, rendering the soil vulnerable to erosion agents. In the eight communities assessed for this study,

the scenario described above was no different. The practices of these miners within the villages have resulted in the loss of the communities' once dense vegetation cover to less dense vegetation. A number of farmers have lost their farms at the expense of increasing mining operations. Deforestation is also severe in the study area it is partly caused by farmers who are displaced by the miners and have to re-establish their farms.
According to the data from the Ministry of Food and Agriculture, productivity has been on a decline (contrary to the average rate of annual population growth which has been 2.2% since 2010) until the implementation of the Planting for Food and Jobs (PFJ) in 2017. The new technologies implemented in agriculture have had a great influence on productivity.

3.5 Effects of Surface Mining on Food Security

Until now the arrival of mining in the Amansie West and Souths districts, farming had been the prime source of living in the districts. Currently, a large percentage of its arable lands are being converted to mining areas and a high number of its population are diverting to mining for a living. The communities relied highly on waters from the streams and the rivers for both farming and domestic purposes. However, based on earlier analysis of the questionnaire and the observations of the researcher shows that these sources of water can no longer be depended on. The water bodies are contaminated in the process of washing the mineral-laden soil. The heavy machinery of the miners uses the same roads as the farmers and other members of the communities. This situation has left most roads in the districts in a very bad state even to the extent of some not being pliable by regular vehicles. Additionally, the cost of living is on the rise since the advent of mining companies. From the questionnaire, the majority of the people spend more than 30 percent of their income on food.
Food utilization is the most affected component followed by access, availability and stability in that order. Despite this, the closeness of the final grades scored by each component revealed that surface mining operations had a significant impact on all four components, with only minor variances among them. From the results, the most affected component of food security, utilization had a total grade of 557 followed by access with 495 total grades. Availability and stability followed respectively with 378 and 328 as their total grades. Table 5 below shows the extent to which surface mining operations have impacted the availability, access, utility and stability of food in the districts.
This can be justified by looking at some activities of the mining companies such as the use of toxic minerals in their operations and the use of heavy machinery. In terms of food utilization, chemicals with toxic materials like mercury used contaminate both the land and the water bodies. In Ghana, the use of liquid mercury in small-scale mining continues to destroy the quality of water bodies (Tschakert and Singha, 2007). When mercury is employed in the extraction process, it creates an amalgam and transforms into a stable methyl-mercury molecule, which is harmful to the human body and the environment when consumed, breathed, or absorbed by fauna and flora (Hilson, 2001).

Table 5. Response on the level of impact on food security

Grade	**1**	**2**	**3**	**4**	**5**	**Total Grade**
Availability	28	46	54	19	4	378
Utility	3	19	35	59	35	557
Access	5	30	53	44	19	495
Stability	45	55	36	12	3	326

4. CONCLUSION AND RECOMMENDATION

4.1 Impact of Mining on Land Use

A land use and land cover classification map that included settlement/ bare land, forest, vegetation and mining areas were created. Distribution of the land cover classes was done with GIS and remote sensing techniques. Mining operations are spreading at a fast rate, covering 13.07% of the study area in 2020 as compared to 0.95% in 2007. The classification shows that mining areas continue to increase with a sharp contrast with forest and vegetation. Reclamation of land after mining has been ignored therefore areas that are no longer mined are still bare and cannot be used for other purposes.

4.2 Impact of Mining on Food Security

There has been a depletion of vegetation and top fertile soil in the Amansie West and South districts by mining activities. According to the data submitted and analyzed in the previous chapters, certain components of food security were affected more than others. Availability is not a major concern currently since the implementation of the "Planting for Food and Jobs" in the country by the government. There has been a tremendous increase in productivity for some major crops like maize, rice and plantain in the districts for the past two years. Although some farmers have lost their farms to the miners, farmers also seem to extend their farms into other land covers. This is why croplands are still increasing even though farms are been lost. Food Stability also was not much of a concern for the people because productivity is on the rise during the period of the study and food is readily available on the market.

The components of food security that are concerns of the communities are utilization and access. The aftermath of the mining activities is a great worry for the population because of the current state of the once potable. People of the community can no longer depend on their rivers and streams as their source of water. These same land and water bodies which has been contaminated by mining activities are water the farmers depend on for their work. The advent of mining in the communities has also raised the cost of living in the communities.

Following a thorough assessment of illegal mining activities in the Amansie West and South Districts, the researcher concluded that mining is a source of income for people living in mining communities. Nevertheless, unregulated mining activities are unsustainable and unwelcoming to the communities and have caused environmental pollution in mining areas for them to compete with. Hence, although mining is not a forbidden act, the point to consider here is if an ounce of gold is more valuable than the lives of the people in the communities, the acres of forest being lost, the vegetation and the land. Mining cannot be discarded but the answer here depends on the provision of efficient operations and guidelines, implementation of new technologies and developmental policies that involve the traditional leaders by the government to minimize the adverse environmental impact of surface mining to create an avenue for jobs, investment to strengthen these communities and the environmental development goals as a nation. The research recommends a land reclamation exercise to cure the lands left bare by the mining activities and research the quality of underground water in the mining communities as an alternative source of water for living.

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BIOGRAPHICAL NOTES

Godfred Owusu Amoako is a graduate student at the Department of Geomatic Engineering, KNUST. He holds masters degree in Geomatic Engineering from KNUST, Kumasi, Ghana. He has years of experience in the field GIS and Remote Sensing application for natural resources management.

CONTACTS

Godfred Owusu Amoako
Kwame Nkrumah University of Science and Technology
PMB
Kumasi
Ghana
+233 24 465 0154
nanayawgodfred@gmail.com