Final Project Report (to be submitted by 30th September 2016)

Instructions:

- Document length: maximum 10 pages, excluding this cover page and the last page on project tags.
- Start with an abstract (max 1 page).
- Final report text: Do not forget to mention your methodology; the people involved (who, how many, what organization they are from – if applicable); and the expected added value for biodiversity, society and the company. Finally, state whether the results of your project can be implemented at a later stage, and please mention the ideal timing and estimated costs of implementation.
- Annexes are allowed but will not be taken into account by the jury and must be sent separately.
- Word/PDF Final Report files must be less than 10 MB.
- If you choose to submit your final report in your local language, you are required to also upload your final report in English if you wish to take part in the international competition.
- To be validated, your file must be uploaded to the Quarry Life Award website before **30th September 2016** (midnight, Central European Time). To do so, please log in, click on 'My account'/ 'My Final report'.
- In case of questions, please liaise with your national coordinator.

1. Contestant profile

Contestant name:	**Masen Kafui Koranteng**
Contestant occupation:	Student
University / Organisation	University of Ghana, Legon
E-mail:	
Phone (incl. country code):	
Number of people in your team:	**Two**

2. Project overview

Title:	GEOSPATIAL ASSESSMENT OF BIODIVERSITY CHANGES AROUND THE YONGWA QUARRY
Contest:	GHANA
Quarry name:	YONGWA QUARRY
Prize category: (select all appropriate)	☐Education and Raising Awareness ☒Habitat and Species Research ☒Biodiversity Management ☐Student Project ☒Beyond Quarry Borders

ABSTRACT

West African Quarries Limited operates a quarry located at Odublasi in the Eastern Region of Ghana. The quarry produces limestone for the production of cement products by Ghacem Limited. Quarry activities are perceived to cause disturbances to biodiversity, irrespective of socio-economic and infrastructural developments that are associated with it. This study examined drivers of biodiversity change around the Yongwa quarry, analysed trends of the change, and areas around the quarry prone to these drivers. Stakeholder engagements were used to identify drivers of biodiversity change. Satellite imagery of the area from 2007, 2012, 2013, and 2014 was used in the trend analysis. Field mapping of trees in the area was undertaken to provide baseline data for use by West African Quarries Limited in future biodiversity studies/restoration projects. Identified drivers were; the construction of a new access road; switch in livelihoods of local community members to those that depend on extracting biological resources; unsustainable farming and wood logging practices; social exclusion; afforestation programme around the quarry. The trend in biodiversity change was identified to be irregular with time and in space. Shifting cultivation farming was a key driver to this trend. Habitats along the access road to the quarry were identified to be vulnerable to drivers of biodiversity change and need critical attention in any biodiversity restoration efforts. The approach adopted in the study can be used as an environmental monitoring tool by the company, to observe disturbances to biodiversity around the quarry, or the effectiveness of any biodiversity restoration programme carried out around the quarry.

INTRODUCTION AND BACKGROUND

Mining in any community may improve economic activity in that community. Ghana benefits from mining; development of water and electricity supply, road network expansion, schools and hospitals, direct and indirect employment avenues. An estimate of 5% of Ghana's GDP is accounted for by the mining sector (Ghana Chamber of Mines, 2014). Undesirable consequences of mining on the environment, however, remain a challenge.

The biological diversity of areas around mining sites has been documented to change due to exploratory, operational and closure activities at the mine (Kujala et al., 2015; Sonter et al., 2014; Antwi, 2009). Operational activities, for example, can generate dust and other atmospheric particles/gasses, and noise pollution (above 70 dB according to the laws of Ghana). These impact many plants and animal species, negatively affecting their population and distribution in and around the mine.

Preoperational mine activities, such as the construction of access roads and development of the mining site, are known to contribute to the reduction in biodiversity in these areas of interest. Changes in biodiversity, in this case, is initiated when fragmentation of habitats in the area occurs. Fragmented habitats gradually begin to lose their species and structural similarity with adjacent habitats. The fragmentation also inhibits the easy movement of species across habitats. This creates a condition where habitats are most susceptible to dwindling in species diversity and geographical size (Sonter et al, 2014; Lindenmayer & Fischer, 2013). Meanwhile, higher levels of biodiversity enhance the resilience of a habitat, as respective distinct species are better able to withstand impacts (Dyke, 2016).

Mining may also catalyze the degradation of the environment indirectly. The establishment of access roads to a mine site make it easier to access hitherto, inaccessible areas. This leads to extraction of biological resources available there. Depending on the culture and practices of the surrounding community, extraction may be potentially unsustainable to the biodiversity of the area (eg. Negative farming practices or excessive animal hunting) (Naeem & Bunker, 2009; Kitula, 2006).

PROBLEM STATEMENT

Some mining companies endeavor to practice sustainable mining. Critical to achieving this, is rigorously monitoring environmental changes that may be occurring in and around the mine. Studying land cover changes help in undertaking spatial planning to restore the damaged ecosystem/s to their original state (Antwi, 2009). Undertaking this spatial planning requires proper understanding of prevailing environmental conditions/processes and socio-economic factors, which in most cases are very complex in nature (Szaro & Johnston, 1996).

West African Quarries Limited has operated the Yongwa quarry for more than a decade. The quarry is approaching its closure stage and plans to remediate disturbances to biodiversity are being made. The planning stage would require critical information on drivers of biodiversity change in the area. This is to ensure that positive contributory factors to biodiversity are enhanced while negative contributory factors are minimised.

With the use of Geospatial technologies, changes that may have occurred in the environment can be identified. Identifying the kind of land-cover and vegetation changes that have occurred in the past, could assist in understanding the trend of change in biodiversity of an area, subsequently assisting in predicting habitats that are/or will become most vulnerable to changes in the future (Antwi, 2009). In principle, it is possible to identify critically sensitive areas around a mining site, that may require substantial planning and efforts in sustainably managing its biodiversity pre/post the closure of the mine, using GIS mapping.

RESEARCH AIMS AND OBJECTIVES

The aim of the project was understanding changes in biodiversity that may have occurred around the Yongwa quarry site. Specific objectives for the project were:

- To identify drivers of biodiversity change of the study area.
- To identify the trend in biodiversity change using satellite imagery of the area.
- To identify vegetation (trees) that are locally abundant or depleted around the Yongwa Quarry.
- To identify vulnerable habitats in the study area based on their level of exploitation.

METHODOLOGY

Description of the study area:

The project site is located at Odublasi which is in the Yilo Krobo District of the Eastern Region of Ghana (Appendix 1: Figure 7). The Yilo Krobo District lies within the semi-deciduous forest zone of the country. Parts of the municipality are within the dry semi-deciduous zone (fire zone). Tree types that are widespread in the District include *Elaeis guineensis, Mangifera indica, Azadirachta indica, Ceiba pentandra and Acacia auriculiformis*. The area experiences a substantial amount of precipitation during a bi-modal rainy season in May - June and September – October. Temperature ranges 24.9°C to 29.9°C (GSS, 2014). The Land rises from a height of about 100m in the Southeast to over 600m above sea level on the ridge in the West.

The main occupation in the district is agriculture (57.3% of households) and rises to 72.2% in rural areas (GSS, 2014).

The study site covers approximately 5 km2 with the geographical midpoint (6°11’43.36” N, 0°04’30.31” W) as seen in Figure 8. The study area encompasses a quarry owned by West African Quarries Limited. The quarry supplies limestone to Ghacem Ltd in the production of their cement products. The quarry covers approximately 0.85 km2 of the study area, while the remaining portions of the study area consist of patches of forest, farms, bare land, grassland and small human settlements.

Site Survey and literature review:

Various literature materials (Kujala et al., 2015; Lindenmayer & Fischer, 2013;Kitula, 2006; Naeem & Bunker, 2009; Szaro & Johnston, 1996) were reviewed to seek out information that was applicable to our research site and methods. In addition, previous Quarry Life Award research reports, Environmental Impact reports, population and housing census reports, and academic research reports were reviewed. A reconnaissance exercise was subsequently undertaken at the site.

Satellite Image Acquisition:

After the site reconnaissance, four satellite images of the study area were acquired from Airbus Defense and Space. This was conditioned by financial constraints and availability of reliable satellite imagery (imagery with little cloud cover) of the study area.The images were 2007 (Spot 5), 2012 (Spot 5), 2013 (Pléiades) and 2014 (Pléiades). Further details of the images are found in Appendix 2.

Image processing and analysis:

All image processing and analysis were conducted using the software ArcGIS 10.1 and ENVI 5.0. All four images were first enhanced (using the Interactive stretching tool in ENVI 5.0). A subset (5km2 area) was extracted from each image (using the Region of Interest tool in ENVI 5.0) based on observations from field reconnaissance exercise. 2013 and 2014 images were resampled (using the Layer Stacking tool in ENVI 5.0) to have the same resolution as 2007 and 2012 (10m resolution). An unsupervised classification of the images (using an algorithm called Iterative Self-Organising Data Analysis Technique in ENVI 5.0) was undertaken to identify the various land cover types. High-resolution images from 2013 and 2014 were geo-linked (using the Geographic-Link option in ENVI 5.0) and attention was given to areas where clusters of forest trees and shrubs were found. These clusters were marked out with a red boundary line in 2014 images and blue boundary line in 2013 images. A graphical illustration of the quarry area was generated using data from the mapping exercise (trees) and classified images. The image was first digitised to create a shape file (using ArcMap in ArcGIS 10.1).The shapefile was then exported to ArcScene to develop the illustration.

Vegetation identification and mapping:

Two field visits were made to identify and map the different kinds of tree species that were found at the site, and to verify the results of the classification exercise undertaken with the satellite images. The geographical coordinates of identified tree species were recorded using a GPS device (Garmin Dakota 20) according to the UTM 30N coordinate system. The time of encounter of tree species was also recorded.

Stakeholder engagement and education:

Various stakeholders were engaged in this project at different levels to help achieve the aim of this project. These included; academia, municipal and traditional authority, management of the quarry and local community members. See Appendix 4 for further details.

Stakeholders from academia were engaged in an effort to discover similar studies being carried out in Ghana and the impact this research could potentially make. They pointed out how important the study could be for the community and country going into the future.

Stakeholders in the management category included the Management of the Yongwa quarry. This engagement enlightened us on how the quarry had impacted the environment, especially biodiversity, and how new approaches were constantly being explored to minimize and control such undesired impacts.

Farmers and wood loggers in the area were equally engaged. They admitted their activities contribute to the loss of biodiversity in the area.

Municipal and traditional authorities of the area were also engaged. Traditional authorities shared their indigenous knowledge of the biodiversity of the area and the changes they had observed over the years. An educational discussion with students of the Asesewa Senior High School was organised to discuss various issues on the concept of biological diversity, the types of biodiversity and the essence of conserving biodiversity.

RESULTS

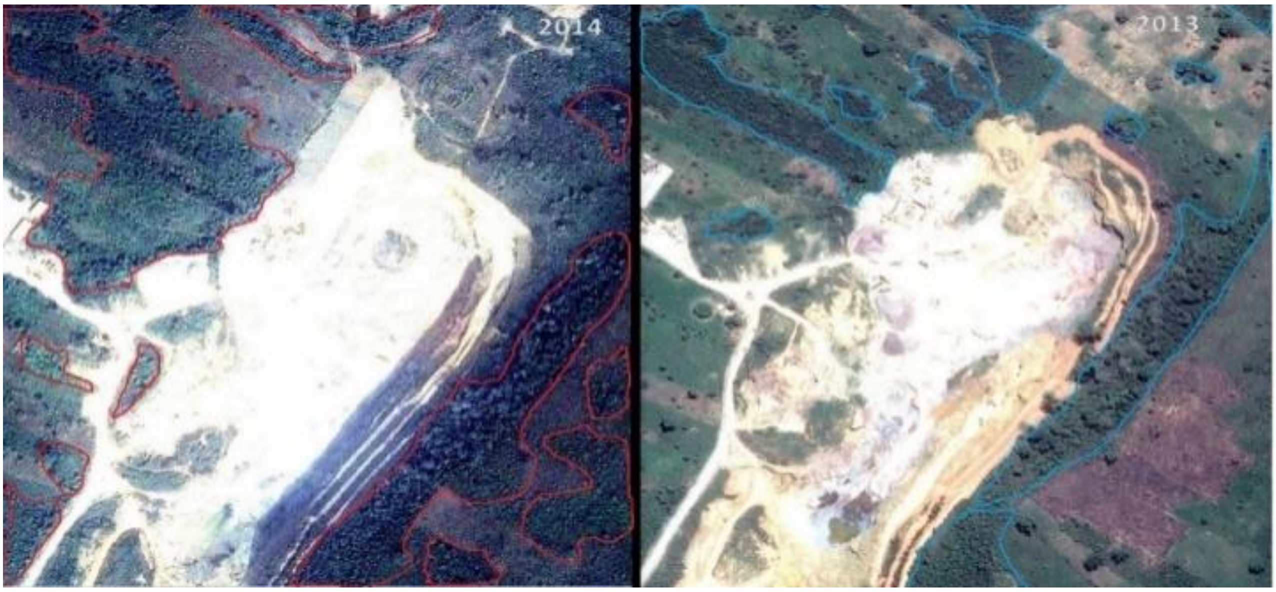

Figure 1: Aerial view of the North Eastern boundary of the quarry in 2014 and 2013

Figure 2: Aerial view of the South Eastern boundary of the quarry in 2014 and 2013

Figure 3: Aerial view of the South Western boundary of the quarry in 2014 and 2013

Figure 4: Aerial view of the North Western boundary of the quarry in 2014 and 2013

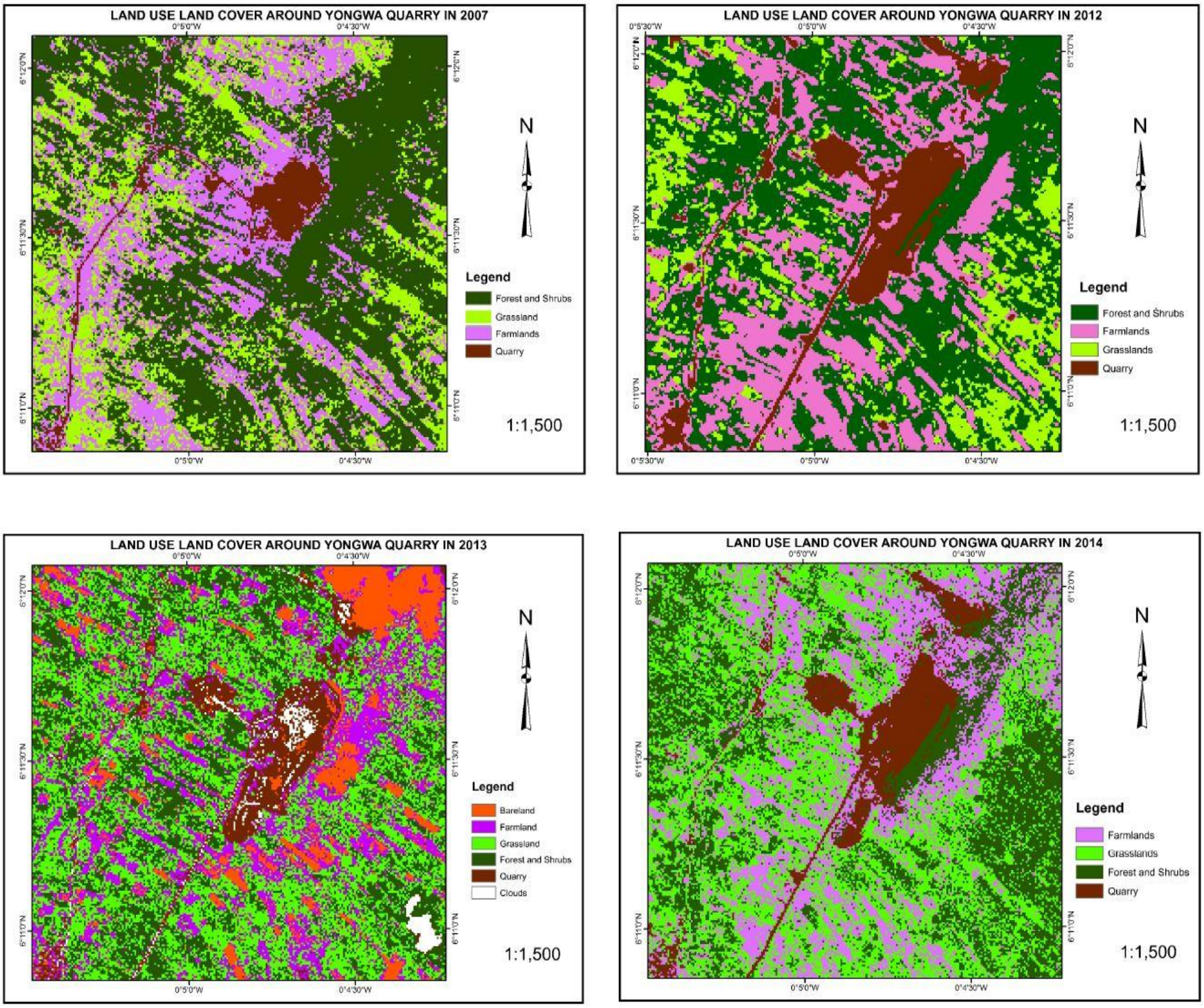

Figure 5: Classified satellite images of the Yongwa quarry area in 2007, 2012 2013 and 2014.

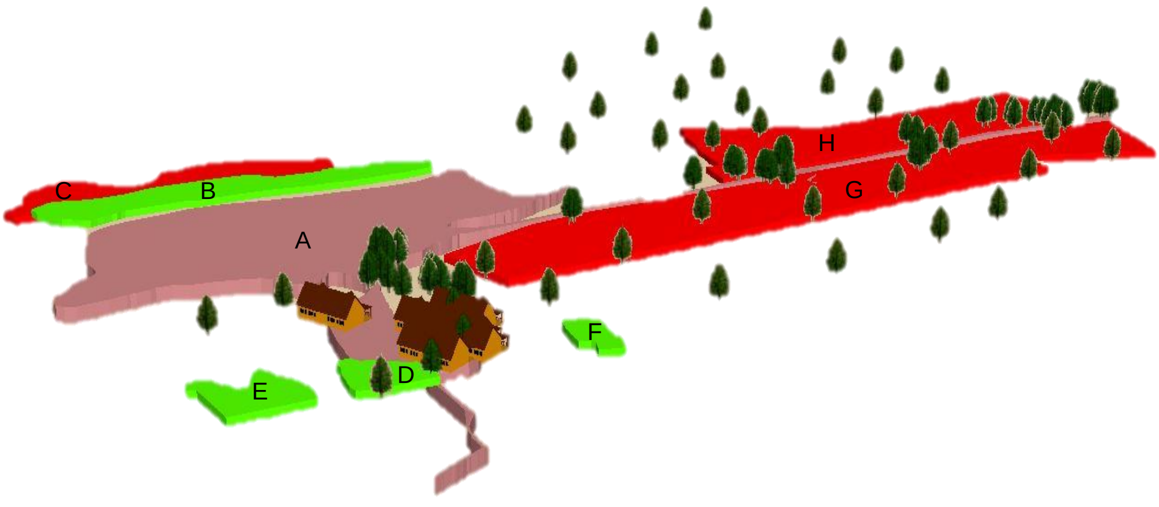

Figure 6: Graphical illustration showing vulnerable habitats around Yongwa quarry

DISCUSSION

In Figure 5, it shows that the quarry expanded in size from 2007 to 2014. In 2012 an additional access road was constructed to connect the southern border of the quarry to the main road. It is noted that farms have been sited along the two access roads, especially in 2012. The roads may have created easy access for locals to exploit hitherto inaccessible forested areas. Field observations showed farmers in the area often employ unsustainable farming practices like slash and burn, clearing out forest trees and heavy application of pesticides. These negatively impacted on biodiversity in the area; the level of diverse lifeforms in the area declines. Negative implications of road constructions on forest ecosystems are cited in literature on a number of occasions (Sonter et al, 2014; Lindenmayer & Fischer, 2013).

Engagement with Chiefs, elders and surrounding community members revealed the community's involvement and contribution in modifying the biodiversity of the area. In a narration by a Chief, community members primarily occupied themselves with small scale stone quarrying decades ago, to supply the local construction industry with flooring material (Terrazzo). The acquisition of the quarry site by Ghacem inevitably meant the majority of the community members lost their livelihoods in stone quarrying. Alternatives such as farming, hunting of game, wood logging and charcoal making became new sources of livelihood for the affected people. These alternative livelihoods, however, are considered as strong drivers of biodiversity change in forested areas (Norrisa, et al., 2010; Gyasi, et al., 1995). Generally, these modifications have been reported to be negative impacts on biodiversity (Phalan, et al., 2011). This was confirmed by the unsustainable farming practices witnessed in the area during field visits, with little consideration for Agri-silviculture for example. In addition, wood logging was observed in the area and is partly used for charcoal and construction, among other things. Debatably, the switch in livelihoods has led to the degradation of the forest in the community and around the quarry, and the biodiversity of the area in general.

Aquatic ecosystems are absent around the Yongwa quarry site; the biodiversity around the quarry is terrestrial in nature. Factors that positively contribute to biologically diverse terrestrial ecosystems are climate and soil conditions (Stuart et al, 2011). These conditions result in primary succession and an eventual boom in vegetation species (grass, herbs, shrubs and trees). Other organisms (insects, reptiles, birds and mammals) may be attracted to the area to seek food, shelter, and security. Microbes could then become common as they degrade and decompose dead organisms within that environment. An ecosystem of producers (plants), consumers (animals) and decomposers (fungus, bacteria) is thus created. It may be implied to a reasonable extent that, a vegetated terrestrial environment has a more biologically diverse community than one with little vegetation (Cardinale et al, 2011). It is imperative to indicate that, an area with more variety of habitats (in the case of this project, distinct habitats may be considered as forests, grassland, farmland and bare land) may hold more biodiversity potential than one with little (McGrady-Steed et al, 1997). Naeem and Bunker (2009), also pointed out that landscapes with a large number of small patches and fragmentation in space and time, are prone to intense variations in species diversity in time. This according to them was caused by consistent extinction and colonization within the fragmented patches.

Bearing in mind these emphasis stated above, highly vegetated areas around the quarry were highlighted in aerial photographs taken in 2013 and 2014 as seen in Figures 1- 4. It is realized that larger forest patches existed around the quarry in 2014 than in 2013. This possibly is an indication that the diversity of organisms found around the quarry was higher in 2014 than in 2013. This prompted further investigation into the contributory drivers to the phenomena. Engagement with various stakeholders (quarry management, community Chiefs and elders, local farmers and wood loggers) revealed two contributory drivers: (i) The management of the Yongwa quarry implemented a tree planting exercise in 2013, around the quarry, to beef up the tree population in the area. (ii)

Crop yields were becoming un-encouraging from continuous farming in the area, and some farmers shifted to other areas further away from the quarry site to farm. As indicated by Naeem & Bunker (2009) and Kitula (2006), quarries impact negatively on biodiversity around them, however, delibrate efforts by the quarry management seemed to be mitigating the disturbances to biodiversity around the quarry.

Figure 6 highlights an area in green (B) which is reasonably inaccessible due to its height above ground and sloping nature. Most people will consider it rather dangerous to venture into those parts around the quarry. Per this observation, it is expected that plant diversity in the area could remain high and fairly constant over a longer period of time, due to little or moderate anthropogenic interference. The vegetation may eventually attract animals to it occasionally, but its proximity to the quarry could cause consistent fleeing of animals from it, especially during rock blasting episodes and the generation of loud noise by rock crushing machinery. Areas D, E and F in Figure 6, were all observed to remain fairly constant in all the satellite images, with a little modification made to the vegetation in those areas. Area C, G, and H were identified to have experienced consistent modifications to their vegetation over time.

Comparing information found in Environmental Impact reports and Municipal/District survey reports,to our field survey exercise, we realised all locally widespread tree species in the area (*Elaeis guineensis*, *Mangifera indica*, *Azadirachta indica*, *Ceiba pentandra* and *Acacia auriculiformis*) were still found around the quarry in appreciable numbers. The most abundant tree species found around the quarry site was *Acacia auriculiformis*.

CONCLUSION AND RECOMMENDATIONS

In conclusion, drivers that have contributed to the modification of biodiversity around the Yongwa quarry include; the development and expansion of the quarry; the construction of a new access road; the switch in livelihoods of local community members to those that depend on extracting biological resources; unsustainable farming and wood logging practices; social exclusion; reforestation programme around the quarry.

The trend of change in biodiversity has been irregular with time, from 2007 to 2014. Where the environment experienced continuous degradation up to 2013, before starting to show signs of recovery in 2014. This is due to deliberate tree planting efforts by the quarry management and the reduction of farming in the area. The trend in biodiversity change was identified to be irregular in space. Shifting cultivation farming was a key driver to this trend.

A few areas were found around the quarry to be less vulnerable to these drivers of biodiversity change. Noticeable among them is the area found on the mountain top. Sections of the access road to the quarry may, however, be considered as the most vulnerable habitats to modification, which may need critical attention in any biodiversity restoration efforts, as activities from both the quarry and the surrounding community have consistently led to the modification of its biodiversity.

Recommendations

- The reforestation effort being undertaken by the quarry management should be continued and intensified if possible. This will contribute positively to enriching the biodiversity around the quarry and mitigate disturbances caused by the surrounding community.
- Fruit trees, including Mango (*Mangifera indica*) and Soursop (*Annona muricata*), should be strongly considered during the plantation of trees in and around the quarry. This will ensure that the community gets more value out of the area in the form of food (fruits), and help to prevent them from invading the area to cut down all the trees for farming and other economic purposes.

- Regular educational exercises in collaboration with relevant state and private agencies in agriculture and forestry management need to be undertaken for members of the surrounding community. This is to ensure sustainable farming and wood logging practices are carried out in the area.
- The issue of social inclusion has to be critically considered prior to the closure of the quarry, as an exclusion in the past has inevitably steered community members whose dependence on biological resources, led to the heavy depletion of the biodiversity around the quarry.
- In order to minimize the continuous modification of biodiversity in the area, we recommend that the company acts as a facilitator in introducing alternative livelihoods, among community members, that do not dwell on excessively extracting and/or modifying natural resources in the area. These may include technically skilled jobs like engineering and craftsmanship, and services jobs like driving, trading, and repair of electronics.
- As part of efforts to effectively monitor, manage and restore the environment around the quarry, West African Quarries Limited can implement a vegetation mapping project where the various tree species found in and around the quarry will be mapped out and vulnerable areas around the quarry can be monitored on an annual basis.

FUTURE IMPLEMENTATION TIMELINE

The project brought to light factors that are modifying the biodiversity around the Yongwa quarry as well as the pattern of this modification. It also highlighted areas around the quarry that may require critical attention and planning during any biodiversity restoration effort around the quarry. As an Environmental Monitoring Tool, this project can be undertaken on an annual basis by West African Quarries Limited. It can help the company track any changes that may be ongoing around their quarry, and also help in effectively planning and executing biodiversity restoration projects/programs in the area. For effective monitoring, the project should be undertaken at least twice a year; once in the raining season and dry season.

FUTURE IMPLEMENTATION COST

Item	**Unit Cost**	**Quantity**	**Total cost**
Satellite image (Pléiades ORTHO)	US$97/5km^2	4	US$388
GPS device	US$279	1	US$279
			US$667

Table 2: Estimated cost of implementing the project.

The cost of implementing this project in the future is dependent on the scope of work the company would want to consider. In the case where the company plans to adopt it as an annual environmental monitoring tool as recommended earlier, the cost of satellite images may be lower(US$194) than is found in the table above. In principle, the company can undertake an annual monitoring program at an estimated cost of US$473 (excluding cost incurred in engaging professionals/non-professionals).

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To be kept and filled in at the end of your report

Project tags (select all appropriate):

This will be use to classify your project in the project archive (that is also available online)

Project focus: ☒Biodiversity management ☐Cooperation programmes ☐Education and Raising awareness ☐Endangered and protected species ☐Invasive species ☒Landscape management - rehabilitation ☒Rehabilitation ☒Scientific research ☐Soil management ☐Urban ecology ☐Water management Flora: ☐Conifers and cycads ☐Ferns ☐Flowering plants ☐Fungi ☐Mosses and liverworts Fauna: ☐Amphibians ☐Birds ☐Dragonflies & Butterflies ☐Fish ☐Mammals ☐Reptiles ☐Spiders ☐Other insects ☐Other species	Habitat: ☐Cave ☐Cliffs ☒Fields - crops/culture ☒Forest ☒Grassland ☐Human settlement ☒Open areas of rocky grounds ☐Recreational areas ☐Screes ☐Shrubs & groves ☐Soil ☐Wander biotopes ☐Water bodies (flowing, standing) ☐Wetland Stakeholders: ☒Authorities ☒Local community ☐NGOs ☐Schools ☒Universities

APPENDIX 1: Study Area Maps

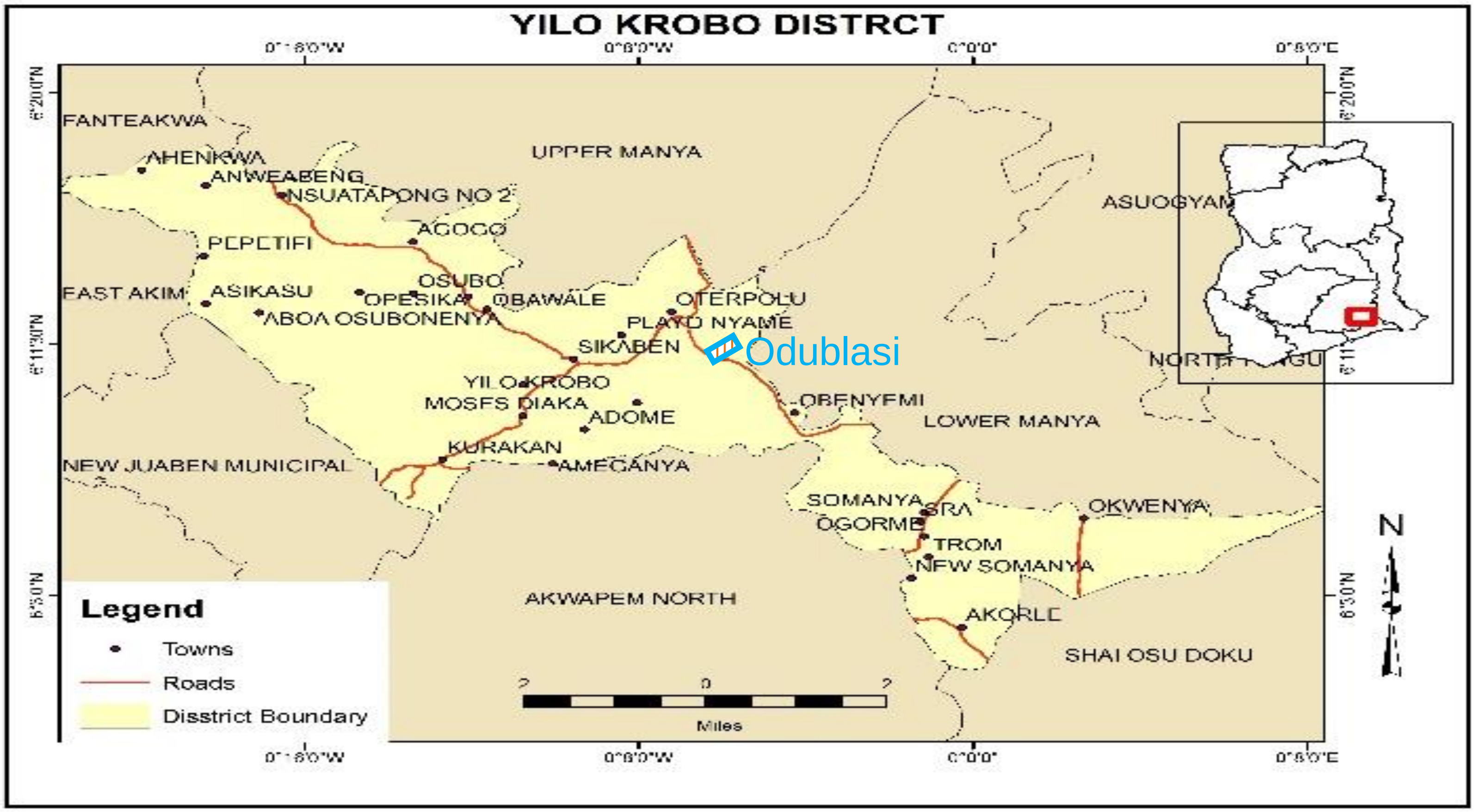


Figure 7: Yilo Krobo District Map

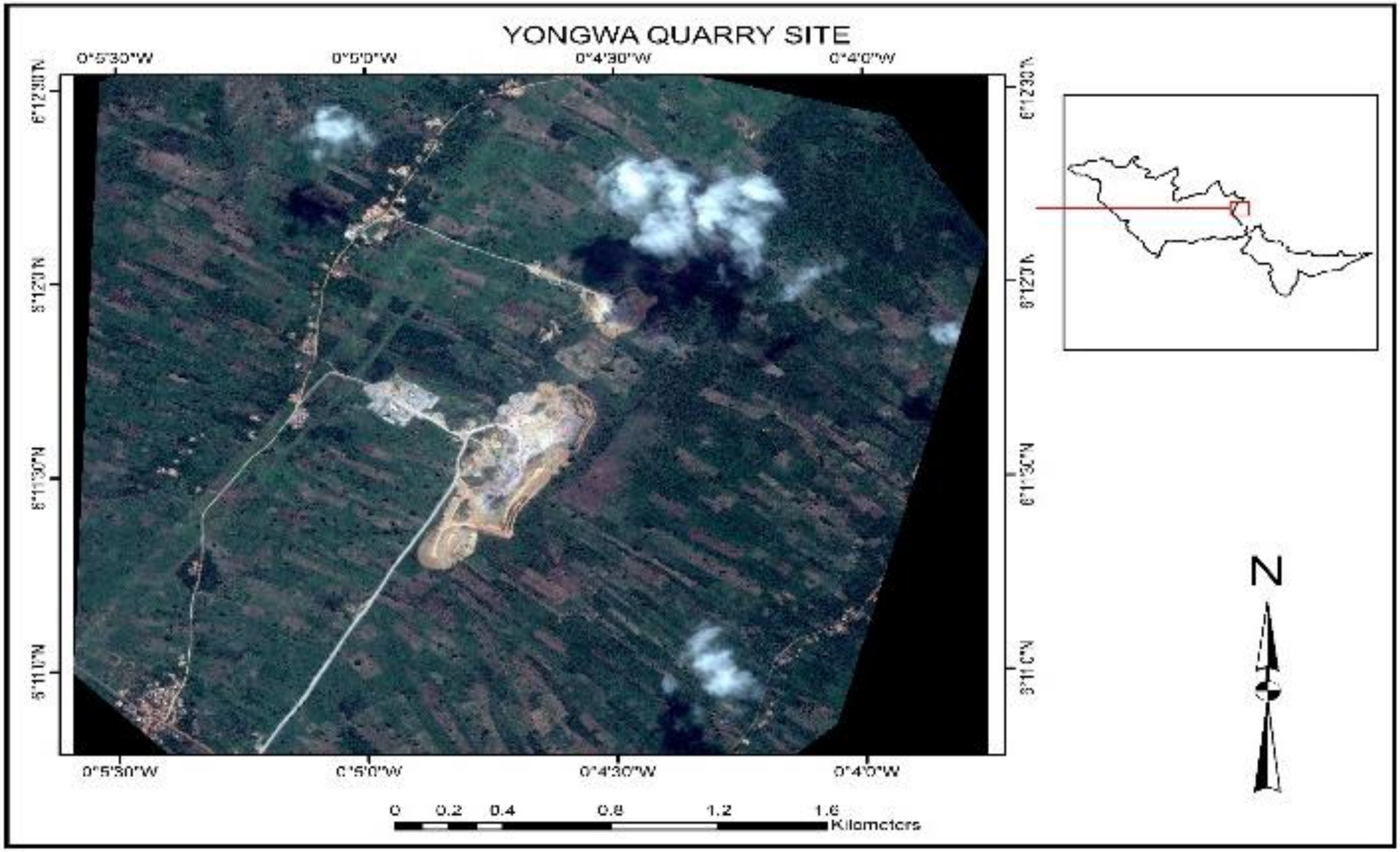


Figure 8: Geographical Location of the Yongwa quarry site

APPENDIX 2: Satellite Images Used in the Project

Table 3: Satellite images acquired from Airbus Defense and Space.

Satellite	**Date**	**Image description**
Pléiades ORTHO	2014/12/27	Area: Yongwa Ghana = 5sqkm. Resolution: 50cm, 4 bands (G,B,R,NIR), Ortho UTMWGS84 Geotiff 16 bits
Pléiades ORTHO	2013/04/07	Area : Yongwa Ghana = 5sqkm Resolution: 50cm, 4 bands (G,B,R,NIR), Ortho UTMWGS84 Geotiff 16 bits
SPOT ORTHO	2012/12/26	Area : Yongwa Ghana = 5sqkm Resolution: 2.5m, color 3 bands (G,R,NIR), Ortho UTMWGS84 DIMAP GeoTiff
SPOT ORTHO	2007/01/29	Area : Yongwa Ghana = 5sqkm Resolution: 2.5m, color 3 bands (G,R,NIR), Ortho UTMWGS84 DIMAP GeoTiff

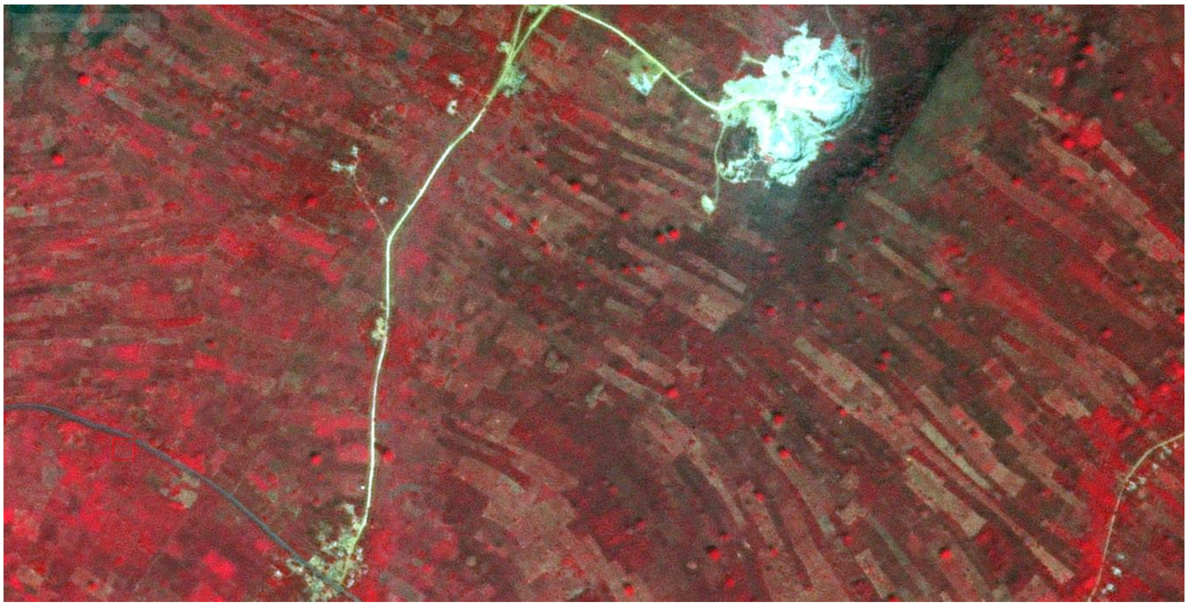


Figure 9: Raw satellite imagery of Yongwa quarry in 2007

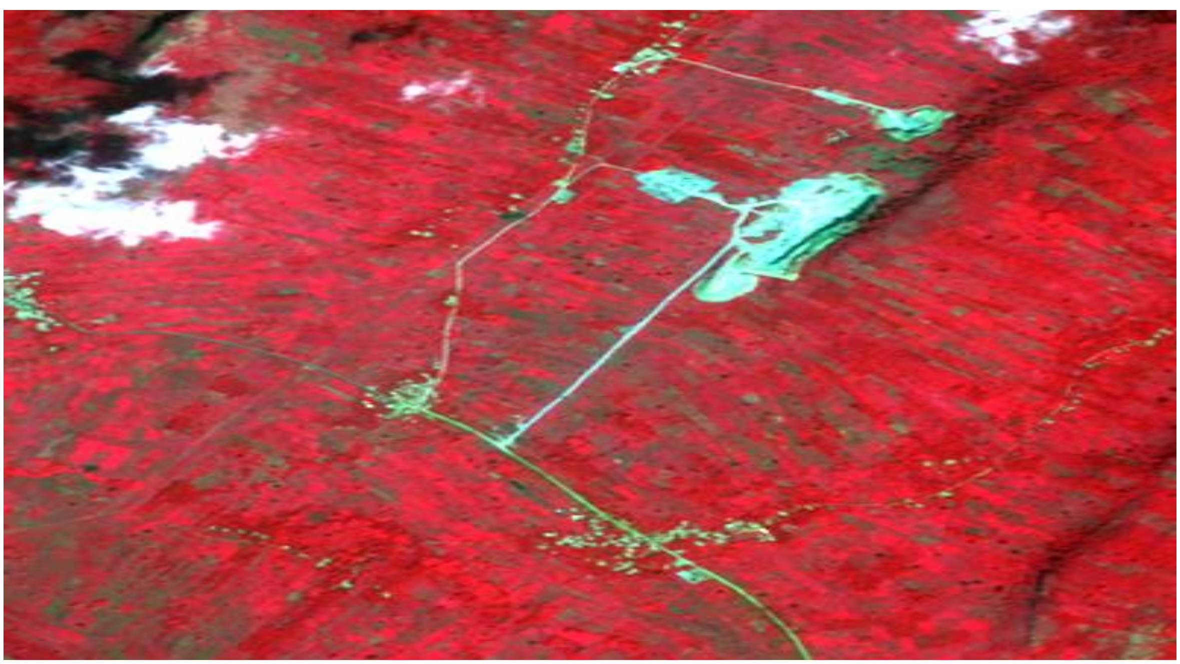
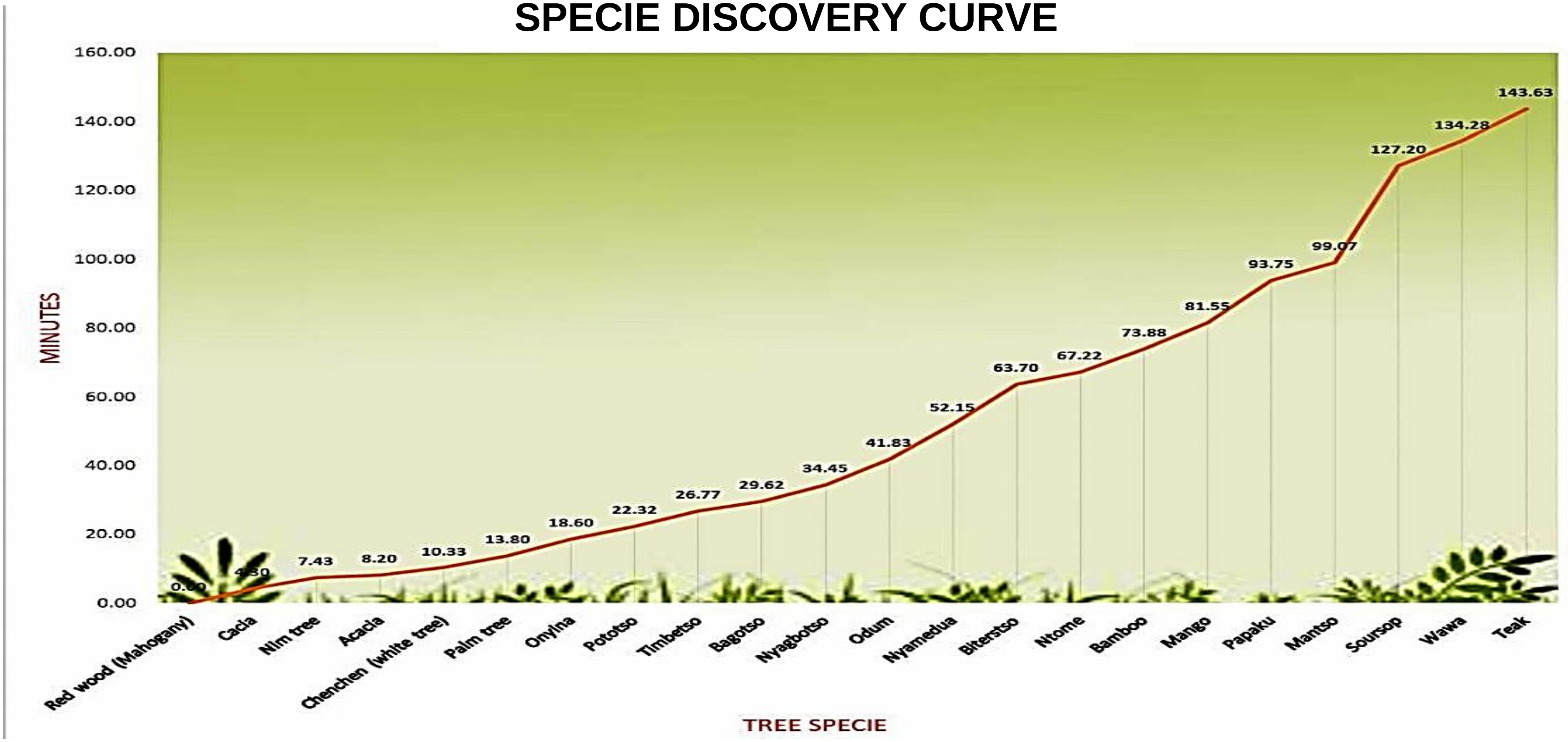


Figure 10: Raw satellite imagery of Yongwa quarry in 2012

Figure 11: Raw satellite imagery of Yongwa quarry in 2013

Figure 12: Raw satellite imagery of Yongwa quarry in 2014

APPENDIX 3: Trees found at Yongwa



Some tree species found around the Yongwa quarry

Figure 23: Annona muricata

Figure 14: Acacia auriculiformis

Figure 16: Triplochiton scleroxylon

Figure 17: Khaya senegalensis

Figure 1 : Elaeis guineensis

Figure 20: Milicia regia

Figure 193 : Ceiba pentandra

Figure 21: Alstonia boonei

Figure 5 : Dracaena arborea

Figure 423: Azadirachta indica

Figure 24: Mangifera indica

Figure 256 : Cassia siamea

Table 3: List of tree species found around the Yongwa quarry

Plant Name (Local)	Scientific Name	IUCN Status	GPS Coordinates
Red wood (Mahogany)	*Khaya senegalensis*	Vulnerable	6°10' 48.6804" -0°5' 13.175"
Caccia	*Cassia siamea*	Lower Risk/least concern	6°10' 48.81" -0°5' 13.499"
Nim tree	*Azadirachta indica*	Extant	6°10' 48.6804" -0°5' 13.567"
Acacia	*Acacia auriculiformis*	Least concern	6°10' 48.4824" -0°5' 12.98"
Chenchen (white tree)			6°10' 48.054" -0°5' 12.073"
Palm tree	*Elaeis guineensis*	Extant	6°10' 47.928" -0°5' 12.401"
Onyina	*Ceiba pentandra*	Extant	6°10' 49.6524" -0°5' 12.358"
Pototso			6°10' 52.2768" -0°5' 10.914"
Timbetso			6°10' 53.742" -0°5' 11.166"
Bagotso			6°10' 52.8996" -0°5' 11.588"
Nyagbotso			6°10' 53.2848" -0°5' 10.583"
Odum	*Milicia regia*	Vulnerable	6°10' 55.38" -0°5' 7.321"
Nyamedua	*Alstonia boonei*	Extant	6°11' 1.5468" -0°5' 4.654"
Biterstso			6°11' 3.1848" -0°5' 6.922"
Ntome	*Dracaena arborea*	Least concern	6°11' 3.1812" -0°5' 6.302"
Bamboo	*Bambusoideae/ Bambusa sp.*	Extant	6°11' 9.5856" -0°5' 0.258"
Mango	*Mangifera indica*	Data Deficient	6°11' 12.3864" -0°5' 0.402"
Papaku			6°11' 13.1892" -0°4' 58.904"

Mantso			6°11' 15.9468" -0°4' 57.493"
Soursop	*Annona muricata*	Extant	6°11' 35.4516" -0°4' 49.714"
Wawa	*Triplochiton scleroxylon*	Lower Risk/least concern	6°11' 37.3452" -0°4' 51.002"
Teak	*Tectona grandis*	Extant	6°11' 36.6792" -0°4' 53.933"

APPENDIX 4: Stakeholder engagement and education

Engagement with Chiefs and elders of Manao, Oborpah, Bueyonyeh and Odublasi

Stakeholder	Visit Type	Purpose	Methodology	Key Issues	Availability online
Prof. Frank Nyame. University of Ghana, Legon	Office meeting	Establish an understanding of benefits and drawbacks of mining to Ghana.	Discussion & video recording	• Economic benefits • Infrastructure development • Environmental degradation • Responsible mining	https://www.youtube.com/watch?v=f3ozik0zft0
Dr. Opoku Pabi University of Ghana, Legon	Office meeting	Establish an understanding of GIS/Remote sensing and their applications in Ghana	Discussion & video recording	• Adoption of GIS in natural resource management • Biodiversity and GIS	https://www.youtube.com/watch?v=93RHSMPBu1E
Mr Charles Ankobea Mine Engineer, Yongwa quarry	Site visit	Establish an understanding of activities at the quarry site	Discussion, field observation & video recording	• Operational activities at the site • Effects on biodiversity • Biodiversity promotion strategies	https://www.youtube.com/watch?v=v-IqruFbmgo
Mr Moses K. Osiosi Farmer, Yongwa area	Site Visit	Establish an understanding of the relationship between their activities and biodiversity.	Discussion & video recording	• Biodiversity history of Yongwa • Effect of quarry on farming and biodiversity	https://www.youtube.com/watch?v=F21yzTTRSbs

Mr. J. K. Acolatse MCE of Yilo Krobo Municipal Assembly	Office meeting	Inform, solicit support and collect information on the district.	Discussion	• Municipality policy on biodiversity conservation	http://www.quarrylifeaward.com/project-updates/2016-07-01-stakeholder-engagement
Nene Samuel Ohepeni & Elders Chief & Elders of Bueyonyeh, Oborpah and Manao	Meeting with chiefs and other opinion leaders	Inform, seek support and permission to engage the community.	Customary protocol & Discussion	• Introduction of project • History of biodiversity in the communities • Factors influencing biodiversity	http://www.quarrylifeaward.com/project-updates/2016-07-01-stakeholder-engagement
Nene Nartey Komesor & Elders Chief & Elders of Odublasi	Meeting with chiefs and other opinion leaders	Inform, seek support and permission to engage the community.	Customary protocol & Discussion	• Introduction of project • History of biodiversity in the communities • Factors influencing biodiversity	http://www.quarrylifeaward.com/project-updates/2016-07-01-stakeholder-engagement

Educational interaction

Educational discussion with students of Asesewa Senior High School

APPENDIX 5: Biodiversity at Yongwa

Some insects seen around the Yongwa quarry

Figure 26: Butterflies *(Lepidoptera sp.)*

Figure 7 : Butterflies *(Lepidoptera sp.)*

Figure 28: Butterflies *(Lepidoptera sp.)*

Figure 29 : Moth *(Eudaemonia argus)*

Figure 308 : Pied crow *(Corvus albus)*