EFFECTS OF SURFACE MINING AND INFRASTURCTURAL DEVELOPMENT ON RURAL RESOURCES DEGRADATION IN PART OF ADAMAWA STATE, NIGERIA

Abstract

Increase in intervention with the Earth's surface for various purposes affects environmental resources. In Hong Local Government Area from 1976 to 2009 there have been increases in laterite harvesting, road networks and settlement sites with adverse effects on rural resources. The types of data required are information related to mining pits, rural resources harvested and types of infrastructural developments that were generated from landsat images, the field, respondents and published related materials. The materials used for data collection were measuring tape, Global Position System and interview schedule. ArcGIS (Version 9.3) was used to analyze the landsat imageries. The scope covers Hong Local Government Area. The focus was to identify the rural resources that are adversely affected by surface mining and infrastructural development. The result indicates that rural resources such as vegetation, surface water and economic lands have decreased significantly due to increase in pits, dump hills and infrastructural development. It is recommended that pits and quarry sites should be reclaimed through landfill by the construction companies. Furthermore, fast growing and economic trees that are adapted to the environment should be planted on the affected areas by community members to improve vegetation cover. Likewise, prospective research should be conducted to determine the species and magnitude of the endangered wild animals. The result implies an increase in mining and infrastructural developments lead to degradation of vegetation, surface water and economic land on the affected areas.

Key wards: 1. Rural resources 2. Human activities 3. Mining 4. Pits 5. Degradation

Introduction

Man has been struggling against physical environment to satisfy his basic needs especially in areas he considers convenient to settle on. He alters such area by clearing the vegetation cover, harvest laterite to construct shelter and road networks. Odebode (2004) stated that with increase in human population associated with diverse demand and sophisticated methods of environmental resources exploitation to meet the needs of teaming population have led to degradation of the environmental resources.

Harris *et al.,* (1998) maintained that land is a precious resource that is needed for construction of houses and infrastructure; provide minerals, water, and soil for crop cultivation; and its vegetation allows production of domesticated and wild animals. Faniran

(1985) maintained that mining, construction of road networks and settlements have created pit holes, level surfaces, mounds and ditches of various sizes and depth that modify the existing landscape by creating channel for run-off, increase the sediment supply to the adjacent surface waters and affected the economic lands.

Shaib (1991) stated that in 1950s the traditional dwellings in Africa was predominantly constructed with materials made up mainly of poles, muds, grasses and wattle that were locally available. Hence, the adverse effects on environmental resources were insignificant because the population was low. Still, according to Upton, 1997 with increase in human comforts such as modern road networks and buildings have significantly affected the local environment adversely. As a result certain components of the natural environment have been converted into deteriorated man-made features which affect rural resources that are harvested by man.

Aina and Salau (1992) stated that from 1976 when Nigeria adapted 12 states structures, excavations for laterite have increased occasioned by increase in infrastructural development such as road networks and housing sectors. Adewole *et al* (2007) stated that infrastructural expansion such as schools, hospitals, houses and road networks brings about development within rural areas, but adversely affects the rural resources such as water, arable land, vegetation cover, settlement lands and wildlives.

Evaluating Mining Projects (2009) observed that mining companies simply dump tailings in the nearest convenient locations, including nearby arable lands, rivers and streams; and do not reclaim the affected sites. Rural Environmental Management (2008) in study on the problems in rural environment stated that the degradation of environmental resources such as economic lands, vegetation cover and water resources affects economic prosperity of the developing countries.

Results of researches especially those of Adewole *et al* (2007), Odebode (2004), Shaib (1991) and Faniran (1985) are important by identifying the socio-economic activities of man that affects the environment, and the adverse effects of increase in population on environmental resources. However, the studies are not restricted to small scale surface mining and rural infrastructural development neither significantly assess the rural resources that are so affected adversely by small scale mining and infrastructural development nor restrict their studies to rural communities of Hong Local Government Area of Adamawa State, Nigeria.

It is observed that there is significant exploitation of environmental resources such as laterite, sand, gravels; and expansion of roads and settlements that contributes substantially to the degradation of rural resources such as surface water and vegetation cover. These cause a chain of problems such as reduction in arable and building lands, and systematic reduction in vegetal and surface water resources. The research is conceived to assess the effects of laterite mining and rural infrastructural development on rural resources deterioration in Hong Local Government Area from 1976 to 2009. The scope is restricted to peasant communities while the issues addressed include identification of specific minerals mined, rural infrastructures; rural resources that are affected adversely by mining and infrastructural development; and the effects of resources degradation on economic activities of the communities. The rural resources are restricted to vegetation, wildlives, fresh water, building and arable lands that are mostly used. Likewise, mining is restricted to surface extraction of sand, laterite and gravels from the Earth's surface while infrastructure include facilities such as roads and shelters.

Background to the Study Area

Hong Local Government Area lies between latitudes $10^{0}00'$ N to $10^{0}16'$N and between longitudes $12^{0}38'$ E to $13^{0}16'$E. It is located in Adamawa State, Nigeria with an approximate area of 2,486sq. km. The wet season is usually from the month of May to October with mean annual rainfall of 1042.8mm and the monthly average is 86.9mm while the dry season is from

November to April (Gandapa, 2003). Low temperatures are experienced during the month of August to January due to cloud cover and the influence of harmattan. The mean monthly temperature is about 27.9^0C while the hottest is about 40^0C (Adebayo, 1999). The area lies on hard crystalline basement complex rocks of pre-Cambrian comprising mainly of granitic outcrop (Akintola, 1982). It is a hilly region with prominent hills such as Tholbang, Motuch, Kulinyi, Kinging, Hizza and Duva among others while the prominent rivers include Bubulum, Dogwaba, Fa'a, Koko, Ngilang and Yau (Garkida, Nigeria, Sheet 155). The relief and drainage are sources of gravels and laterite while the rivers are used for fisheries, animal watering and peasant irrigation**.** The vegetation is significantly dominated by tall grasses with scattered and short woody plants that are harvested for fuelwood, shelter materials, food supplements (fruits and vegetables) and pasture.

The land cover of the area is predominantly vegetation cover, farmlands, settlement sites, rock outcrops, water bodies and road networks. The economic activities of the people include arable farming, pastoralism, hunting and gathering among others. The population has increased from 112,845 in 1976 to 170,452 in 2009 with systematic increase in farmlands, settlements and road network sizes at the detriment of vegetation cover. From 1976 there have been increases in sand, laterite and gravel harvesting. For example, by the Diestraccavalsecia (DTV) in 1976, Armey Roadstone Company (ARC) in 1982, Directorate of Food, Roads and Rural Infrastructure (DFFRI) in 1987, Julius Berger in 2003 and AG Vision in 2009 to construct and rehabilitate both the main and minor roads**.**

Additionally, the increase in major settlements from 202 in 1991 to 231 in 2006, and increase in parastatals from 131 in 1998 to 283 in 2010 have increased laterite mining that create more pits. This adversely affects rural resources such as vegetation, wildlives, surface water and economic lands (building sites, grazing and arable). The laterite is used as landfill

for road construction and to earthen wall of buildings, filling of floor spaces where necessary, for molding of mud blocks and plastering of walls.

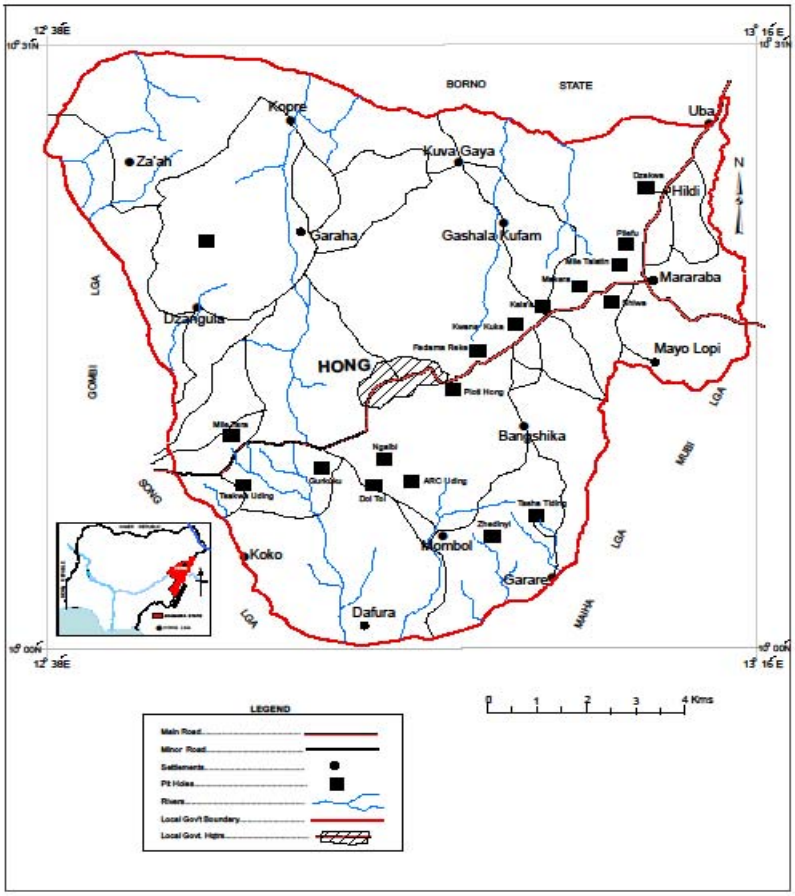

Figure 1: Hong Local Government Area Showing the Sample Pits
Source: Garkida, Nigeria, Sheet 155

Materials and Methods

The types of data required for the study are information related to landuse land cover, mining sites, rural resources and types of infrastructural developments. These were generated from the field using measuring tape, Global Positioning System (GPS), and interview schedule. The respondents provide information on types of rural resources that are affected adversely by mining and infrastructural developments**;** measuring tape to determine sizes of

pits; and GPS to identify the geometric location of the sample pits. Other sources include landsat images that were analyzed using Geographic Information System (GIS) and remote sensing techniques that provide data on landuse land covers, and published related materials provide information on background to the study.

Purposive sampling method was adopted to sample the major pits for measurement of length, width and depth. The sample pits were restricted to mechanical dug because of their significant area coverage, but exclude pits that are manually dug due to insignificant sizes. Nonetheless, where the pits are so close to each other (about 500 metres apart), only those that are larger were measured because they have more implications on rural resources deterioration. A total of 500 respondents were purposively selected for discussions. These were drawn from 25 sample settlements that are located within the mining pits and major roads. In each settlement 20 respondents were interviewed which consist of both adult male and female those were selected using availability sampling.

Landsat images of 1976, 1987, 1998 and 2009 were used to generate data on the bare surface, built-up area, vegetation cover and water body. Using ArcGIS (version 9.3), the following resolutions were adopted: 1976 MSS 50m (resample), 1987 TM 30m and 2009 ETM 15m (ERDAS Imagine, 1997). Landsat image was appropriate because it has a longer period (1972) of acquisition of data than SPOTS (1986) and Nigeriasat 1 (2003). Furthermore, landsat is more appropriate than SPOTS and Nigeriasat 1 because the study of land cover has to do with area coverage. To process the data, signature files were developed using four colour bands to identify the required data on land cover such as built-up area, vegetation cover, bare surfaces and water body that were extracted from the images. These were run on supervised classification model that generated statistics for the signature files created (ERDAS Imagine, 1997). The focus is to determine the area coverage of the classes.

Results and Discussions

Highlight of the result shows that mining and infrastructural development affects rural resources adversely. The data generated from field measurements, interviews and landsat images indicate that devastated terrains which include concrete surfaces, pits and dump hills reduced basic resources such as vegetation cover, surface water, building sites, wildlives, arable and grazing lands. More than 14% of the total landmass (2486sq.km.) is covered by pits which adversely effects meaningful economic utility of the environmental resources on the affected areas. More importantly, landuse land cover decreased by 54.76%, 0.89% and 0.05% for vegetation cover, built-up area and water bodies while there are increase by 36.07% and 8.23% for agricultural and bare lands in that order from 1976 to 2009.

Discussions

From Table 1, the average depth of the pits is 3.24m. This is capable of affecting arable, grazing and settlement lands. Because the depressions retain water, and are devoid of organic soils that are infertile at the detriment of plant growth. More importantly, the altitude of the study area ranges from 426 to 1158m above mean sea level (Garkida, Nigeria, Sheet 155) while the average elevation of the pits is 560.66m. This implies that the pits are on higher points that could initiate gully erosion with adverse effects on rural resources such as surface water siltation and economic land incision downslope.

Table 1 presents results of the measured sample pit in Hong Local Government Area.

Table 1: Measured Sample Pits

S. No.	Pit Site	Depth (m)	Area (m^2)	Location		Height (m)
				Latitude	Longitude	
1	Motuku Uding	7	212,500	$10^0 09'.776''$	$12^0 54'.879''$	580.87
2	Dol Tol	6	6,426	$10^0 09'.961''$	$12^0 55'.246''$	574.47
3	Fadama Reke	2	6,336	$10^0 14'.141''$	$12^0 58'.069''$	605.84
4	Gurkuku	2	4,173	$10^0 10'.324''$	$12^0 53'.378''$	543.10
5	Jannumba	3	4,628	$10^0 18'.635''$	$13^0 07'.905''$	569.90
6	Kwana Kuka	3	9,142	$10^0 14'.193''$	$13^0 00'.034''$	555.59

7	Makera	4	5,986	$10^0 16'.474''$	$13^0 04'.061''$	569.90
8	Mile Talatin	3	4,032	$10^0 17'.231''$	$13^0 05'.294''$	571.12
9	Mile Tara	2	3,397	$10^0 10'.607''$	$12^0 50'.954''$	533.05
10	Ngalbi	5	5,300	$10^0 14'.071''$	$12^0 56'.459''$	548.88
11	Pilefu	2	3,888	$10^0 18'.084''$	$13^0 07'.307''$	558.63
12	Ploti Hong	2	3,315	$10^0 14'.054''$	$12^0 56'.461''$	545.53
13	Shiwa Kala'a	3	30,906	$10^0 15'.554''$	$13^0 00'.061''$	566.50
14	Tasha Tiding	3	8,961	$10^0 07'.782''$	$12^0 57'.555''$	531.52
15	Tsakuwa.Kala'a	3	5,031	$10^0 14'.741''$	$13^0 01'.328''$	561.98
16	Tsakuwa Uding	3	8,040	$10^0 11'.001''$	$12^0 54'.170''$	560.15
17	Vami Kala'a	4	34,465	$10^0 14'.565''$	$13^0 00'.740''$	549.19
	Total = 17	$\bar{x}$ = 3.24	356,526 (14.32%)			$\bar{x}$ = 560.66

Source: Field Study, 2014

Effects of Mining and Infrastructural Development on Rural Resources Degradation

Table 2 presents a summary of the respondents' opinions on the rural resources that are affected adversely by mining and infrastructural developments.

Vegetal Resources Degradation: From the table, 30.60% of the respondents stated that the major effect of mining and rural infrastructural development on the environment is vegetal resource degradation. For example, from the result of landsat image analysis, the area covered by vegetation decreased from 1662sq. km. in 1976 to 1170sq. km. in 2009. This is partly attributed to the increase in bare surfaces such as road networks and settlement sites that increased from 77sq. km. in 1976 to 250sq. km. in 2009 as well as the built-up area increased from 9sq. km. in 1976 to 40sq.km in 2009.

The massive removal of dense vegetation cover as shown on Figure 1 to mine laterite, construct road and settlement deprive the rural populace the access to essential vegetal products. Some native species that are potentially identified as a component of herbs like '*uhi hafa'*; vegetables such as *Balanites aegyptiaca*; fruits which include *Vitellaria paradoxa*;

palatable pasture such as '*dishadala*' and '*gudupu*'; fuelwood species like *Anogeissus leiolarpus*; and thatch species like '*tsaba*' and '*hatsula*' are endangered.

Table 2: Respondents' View on the Types of Rural Resources Affected by Mining and Infrastructural Development

Types of Rural Resources	Respondents	Percentage
Vegetal resources degradation	153	30.60
Arable land deterioration	102	20.40
Water resources depletion	84	16.80
Reduction in grazing lands	65	13.00
Reduction in building lands	54	10.80
Wildlife depletion	42	8.40
Total	500	100.00

Source: Field Study, 2014

Figure 1: Crowded Vegetation Covers. **THE PICTORIAL DATA WERE NOT IN A LINE?????**

From the result of image analysis, the increase in farmland, bare land and built-up areas by 36.07%, 8.23% and 0.89% accordingly from 1976 to 2009 have decreased vegetation cover by 54.76%. These reduce accessibility to vegetal resources such as fuelwood the major source of generating domestic energy, and significantly deteriorate community range lands. For example, '*dol'* Kwabuku floodplain at Kala'a that retains water and

palatable pastures in the dry season (February to May) is affected by the main road (Hong to Mubi) that passes through has reduced its utility due to reduction in surface coverage, surface water, succulent pasture and the risk of livestock crushing by plying vehicles. More importantly, the expansion and increase in main and minor roads such as from Gombi through Hong to Mubi and Uba (85km), Hong to Kwaheli (28km), Hong to Dabna (16km), Thalhuya to Gashala (7km), Wuro-Bokki to Uding (4km) and Midila to Maiha (39km) among others have exposed the community reserve lands to commercial fuelwood harvesting. These have significantly contributed to the depletion of woody plants and arable lands at the detriment of the rural communities.

From the result of field study, there are 99 and 79 woody plant stands on 600sq.m. on fallow and reserve lands, but have been completely removed on all road surfaces, sample pits of about 357sq.km. and built-up area of 40sq.km. The permanent elimination of vegetation cover on the affected areas have accelerated the scarcity of vegetal products such as *Typha elephantina* and *Vetiveria zezanioides* that are essential roofing materials; *Imperiata cylindrica* for making broom; and *Pennisetum pedicellatum* that provide palatable pasture to the domesticated herbivores such as cattle, sheep and goats. Furthermore, the usual accessible native vegetables such as *Hibiscus asper*, *Sesamum indicum* and '*gabidku*' that germinate at the start of rainy season are no longer observed on the pits, road surfaces and settlement sites.

Arable Land Deterioration: From the result, 20.40% of the respondents are of the opinion that mining and construction modify large arable lands by conversion into pits, dump hills and concrete surfaces that reduce utility of fertile arable lands. For example, the main and minor roads measuring about 1275km. long have taken over significant arable lands at Mararaba, Hong, Midila and Kala'a. The reduction in arable lands on the pits as shown on Figure 2, and built-up area such as road networks that increased from 0.36% in 1976 to 1.61% in 2009 as revealed by image analysis have reduced the households' livelihood of

224 those living along the affected areas. This is because the size of the farmlands have been
225 reduced and fragmented by the artificial structures such as pits, road networks and settlement
226 sites that significantly affect crop production adversely. The adverse effects of the
227 intervention is more pronounced in more populated settlements and those located at the
228 datum of hills such as Hong, Pella, Uding, Dzumah and Gashaka. In these areas there is much
229 pressure on the limited arable lands.

230 The pits, huge dumps, concrete road surfaces, and roofs of buildings initiate water
231 erosion that removes fertile soils from the farmland surfaces. For example, on the sides of the
232 main road at Midila gullies have developed that reduce the potentials (size and utility) of
233 arable lands. The gullies restrict the use of mechanical and ox-drawn plows because of the
234 rugged terrain. The utility and productive capacities of the arable lands are reduced on the
235 dump hills (heap of scraped loose organic layer), for example, at Sara Ngau as shown on
236 Figure 2 (c)**,** and permanently terminated on concrete road surfaces. Besides, wetlands at
237 Kala'a, Mijili, Fadama Reke and Pella that support gainful cultivation on crops such as
238 *Mangifera indica*, *Oryza sativa*, *Colocasia esculenta* and *Saccharum officinarum* are
239 significantly reduced by both the main and minor roads. This is because parts of the wetlands
240 that are arable have been taken over by the concrete surfaces. The farm produce of the
241 affected farmers are significantly reduced due to reduction in farmland sizes.

242 Water Resources Depletion: According to 16.80% of the respondents, the intervention
243 with the natural flow of water channels by the pits, dump hills, diversions, culverts, concrete
244 surfaces and surface leveling or landfill affects fresh water resources adversely. Fresh water
245 sources such as rivers Ngilang, Dogwaba, Bubulum and Fa'a that provide habitat to aquatic
246 lives such as fish, '*gwadura*', crabs and frogs, and sources of nutrition to terrestrial animals
247 have decreased. For example, from the result of image analysis, the water body decreased
248 from 0.08% in 1987 to 0.04% in 2009 due to obstruction by culverts construction, diversion

of flow, and deposition of sediments that are generated from the dump hills. Therefore, rivers such as *'Dol'* Tol, Ngilang and Gurkuku have changed from perennial to seasonal with insignificant disconnected pools on their bed in the dry seasons which are unable to meet their social and environmental requirements such as provision of fresh water for domestic uses (peasant irrigation, animal watering and sanitation) and habitat for aquatic lives. More importantly, the hilly and loose nature of the dump hills**;** concrete road surfaces; settlement sites; and the pits generate silt materials that are deposited into surface water. For example, run-off from dump hills at Sara Ngau as shown on Figure 2 (c) deposit silts into '*Dol*' Dar that partially contribute to its drying up. This leads to the depletion of fresh water resources such as fisheries.

Some of the artificial pits as shown on Figure 2 (g, h and i) serve as wet points for domestic uses such as sanitation, molding mud blocks and animal watering because they retain water for a longer dry period (December to May) after cessation of rainfall in October. However, they pose problem such as children and cattle are occasionally drawn in the pools during swimming and animal watering. The bulls that serve as a means of cash saving and sources of labour for plowing the farmlands are lost. Also the children that significantly utilize facilities like schools, and form the human resource base of the community are occasionally lost.

Reduction in Grazing Lands: Pastoralism as an economy in the area depends significantly on community range lands. From the table, 13% of the respondents revealed that infrastructure developments have taken over significant economic lands. For example, the sample pits (about 357sq.km.); built-up and bare surfaces increased from 0.36% to 1.16%, and 3.10% to 10.06% accordingly from 1976 in 2009 (from landsat image analysis) have taken over significant grazing lands by conversion into bare and rugged land surfaces as shown on Figure 2 are devoid of palatable pasture species of grasses such as *Imperiata*

cylindrica and *Cynodon dectylon*, and woody plants like *Acacia albida* that are suitable feeds to livestock such as cattle, sheep and goats. Nonetheless, the common practice of tethering goats and sheep on fragments of un utilized lands that are close (100-500m) to settlements have completely ceased on the concrete road surfaces and pits because the areas are devoid of plant growth.

Reduction in Building Lands: The result indicates that 10.80% of the respondents are of the opinion that reduction in building land is the major effect of surface mining on rural resources in the area. This situation is observed in places where mining sites are located too close to settlements as shown on Figure 2 (g and h). For example, the well-drained and suitable building sites at Tsakuwa Kala'a, Jannumba, Ploti Hong and Tsakuwa Uding have been taken over by the pits measuring 5031sq.m, 4628sq.m, 3315sq.m. and 8040sq.m. accordingly that are difficult to reclaim. The increases in surface roughness of the well-drained building sites by the pits further reduce the expansion of some settlements in the affected areas. For example, Kala'a has limited building sites because it is located on the well-drained area between '*Dol*' Kwabuku, Kwaleta and Killa. With the construction of the main road that pass through the settlement, and the pits at Vami covering an area of about 34,465sq.m. and Tsakuwa Kala'a about 5,031sq.m. further reduce the limited building sites.

Wildlife Depletion: According to 8.40% of the respondents the depletion of wildlives are associated with destruction of natural habitats. For example, vegetation cover and fresh water that are habitats for wildlives such as mammals, aves, insects, fishes, reptiles, and amphibians are depleted. Because of the alteration of the terrestrial habitat wildlife such as guinea fowls and buffalos that move freely have migrated out of the affected areas while the more sedentary animals such as rats and mice which form sources of nutrition are endangered.

From the result of landsat image analysis, the water body decreased from 0.08% in 1987 to 0.04% in 2009. This is attributed to the increase in road construction (site clearance, laterite mining, landfill and diversion of channel flow) that accelerate erosion and siltation with broader disadvantage on drying up of surface water. Even so, wetlands such as Fa'a, Ngilang, Bubulum and Dogwaba that are fresh water habitat to native aquatic animals (fish, crab, and '*gwadra*') have reduced in content because of landfill, diversion and drying up of surface water due to deposition of loose materials that are generated from the dump hills and road sides. For example, there is significant depletion of fishery a common source of protein and commodity of trade in the area.

Furthermore, by pleasure to the alteration of the terrestrial habitat such as conversion of the crowded vegetation cover to pits as shown on Figure 2, and the natural landscape to man-made concrete road surfaces threaten diverse wildlife species within the local environment. For example, predators like lion is an endangered species due to scarcity of prey like buffalo that depend on crowded vegetation cover for concealment from sight. More importantly, the alteration of the sites of reproduction (vegetation cover and channels of flowing water); the activities of quarrying like frequent blasting of granite with dynamite and crushing associated with quarry sites at Motuku Uding as shown on Figure 2 (b); and noise from frequent passing vehicles and human beings have frighten away the wild animals such as leopard and lion because they do not co-exist with frequent noises. Moreover, the man-made hostile environment (concrete road and pit surfaces) that inhibits hollowing (snug) account for the depletion of burrowing animals such as rats and mice that were commonly hunted for bush meat.

It is also important to state at this point that both the main and minor roads are hazardous to wildlives especially the nocturnal such as rats, mice and rabbits; and diurnal which include monkeys, squirrels and antelopes. The roads are characterized with wide,

smooth surfaces and fairly straight that facilitate plying by vehicles at high speed that occasionally crash the animals when crossing. These animals are vital natural resources such as sources of protein and commodity of trade in the communities. Likewise, the scarcity of wildlives (aquatic and terrestrial animals) due to alteration of the natural habitat has made the indigenous potential harvesters to loss their part-time employment that reduce their additional sources of income and standard of living.

(a). Dol Tol Pit (b). Motuku Uding Pit (c). Sara Ngau Dump Hills

(d). Vami Kala'a Pit (e). Tasha Tiding Pit (f). Ngalbi Pit

(g). Tsakuwa Kala'a (h). Jannumba (i). Wurro Bokki

Figure 2: Wrecked Sample Sites **THE PICTORIAL DATA WERE NOT IN A LINE?????**

The results of the study is in line with Evaluation Mining Projects (2009) that mining and infrastructural development affects the environment and associated wildlives through habitat loss such as massive vegetation clearance and drying up of surface water; and those of Jovanjean *et al* (2014) that vegetation degradation have impact on people's livelihood and income generation through reduction and loss of economic activities.

Based on the result of this study, the implication of mining and infrastructural development extends beyoung the limit of the environment in which the activities take place. The activities associated with mining and constructions endanger both aquatic and terrestrial wild animals; deteriorate surface water, vegetation cover, arable and settlement lands especially near populated settlements. These resources that support human being and perform significant ecological functions are deteriorating.

Conclusion

Based on the findings of this research, intervention with the environment such as mining, settlement and road constructions reduce utilization of both terrestrial and aquatic resources of the area. Quarrying, laterite mining and scrapping of site surface associated with construction of settlement and road networks create some artificial features such as dump hills, pits, pools, and concrete bare surfaces that reduce utility of the rural resources such as arable, grazing and settlement lands; vegetation, water and wildlives. Vegetal resources, arable and settlement lands are the most prominent rural resources that decrease in accessibility especially around the more populated settlements, and in settlements situated at the datum of highlands.

The construction companies such as DTV, ARC, Julius Berger and AG Vision left wrecked terrains that have no economic values at the disadvantage of the populace who depend on the economic lands for arable farming, settlement and grazing. More importantly, the affected areas left permanent mark on the environment especially the abandoned quarry and pits that

363 are not reclaimed as well the dump hills and waste rock boulders were left covering
364 significant economic land which are dangerous to both animals and man. More importantly,
365 the study adopted geographic information system and remote sensing techniques, and field
366 measurements to identify the magnitude of changes in vegetation cover, bare land, built-up
367 area and water bodies that reduce rural resources.

368 **Recommendations**

369 Based on the findings of this research, the following recommendations are identified
370 for sustainable management of rural resources in the study area.

371 The revenue derived from issuance of license to road construction companies such as
372 DTV, ARC, Julius Berger and AG Vision to harvest sand, laterite and to quarry gravels
373 should be invested into the affected sites for reclamation in form of landfill, tree planting on
374 native species that are adopted to the environment, fast growing and of economic importance
375 to the communities.

376 The abandoned quarry and pit sites with compacted or inadequate soils should be
377 reclaimed with soil materials in which vegetation can be established which controls
378 accelerated erosion. More importantly, specific areas should be ear-marked for laterite
379 mining as against the indiscriminate. This will reduce the numerous pits that exist along sides
380 of the main and minor roads with broader advantages on conservation of environmental
381 resources.

382 The research did not quantify the wild animals that are endangered. This may be
383 rectified by further research that may positively affect the results. In accordance with this,
384 further research should be embarked upon to determine the magnitude and species of wild
385 animals that are endangered which may give more impression. More importantly, prospective
386 researchers are encouraged to develop their studies along the limitation of this study on how

to improve the environment for sustainable conservation of the declining rural resources in Hong Local Government Area in particular and the world in general.

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