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

39   (1985) maintained that mining, construction of road networks and settlements have created

40   pit holes, level surfaces, mounds and ditches of various sizes and depth that modify the

41   existing landscape by creating channel for run-off, increase the sediment supply to the

42   adjacent surface waters and affected the economic lands.

43   Shaib (1991) stated that in 1950s the traditional dwellings in Africa was

44   predominantly constructed with materials made up mainly of poles, muds, grasses and wattle

45   that were locally available. Hence, the adverse effects on environmental resources were

46   insignificant because the population was low. Still, according to Upton, 1997 with increase in

47   human comforts such as modern road networks and buildings have significantly affected the

48   local environment adversely. As a result certain components of the natural environment have

49   been converted into deteriorated man-made features which affect rural resources that are

50   harvested by man.

51   Aina and Salau (1992) stated that from 1976 when Nigeria adapted 12 states

52   structures, excavations for laterite have increased occasioned by increase in infrastructural

53   development such as road networks and housing sectors. Adewole *et al* (2007) stated that

54   infrastructural expansion such as schools, hospitals, houses and road networks brings about

55   development within rural areas, but adversely affects the rural resources such as water, arable

56   land, vegetation cover, settlement lands and wildlives.

57   Evaluating Mining Projects (2009) observed that mining companies simply dump

58   tailings in the nearest convenient locations, including nearby arable lands, rivers and streams;

59   and do not reclaim the affected sites. Rural Environmental Management (2008) in study on

60   the problems in rural environment stated that the degradation of environmental resources

61   such as economic lands, vegetation cover and water resources affects economic prosperity of

62   the developing countries.

63   Results of researches especially those of Adewole *et al* (2007), Odebode (2004),

64   Shaib (1991) and Faniran (1985) are important by identifying the socio-economic activities of

65   man that affects the environment, and the adverse effects of increase in population on

66   environmental resources. However, the studies are not restricted to small scale surface mining

67   and rural infrastructural development neither significantly assess the rural resources that are

68   so affected adversely by small scale mining and infrastructural development nor restrict their

69   studies to rural communities of Hong Local Government Area of Adamawa State, Nigeria.

70   It is observed that there is significant exploitation of environmental resources such as

71   laterite, sand, gravels; and expansion of roads and settlements that contributes substantially to

72   the degradation of rural resources such as surface water and vegetation cover. These cause a

73   chain of problems such as reduction in arable and building lands, and systematic reduction in

74   vegetal and surface water resources. The research is conceived to assess the effects of laterite

75   mining and rural infrastructural development on rural resources deterioration in Hong Local

76   Government Area from 1976 to 2009. The scope is restricted to peasant communities while

77   the issues addressed include identification of specific minerals mined, rural infrastructures;

78   rural resources that are affected adversely by mining and infrastructural development; and the

79   effects of resources degradation on economic activities of the communities. The rural

80   resources are restricted to vegetation, wildlives, fresh water, building and arable lands that are

81   mostly used. Likewise, mining is restricted to surface extraction of sand, laterite and gravels

82   from the Earth's surface while infrastructure include facilities such as roads and shelters.

83

84   **Background to the Study Area**

85   Hong Local Government Area lies between latitudes $10^0 00'$ N to $10^0 16'$N and between

86   longitudes $12^0 38'$ E to $13^0 16'$E. It is located in Adamawa State, Nigeria with an approximate

87   area of 2,486sq. km. The wet season is usually from the month of May to October with mean

88   annual rainfall of 1042.8mm and the monthly average is 86.9mm while the dry season is from

89 November to April (Gandapa, 2003). Low temperatures are experienced during the month of

90 August to January due to cloud cover and the influence of harmattan. The mean monthly

91 temperature is about 27.9^0C while the hottest is about 40^0C (Adebayo, 1999). The area lies on

92 hard crystalline basement complex rocks of pre-Cambrian comprising mainly of granitic

93 outcrop (Akintola, 1982). It is a hilly region with prominent hills such as Tholbang, Motuch,

94 Kulinyi, Kinging, Hizza and Duva among others while the prominent rivers include

95 Bubulum, Dogwaba, Fa'a, Koko, Ngilang and Yau (Garkida, Nigeria, Sheet 155). The relief

96 and drainage are sources of gravels and laterite while the rivers are used for fisheries, animal

97 watering and peasant irrigation. The vegetation is significantly dominated by tall grasses with

98 scattered and short woody plants that are harvested for fuelwood, shelter materials, food

99 supplements (fruits and vegetables) and pasture.

100 The land cover of the area is predominantly vegetation cover, farmlands, settlement

101 sites, rock outcrops, water bodies and road networks. The economic activities of the people

102 include arable farming, pastoralism, hunting and gathering among others. The population has

103 increased from 112,845 in 1976 to 170,452 in 2009 with systematic increase in farmlands,

104 settlements and road network sizes at the detriment of vegetation cover. From 1976 there

105 have been increases in sand, laterite and gravel harvesting. For example, by the

106 Diestraccavalsecia (DTV) in 1976, Armey Roadstone Company (ARC) in 1982, Directorate

107 of Food, Roads and Rural Infrastructure (DFFRI) in 1987, Julius Berger in 2003 and AG

108 Vision in 2009 to construct and rehabilitate both the main and minor roads.

109 Additionally, the increase in major settlements from 202 in 1991 to 231 in 2006, and

110 increase in parastatals from 131 in 1998 to 283 in 2010 have increased laterite mining that

111 create more pits. This adversely affects rural resources such as vegetation, wildlives, surface

112 water and economic lands (building sites, grazing and arable). The laterite is used as landfill

113   for road construction and to earthen wall of buildings, filling of floor spaces where necessary,

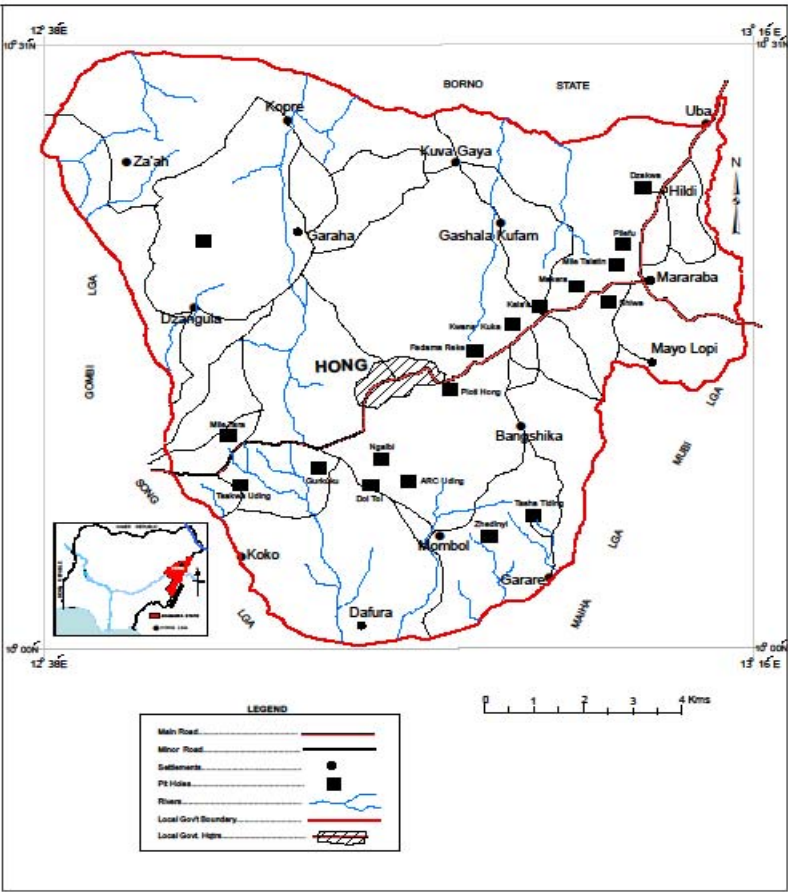114   for molding of mud blocks and plastering of walls.

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

115

116   **Materials and Methods**

117   The types of data required for the study are information related to landuse land cover,

118   mining sites, rural resources and types of infrastructural developments. These were generated

119   from the field using measuring tape, Global Positioning System (GPS), and interview

120   schedule. The respondents provide information on types of rural resources that are affected

121   adversely by mining and infrastructural developments; measuring tape to determine sizes of

122   pits; and GPS to identify the geometric location of the sample pits. Other sources include

123   landsat images that were analyzed using Geographic Information System (GIS) and remote

124   sensing techniques that provide data on landuse land covers, and published related materials

125   provide information on background to the study.

126   Purposive sampling method was adopted to sample the major pits for measurement of

127   length, width and depth. The sample pits were restricted to mechanical dug because of their

128   significant area coverage, but exclude pits that are manually dug due to insignificant sizes.

129   Nonetheless, where the pits are so close to each other (about 500 metres apart), only those

130   that are larger were measured because they have more implications on rural resources

131   deterioration. A total of 500 respondents were purposively selected for discussions. These

132   were drawn from 25 sample settlements that are located within the mining pits and major

133   roads. In each settlement 20 respondents were interviewed which consist of both adult male

134   and female those were selected using availability sampling.

135   Landsat images of 1976, 1987, 1998 and 2009 were used to generate data on the bare

136   surface, built-up area, vegetation cover and water body. Using ArcGIS (version 9.3), the

137   following resolutions were adopted: 1976 MSS 50m (resample), 1987 TM 30m and 2009

138   ETM 15m (ERDAS Imagine, 1997). Landsat image was appropriate because it has a longer

139   period (1972) of acquisition of data than SPOTS (1986) and Nigeriasat 1 (2003).

140   Furthermore, landsat is more appropriate than SPOTS and Nigeriasat 1 because the study of

141   land cover has to do with area coverage. To process the data, signature files were developed

142   using four colour bands to identify the required data on land cover such as built-up area,

143   vegetation cover, bare surfaces and water body that were extracted from the images. These

144   were run on supervised classification model that generated statistics for the signature files

145   created (ERDAS Imagine, 1997). The focus is to determine the area coverage of the classes.

146   **Results and Discussions**

147   Highlight of the result shows that mining and infrastructural development affects

148   rural resources adversely. The data generated from field measurements, interviews and

149   landsat images indicate that devastated terrains which include concrete surfaces, pits and

150   dump hills reduced basic resources such as vegetation cover, surface water, building sites,

151   wildlives, arable and grazing lands. More than 14% of the total landmass (2486sq.km.) is

152   covered by pits which adversely effects meaningful economic utility of the environmental

153   resources on the affected areas. More importantly, landuse land cover decreased by 54.76%,

154   0.89% and 0.05% for vegetation cover, built-up area and water bodies while there are

155   increase by 36.07% and 8.23% for agricultural and bare lands in that order from 1976 to

156   2009.

157   **Discussions**

158   From Table 1, the average depth of the pits is 3.24m. This is capable of affecting

159   arable, grazing and settlement lands. Because the depressions retain water, and are devoid of

160   organic soils that are infertile at the detriment of plant growth. More importantly, the altitude

161   of the study area ranges from 426 to 1158m above mean sea level (Garkida, Nigeria, Sheet

162   155) while the average elevation of the pits is 560.66m. This implies that the pits are on

163   higher points that could initiate gully erosion with adverse effects on rural resources such as

164   surface water siltation and economic land incision downslope.

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

166   Table 1: Measured Sample Pits

S. No.	Pit Site	Depth (m)	Area (m^2)	Location Latitude	Longitude	Height (m)
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

168   Effects of Mining and Infrastructural Development on Rural Resources

169   Degradation

170   Table 2 presents a summary of the respondents' opinions on the rural resources that

171   are affected adversely by mining and infrastructural developments.

172   Vegetal Resources Degradation: From the table, 30.60% of the respondents stated that

173   the major effect of mining and rural infrastructural development on the environment is

174   vegetal resource degradation. For example, from the result of landsat image analysis, the area

175   covered by vegetation decreased from 1662sq. km. in 1976 to 1170sq. km. in 2009. This is

176   partly attributed to the increase in bare surfaces such as road networks and settlement sites

177   that increased from 77sq. km. in 1976 to 250sq. km. in 2009 as well as the built-up area

178   increased from 9sq. km. in 1976 to 40sq.km in 2009.

179   The massive removal of dense vegetation cover as shown on Figure 1 to mine laterite,

180   construct road and settlement deprive the rural populace the access to essential vegetal

181   products. Some native species that are potentially identified as a component of herbs like '*uhi*

182   *hafa*'; vegetables such as *Balanites aegyptiaca*; fruits which include *Vitellaria paradoxa*;

183   palatable pasture such as '*dishadala*' and '*gudupu*'; fuelwood species like *Anogeissus*

184   *leiolarpus*; and thatch species like '*tsaba*' and '*hatsula*' are endangered.

185   Table 2: Respondents' View on the Types of Rural Resources
186   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

187   Source: Field Study, 2014

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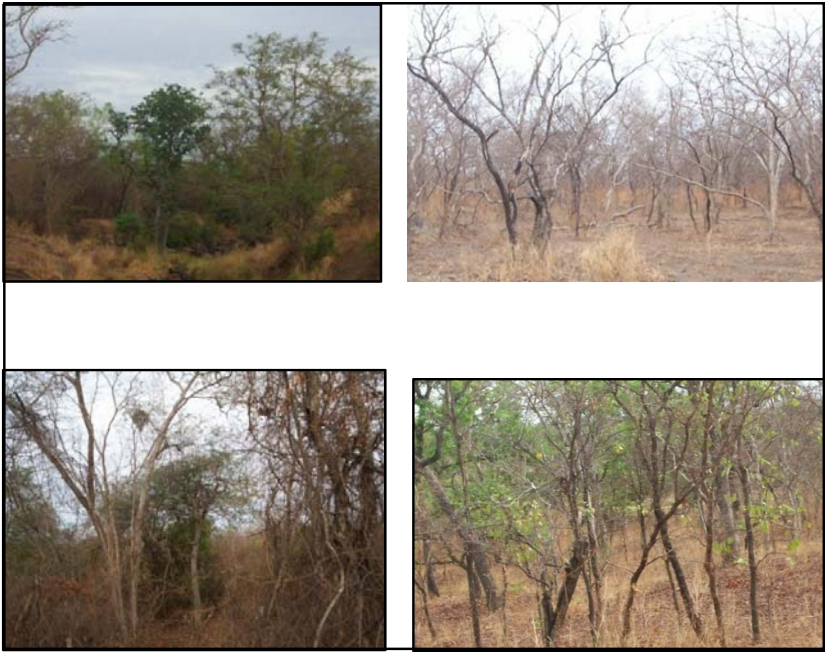
192   Figure 1: Crowded Vegetation Covers.

193   From the result of image analysis, the increase in farmland, bare land and built-up

194   areas by 36.07%, 8.23% and 0.89% accordingly from 1976 to 2009 have decreased

195   vegetation cover by 54.76%. These reduce accessibility to vegetal resources such as fuelwood

196   the major source of generating domestic energy, and significantly deteriorate community

197   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

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

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

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

248   of flow, and deposition of sediments that are generated from the dump hills. Therefore, rivers

249   such as *'Dol'* Tol, Ngilang and Gurkuku have changed from perennial to seasonal with

250   insignificant disconnected pools on their bed in the dry seasons which are unable to meet

251   their social and environmental requirements such as provision of fresh water for domestic

252   uses (peasant irrigation, animal watering and sanitation) and habitat for aquatic lives. More

253   importantly, the hilly and loose nature of the dump hills**;** concrete road surfaces; settlement

254   sites; and the pits generate silt materials that are deposited into surface water. For example,

255   run-off from dump hills at Sara Ngau as shown on Figure 2 (c) deposit silts into '*Dol*' Dar

256   that partially contribute to its drying up. This leads to the depletion of fresh water resources

257   such as fisheries.

258   Some of the artificial pits as shown on Figure 2 (g, h and i) serve as wet points for

259   domestic uses such as sanitation, molding mud blocks and animal watering because they

260   retain water for a longer dry period (December to May) after cessation of rainfall in October.

261   However, they pose problem such as children and cattle are occasionally drawn in the pools

262   during swimming and animal watering. The bulls that serve as a means of cash saving and

263   sources of labour for plowing the farmlands are lost. Also the children that significantly

264   utilize facilities like schools, and form the human resource base of the community are

265   occasionally lost.

266   Reduction in Grazing Lands: Pastoralism as an economy in the area depends

267   significantly on community range lands. From the table, 13% of the respondents revealed that

268   infrastructure developments have taken over significant economic lands. For example, the

269   sample pits (about 357sq.km.); built-up and bare surfaces increased from 0.36% to 1.16%,

270   and 3.10% to 10.06% accordingly from 1976 in 2009 (from landsat image analysis) have

271   taken over significant grazing lands by conversion into bare and rugged land surfaces as

272   shown on Figure 2 are devoid of palatable pasture species of grasses such as *Imperiata*

273 *cylindrica* and *Cynodon dectylon*, and woody plants like *Acacia albida* that are suitable feeds

274 to livestock such as cattle, sheep and goats. Nonetheless, the common practice of tethering

275 goats and sheep on fragments of un utilized lands that are close (100-500m) to settlements

276 have completely ceased on the concrete road surfaces and pits because the areas are devoid of

277 plant growth.

278 Reduction in Building Lands: The result indicates that 10.80% of the respondents are

279 of the opinion that reduction in building land is the major effect of surface mining on rural

280 resources in the area. This situation is observed in places where mining sites are located too

281 close to settlements as shown on Figure 2 (g and h). For example, the well-drained and

282 suitable building sites at Tsakuwa Kala'a, Jannumba, Ploti Hong and Tsakuwa Uding have

283 been taken over by the pits measuring 5031sq.m, 4628sq.m, 3315sq.m. and 8040sq.m.

284 accordingly that are difficult to reclaim. The increases in surface roughness of the well-

285 drained building sites by the pits further reduce the expansion of some settlements in the

286 affected areas. For example, Kala'a has limited building sites because it is located on the

287 well-drained area between '*Dol*' Kwabuku, Kwaleta and Killa. With the construction of the

288 main road that pass through the settlement, and the pits at Vami covering an area of about

289 34,465sq.m. and Tsakuwa Kala'a about 5,031sq.m. further reduce the limited building sites.
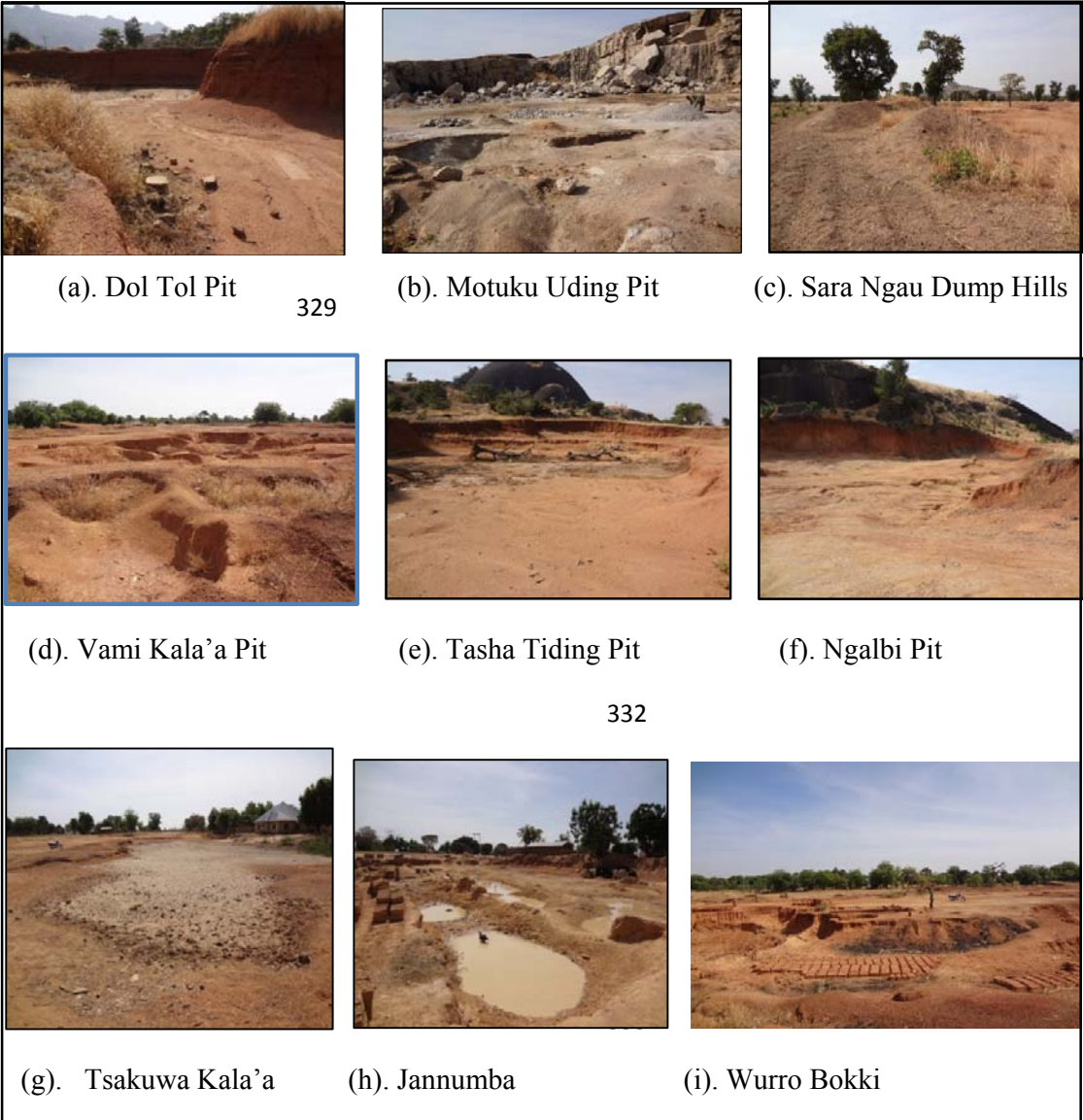
290 Wildlife Depletion: According to 8.40% of the respondents the depletion of wildlives

291 are associated with destruction of natural habitats. For example, vegetation cover and fresh

292 water that are habitats for wildlives such as mammals, aves, insects, fishes, reptiles, and

293 amphibians are depleted. Because of the alteration of the terrestrial habitat wildlife such as

294 guinea fowls and buffalos that move freely have migrated out of the affected areas while the

295 more sedentary animals such as rats and mice which form sources of nutrition are

296 endangered.

13

297   From the result of landsat image analysis, the water body decreased from 0.08% in

298   1987 to 0.04% in 2009. This is attributed to the increase in road construction (site clearance,

299   laterite mining, landfill and diversion of channel flow) that accelerate erosion and siltation

300   with broader disadvantage on drying up of surface water. Even so, wetlands such as Fa'a,

301   Ngilang, Bubulum and Dogwaba that are fresh water habitat to native aquatic animals (fish,

302   crab, and '*gwadra*') have reduced in content because of landfill, diversion and drying up of

303   surface water due to deposition of loose materials that are generated from the dump hills and

304   road sides. For example, there is significant depletion of fishery a common source of protein

305   and commodity of trade in the area.

306   Furthermore, by pleasure to the alteration of the terrestrial habitat such as conversion

307   of the crowded vegetation cover to pits as shown on Figure 2, and the natural landscape to

308   man-made concrete road surfaces threaten diverse wildlife species within the local

309   environment. For example, predators like lion is an endangered species due to scarcity of

310   prey like buffalo that depend on crowded vegetation cover for concealment from sight. More

311   importantly, the alteration of the sites of reproduction (vegetation cover and channels of

312   flowing water); the activities of quarrying like frequent blasting of granite with dynamite and

313   crushing associated with quarry sites at Motuku Uding as shown on Figure 2 (b); and noise

314   from frequent passing vehicles and human beings have frighten away the wild animals such

315   as leopard and lion because they do not co-exist with frequent noises. Moreover, the man-

316   made hostile environment (concrete road and pit surfaces) that inhibits hollowing (snug)

317   account for the depletion of burrowing animals such as rats and mice that were commonly

318   hunted for bush meat.

319   It is also important to state at this point that both the main and minor roads are

320   hazardous to wildlives especially the nocturnal such as rats, mice and rabbits; and diurnal

321   which include monkeys, squirrels and antelopes. The roads are characterized with wide,

322 smooth surfaces and fairly straight that facilitate plying by vehicles at high speed that

323 occasionally crash the animals when crossing. These animals are vital natural resources such

324 as sources of protein and commodity of trade in the communities. Likewise, the scarcity of

325 wildlives (aquatic and terrestrial animals) due to alteration of the natural habitat has made the

326 indigenous potential harvesters to loss their part-time employment that reduce their additional

327 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 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

361 are not reclaimed as well the dump hills and waste rock boulders were left covering

362 significant economic land which are dangerous to both animals and man. <mark>More importantly,</mark>

363 <mark>the study adopted geographic information system and remote sensing techniques, and field</mark>

364 <mark>measurements to identify the magnitude of changes in vegetation cover, bare land, built-up</mark>

365 <mark>area and water bodies that reduce rural resources.</mark>

366 **Recommendations**

367   Based on the findings of this research, the following recommendations are identified

368 for sustainable management of rural resources in the study area.

369   The revenue derived from issuance of license to road construction companies such as

370 DTV, ARC, Julius Berger and AG Vision to harvest sand, laterite and to quarry gravels

371 should be invested into the affected sites for reclamation in form of landfill, tree planting on

372 native species that are adopted to the environment, fast growing and of economic importance

373 to the communities.

374   The abandoned quarry and pit sites with compacted or inadequate soils should be

375 reclaimed with soil materials in which vegetation can be established which controls

376 accelerated erosion. More importantly, specific areas should be ear-marked for laterite

377 mining as against the indiscriminate. This will reduce the numerous pits that exist along sides

378 of the main and minor roads with broader advantages on conservation of environmental

379 resources.

380   <mark>The research did not quantify the wild animals that are endangered. This may be</mark>

381 <mark>rectified by further research that may positively affect the results. In accordance with this,</mark>

382 <mark>further research should be embarked upon to determine the magnitude and species of wild</mark>

383 <mark>animals that are endangered which may give more impression. More importantly, prospective</mark>

384 <mark>researchers are encouraged to develop their studies along the limitation of this study on how</mark>

385   to improve the environment for sustainable conservation of the declining rural resources in

386   Hong Local Government Area in particular and the world in general.

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