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RESEARCH ARTICLE

IMPACT OF COMPACTION AND BLASTING ACTIVITY ON LIVESTOCK DURING CONSTRUCTION OF STANDARD GAUGE RAILWAY IN MAKINDU-KIBOKO AREA OF MAKUENI COUNTY, KENYA.

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Abstract

The study aimed to identify effects of railway construction activities on livestock during construction of Mombasa-Nairobi Standard Gauge railway at Makindu-Kiboko area. Purposive sampling method was used; all households within 0-200 meters on either side of the railway line and blasting site who reported an effect associated with railway construction activities were interviewed. Out of 169 households interviewed, only 25 (15%) reported effects to their livestock. Construction activities like blasting rocks and soil compaction resulted in ground vibrations, noise and dust that were harmful to livestock and vegetation. About 14% and 8% reported mortalities in chicken and goats respectively. About 2% reported failure of eggs to hatch. Dust resulted in crop and pasture loss in addition to health effects on livestock. Noise pollution and cracks on buildings were also reported. In conclusion, construction activities like rock blasting and soil compaction have negative effects on livestock health in addition to crop and pasture losses and mitigation measures need to be put in place before such an undertaking is commenced

Introduction:-

Background of study

The Mombasa-Nairobi Standard Gauge Railway (SGR) is the first section of Northern Corridor of East Africa Railway Network. Once complete, it will offer freight transport among such countries as Kenya, Uganda, Rwanda, Burundi, Congo-Kinshasa and South Sudan. The project is part of infrastructure for the completion of modern East African railway network and the East African integration process (CRBC, 2015). On completion, the railway line is expected to increase regional trade opportunities, reduce transport and mentainance costs and reduce road accidents.

Figure 1

Figure 2

Figure 1: Proposed East African railway network:-
Figure 2: Location of study area, Makindu:-
Generally, the new railway runs parallel to the existing Mombasa-Nairobi transport corridor. In some areas, it deviates from the existing line in order to attain a relatively straight alignment which will enhance train speed. The railway line passes through eight (8) Counties namely: Mombasa, Kilifi, Kwale, Taita-Taveta, Makueni, Kajiado, Machakos and Nairobi. It will have a total length of 485km once complete. This is one of the flagship projects of Kenya's vision 2030 (AWEMAC, 2012).

Agro-Climatic Condition and Biodiversity:-
The area under study is mainly flat rising gently towards Kiboko. It receives an average of 600 mm of rainfall annually and an average annual temperature of 23^0 C (Gichuki, 2000; AWEMAC, 2012). Makindu/Kiboko and its environs are rich in biodiversity of plants and animal species. Plant species include trees, shrub species, forested lands and indigenous vegetation typical of semi-arid savannah (Touber, 1983). The indigenous species are beneficial to local community through provision of fuel wood, timber, posts, fodder, shade, fruits among others and provide environmental protection through soil conservation and nitrogen fixing. Much of the original vegetation has been modified through cutting of trees, bush clearing, burning and grazing. Animal species include indigenous cattle, sheep, goats, donkeys and chicken (AWEMAC, 2012). The project area has scarce water resources.

Geology:-
The geology of the area comprises recent volcanic rocks and a basement complex system. Granite rocks are found around the hills which are a major water catchment in the area. The rest of the area is almost entirely built up of recent lava flows and some volcanic cones. The flood plains and bottom lands occupy only minor portions (Mganga, 2009). The soils comprise ferrasols, nitisols, luvisols and cambisols (Touber, 1983). Most of these soils are compact and have a massive structure with strong surface sealing which causes much runoff during heavy rains. Pockets of black cotton soils rich in clay content can also be found scattered in the area (Musimba *et al*., 2004).

Population and Socio-economic activities:-
Population in the study area is usually sparse except around towns. Makindu has a total population of 70,302, consisting of 34,406 males, 35,896 females and 15,425 households. It occupies an area of 846.2 square Km with a population density of 83 people. The population of Kiboko is 10,809 consisting of 5,526 males, 5,283 females and 2,434 households. It occupies an area of 346.3 square Km with a population density of 31 persons (KNBS, 2009). The study area is a predominantly residential/business and agro pastoral area where the main socio-economic activities are small scale businesses, crop and livestock farming among others. Subsistence production is the main activity in rural areas of Makindu and Kiboko area. The industrial sector in the area is poorly developed. Types of trade within Makindu and its environs include retail, open air markets, hardware stores, livestock trade, agricultural produce, lumbering/timber production, fabrication/garages and sand/murram harvesting. Dairy farming is undertaken both for subsistence and commercial purposes

Infrastructure development:-
The study area has inadequate road network. Electricity distribution is through power lines to the many institutions and homesteads in the area

Problem statement and objective of study:-
The study was conducted in the area stretching from Ikoyo in Kiboko location to Kiu and Misongeni areas of Makindu location, Makueni County. The contractor (China Roads and Bridges Corporation) was compacting and excavating soil in addition to blasting rocks in the above area purposely to create a passage for the standard gauge railway line and make ballast. These activities usually result into vibrations, noise and dust. Excessive vibrations have been found to cause damage to structures neighbouring blast sites. Also, dust emitted can cause crop and livestock losses in addition to affecting human health while noise can cause annoyance to nearby community (Rebuilding 193.com). The study objective was to determine the environmental impacts that activities like excavation, compaction and blasting have on livestock during construction of standard gauge railway in the study area.

Methodology:-

Purposive sampling method was used; only households within 0-200 meters on either side of the railway line and blasting site who reported an effect associated with railway construction activities were interviewed. In total, 169 households were interviewed. Field data collection was through; (a) Interviews and oral discussions with household heads of the affected families about excavation, compaction and blasting operation and its implications on the households (b) Observations of the affected properties with the main focus on damage types and age of damages, like effect of dust on crops/pastures and livestock (c) Measurement of distances between the affected properties and the blast site to ascertain whether the structures are within the waves influence zone. Data was then tabulated to make summaries.

Results:-

The Blast site was located at -2.5333°, (latitude), 38.0500° (longitude) at a general elevation of between 800-900m above the sea level. The main livestock types reared were indigenous zebu cattle, Small East African Goat (SEAG), sheep and donkeys. Poultry, mainly indigenous chicken were also reared. A total of 169 households were interviewed, of which 25 households (15%) reported various effects on their livestock. About 14% reported chicken deaths ranging from 2 to 60 chicken. About 8% reported mortalities in goats ranging from 1-10 goats while 2% reported failure of incubated eggs to hatch ranging from 10 to 84 eggs. Other effects were mortalities of 2 cows, 6 ducks and abortion of one goat. The main clinical sign reported by farmers preceding deaths was respiratory distress; some farmers even had their livestock treated before death. Farmers associated these deaths to railway construction activities; they indicated that there were no deaths and effects on livestock occurring prior to railway construction.

The neighborhood of the excavation, compaction/blast site was characterized by buildings and farmlands. On-farm tree growing was evident with fruit trees and other agro forestry dominating. The agro forestry tree species were found intercropped with a variety of food crops such as maize, beans, green grams among others. Dust emitted resulted in crop and pasture loss in some of these crops since they were covered in dust hence unable to undertake photosynthesis (Figure 3). This is in addition to dust effects on livestock health especially predisposing respiratory diseases.

Figure 3: Dust covered crops:-

In addition to effects on livestock and crops, all households (169) reported cracks on their buildings. Farmers attributed the cracks to; (1) Ground vibrations due to compaction activities on the railway line. (2) Vibrations due to blasting of rocks on railway line and during ballast making. (3) Vibrations and noise caused by trucks during railway construction. The areas affected by the blasting were approximately within the radius of 450m from the blast site. Other negative impacts associated with standard gauge railway construction include; Ground cracks, noise pollution, flying stones, contamination of water sources, and release of harmful gases. All these effects serve as a risk to humans, crops and animals in addition to pasture losses.

Discussion:-

Vibration effects on livestock:-

The Kenya Noise and Excessive Vibration Pollution Control Regulations 2009 prohibits excessive vibrations. Regulation 4 prohibits any person to make or cause to be made excessive vibrations which annoy, disturb, injure or endanger the comfort, health or safety of others and the environment. The regulations provide that any person carrying out construction, demolition, mining or quarrying work shall ensure that vibration levels should do not exceed 0.5 centimeters per second beyond any source property boundary or 30 meters from any moving source.

Berardinelli *et al.,* (2003) indicates that vibrations affect shell eggs quality. Taek *et al.,* (2011) indicates that repeated vibrations affect productivity of laying hens. Mechanical vibrations are reported be responsible for the incidence of cracks, in addition to promoting the agitation of internal constituents (yolk and albumen), which could potentially compromise the quality of hatchlings. Vibrations also cause stress, discomfort and depreciation of the welfare of poultry; they cause a drop in levels of glucose and corticosteroids and thus affect other body parameters like meat quality (Ana *et al.,* 2014). Stress from vibrations also lower an animal's resistance to infection and significantly contributes to welfare problems, animal diseases, and meat contamination (AWI, 2011). Vibration effects also suppress animal behaviors (Courtney, 2014)

Noise effects on livestock:-

The Kenya Noise and Excessive Vibration Pollution Control Regulations 2009 prohibits excessive noise. According to regulation 3 (1), no person shall make or cause to be made any loud, unreasonable, unnecessary or unusual noise which annoys, disturbs, injures or endangers the comfort, health or safety of others and the environment. Regulation 5 further make it an offence any noise in excess of the noise levels set in the First Schedule to these Regulations, unless such noise is reasonably necessary to the preservation of life, health, safety or property.

Noise has been reported to suppress animal behaviours (CHSRA, 2012; Courtney, 2014). Longer lasting noise can affect the health of animals. Noise causes a variety of physiological effects in mammals such as changes in the cardiovascular homeostasis, secretion of hormones, reproductive physiology and energy metabolism. It also causes a general stress reaction hence affecting most body organs. Mammals in particular react to sudden high intensity noise through startle response, freezing, and fleeing from the sound source. The degree of reaction varies with species, age and individual animal (Brouček, 2014).

Dust effects on livestock and vegetation:-

The Kenya Environmental Management and Coordination (air regulations) Act 2014 prohibits any person from causing any immediate or subsequent air pollution exceeding allowed limits. Dust in the air causes a respiratory burden to livestock. It causes disease patterns in the context of either mechanical, chemical, infections, immunosuppressant, allergies or toxic. For the development of a disease the respective infectious agent must be present in the dust (Hartung and Saleh, 2007). Dust can also affect various types of vegetation including crops, grasslands, trees and woodlands; it affects photosynthesis, respiration, transpiration and allows penetration of gaseous pollutants. Dust deposition on plants may also alter their structure (Farmer, 1993)

Blasting:-

The Kenya Explosives Act, 1986 provides that no person shall use any blasting material *(a)* Unless he is in possession of a permit issued by or under the authority of an inspector; or *(b)* Unless he is, while using such blasting material, under the immediate and constant supervision of a person who is in possession of such a permit.

Blasting is usually done to create new drainage ways, new roads, bridges, railroads, ballast making and to facilitate easier movement of rock debris by machinery. It results in dust, noise in addition to ground and air vibrations which can damage the environment (Rebuilding 193.com). Blasting and its timing are regulated by by-laws laid down by counties/countries. According to Kenya Explosives Act (1986) the blasters must be licensed and knowledgeable in handling explosives

Figure 4

Figure 4: Ballast laid on standard gauge railway line

The National Policy for Disaster management in Kenya (2009) sets out guidelines for responding to hazards arising from blasting. Stark (2004) indicates that contractors should be strictly liable to trespatory and none trespatory invasions although Stark (2002) proposes that blasters should not be liable to non trespatory invasions unless they have been negligent. During blasting, energy waves are transmitted through the ground as vibrations, and through the air as overpressure or air blast, this causes vibrations and leads to change in air quality (Rebuilding 193.com).

Soil compaction:-

It is the process in which a stress applied to soil causes densification as air is displaced from the pores between the soil particles. Normally, compaction is the result of heavy machinery compressing soil, but it can also occur due to other causes e.g. pressure due to the passage of animal feet. Vibrations transmitted through the ground may cause annoyance to people and animals (Rebuilding 193.com). Svinkin (2004) suggests that monitoring and control of vibrations should be done and reasonable vibration criteria for each site applied. Therefore monitoring construction vibrations have to be started prior and during construction to provide safety and serviceability of sound and vulnerable structures.

Appendices:-

Table 1: Effects of vibration, noise and dust on livestock

Household	Number of chicken dead (All ages)	Number of eggs failed to hatch	Number of Dead goats	Other effects
1	18	0	3	
2	7	0	0	
3	2	0	0	
4	8	0	0	
5	15	0	6	
6	8	0	6	6 Ducks dead
7	4	36	3	
8	27	0	7	
9	16	0	0	
10	0	0	8	
11	20	0	0	
12	18	0	4	1 Goat abortion
13	7	84	2	
14	2	0	0	
15	10	0	0	
16	10	40	0	
17	6	0	0	
18	6	0	0	
19	60	10	3	
20	0	0	1	1 Heifer dead
21	12	0	4	1 Kid dead
22	2	0	0	1 Cow dead
23	3	0	2	
24	12	0	0	
25	30	0	10	

Conclusion and recommendations:-

Construction activities like rock blasting, excavation and soil compaction result in ground vibrations, dust and noise which have negative effects on livestock health in addition to crop and pasture losses. Mitigation measures need to be put in place before such an undertaking is commenced.

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