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Calves gastrointestinal nematodes and Eimeria prevalence and associated risk factors in dairy farms, southern Ethiopia

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Calves;

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Ethiopia

Research article

ABSTRACT

Dairy production plays a vital role in livestock farming in Ethiopia. Nevertheless, the productivity of the sector has been impacted negatively by the morbidity and mortality of replacement animals. A Cross sectional study was therefore, aimed at estimating the prevalence of *Nematode* and *Eimeria* infection in calves in Hawassa, Shashemene and Arsi Negelle, southern Ethiopia. To this end a flotation technique was used to recover *Nematode* egg and *Eimeria* oocyst from rectally collected faeces. The overall prevalence of gastrointestinal parasitic infection, *Nematode* and *Eimeria* species collectively, was 43.9% (95% CI=38.6-49.4). The estimated proportion of *Nematode*, *Eimeria* and mixed infection was 35.8%, 21.5% and 13.3%, respectively. Among the potential factors considered faecal consistency, age and study area were found to increase recovery of *Nematode* egg and *Eimeria* oocyst in faeces ($p< 0.05$). Area wise, the prevalence has been noted to be higher at Arsi Negelle followed by Hawassa and Shashemene ($p< 0.05$). Besides, younger and diarrheic calves were found more infected by *Nematode* and *Eimeria* species than their adult and non-diarrhic counterpart. Based on their morphological appearance, Strongyle type (20.3%), Trichuris (4.2%) and Ascaris (16.3%) eggs, Eimeria oocysts (21.5%) were observed. In the light of this finding the authors would like to advise the need for strategic intervention.

INTRODUCTION

There is increasing demand for dairy products in urban and peri-urban areas, which indicates the importance of dairying in Ethiopia (Tegegn et al., 2013). Ethiopia's cattle population is estimated at 60.4 million. Calves accounted nearly for about 18% (CSA, 2018). The sustainability of any dairy production depends on the successful program of raising calves for replacement (Bath et al., 1985). In the modern societies, dairy farming has transformed into a business, where the owners have to look at improving the efficiency of the productions. One of the principal means of action to improve profit margins is to control and reduce costs.

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This can be achieved by improving dairy animal health, especially the replacement calves. The costs of young stock diseases are difficult to quantify but are linked to a reduced growth and increased mortality rate. Hence, the pre-weaning period represents a time of significant losses in the dairy industry (Breen et al., 2012).

Health management of replacement animals is crucial for farm profitability. Its productivity can be impacted negatively by the high mortality of replacement animals. The highest morbidity and mortality rates on dairy generally occur before weaning (Breen et al., 2012; Constable et al., 2017; Radostits, 2001). In many dairy farms today, the young stocks are often observed less frequently than adult cows by both veterinary advisors and farm staff, resulting in delayed disease detection and treatment; veterinary attention becomes focused on diseased individuals as they arise rather than working towards producing groups of healthy calves (Breen et al., 2012).

Gastrointestinal *nematodes* and *Eimeria* species are the most important agents causing disease in calves (Bruhn et al., 2012). Calves are most vulnerable to gastrointestinal parasites in their first grazing season, although yearlings and, less often, adults are sometimes affected (Constable et al., 2017). Gastrointestinal parasitic infections, nematode and Eimeria species, play a key role in the economic losses in that they cause low productivity, delayed growth, declined weight gain and death of the animal, and significant expenses of treatment (Höglund et al., 2018; Höglund et al., 2013; Höglund et al., 2001; Sutherland, and Scott, 2010). Even if various studies undergone on cattle helminthosis and Eimeria infections, only limited information available. So this research output added to the existing information to build-up the data base. The aim of this study was to estimate the prevalence of *Nematode* and *Eimeria* species infections in calves and to identify potential risk factors associated with these infections.

MATERIALS AND METHODS

Study areas and animals

The study areas were Arsi-Negelle, Shashemene and Hawassa which are located in southern part of Ethiopia. The altitudes of the study areas range from 1,500 to 2,300 meters above sea level (masl). The annual rainfall varies, measuring 800–1,300 mm in Hawassa, 500–1,091 mm in Arsi Negelle, and 800–1,300 mm in Shashemene. The mean annual minimum and maximum temperatures for Hawassa, Arsi-Negelle and Shashemene were 12.1ºC and 26.4ºC, 12.6 ºC and 27.3 ºC, and 14 ºC and 27 ºC, respectively (National Meteorological Agency, 2017). Small scale dairy farming (i.e. urban and per-urban) was the characteristic feature of all the study areas. In the selected dairy farms, all calves (N=330) aged 12 months or younger were included in the study. The age of the calves was determined through interviews with the farm owners.

Study design and sample size

A cross-sectional study design was employed to estimate the prevalence of GIT *Nematode* and *Eimeria* in calves of the dairy farms. The study was conducted from January 2018 to September 2018. Lists of dairy farms were prepared in collaboration with Arsi-Negelle, Shashemene and Hawassa district animal health service

Office. Then, all farms having greater than or equal to three cows were purposively selected, making a total of 92 dairy farms with three or more calves. The sample size was computed by considering the gastrointestinal parasites prevalence, 61%, reported by Telila et al. (2014) and taking in to account of 95% CI and 5% absolute desired precision(Thrusfield, 2018). Accordingly, the computed sample size was 365. But during the study period 330 calves were found in all the selected farms. Hence, all the available calves were considered for the study.

Study methods

Data on farm size, management practices, and the presence of other animal species were gathered from farm owners using a pretested questionnaire. Subsequently, approximately 15 gm of fresh fecal samples were collected directly from the rectum of selected calves using disposable arm-length gloves. The samples were placed in screw-cap universal bottles and labeled with unique codes matching the corresponding numbers on the data collection sheet. Moreover, other information like farm name, calf age, sex, and faecal consistency (i.e. diarrhea, soft or normal) were recorded on the format prepared for this purpose. Then the samples were placed in cool ice box and transported to the Parasitology laboratory of the Faculty of Veterinary Medicine, Hawassa University. The samples were kept in the refrigerator and examined within 24 hours of the collection. The faecal samples were processed by the flotation technique, and a flotation fluid of saturated sodium chloride solution (Specific gravity=1.2) was used; and the processed samples were examined under 10x or 40x magnifications for *Nematodes* eggs and *Eimeria* oocysts (Zajac and Conboy, 2012; Foreyt, 2001).

Data analysis

Al collected data were entered into a Microsoft Excel spreadsheet, where they were edited, coded, and summarized using descriptive statistics such as means and proportions. Univariable logistic regression analysis was employed to evaluate the association of the putative risk factors considered in this particular study with calves infection by nematodes and *Eimeria* species. Those non-collinear variables (gamma=0.20) with a p-value of ≤ 0.25 in the univariable logistic regression analysis were subjected to a multivariable logistic regression analysis. Finally, the model fitness was assessed by the Hosmer–Lemeshow goodness-of-fit test (Dohoo et al., 2009). For the data analysis STATA 14.2 software was used. The study considered a 95% level of confidence and 5% desired level of precision.

RESULTS

Prevalence of gastrointestinal *Nematodes* and *Eimeria*

The overall prevalence of gastrointestinal parasitic infection was 43.9% (95% CI=38.6-49.4) of which *Nematodes* and *Eimeria* species and mixed infections accounted for 118 (35.8%), 71 (21.5%) and 44 (13.3%), respectively. The prevalence of *Nematode* and *Eimeria* species infection varied between the study areas: Shashemene, Hawassa and Arsi Negelle (Table 1).

Table- 1: Animal level prevalence of *Nematodes* and *Eimeria* species infections of calves vs. variables considered for the study

Variables	Variables level	No examined	*Nematode* species		*Eimeria* species	
			No (%) positive	95% CI	No (%) positive	95% CI
Study area	Shashemene	114	26 (22.8%)	16.0-31.2	14 (12.3%)	7.4-19.7
	Hawassa	179	74 (41.3%)	34.3-48.7	42 (23.5%)	17.8-30.2
	Arsi Negelle	37	18 (48.6%)	33.0-64.6	15 (40.5%)	25.9-57.1
Age	0-3 months	142	39 (27.5%)	20.7-35.4	24 (16.9%)	11.6-24.0
	4-6 months	113	47 (41.6%)	32.8-50.9	32 (28.3%)	20.7-37.4
	7-12 months	75	32 (42.7%)	31.9-54.2	15 (20.0%)	12.4-30.7
Sex	Female	212	78 (36.8%)	30.5-43.5	48 (22.6%)	17.5-28.8
	Male	118	40 (33.9%)	25.9-43.0	23 (19.5%)	13.3-27.7
Animal composition	Cattle only	269	109 (40.5%)	34.8-46.5	63 (23.4%)	18.7-28.9
	Mixed*	61	9 (14.8%)	7.8-26.2	8 (13.1%)	6.6-24.3
Faecal consistency	Normal	148	44 (29.7%)	22.9-37.6	22 (14.9%)	10.0-21.6
	Semi-formed	150	56 (37.3%)	30.0-45.4	38 (25.3%)	19.0-33.0
	Diarrhea	32	18 (56.3%)	38.7-72.4	11 (34.4%)	19.9-52.4
Total		330	118 (35.8%)	30.7-41.1	71 (21.5%)	17.4-26.3

* Mixed= Mixed with other domestic animals like equine, sheep and/or goats

Logistic regression analysis of potential risk factors for GIT nematode infection

The univariable logistic regression analysis revealed that among the potential factors considered in the study areas, age and faecal consistency were associated with the occurrence of both *Nematode* species (Table 2) and *Eimeria* species in calves (Table 3). All the risk factors, variables, were non-collinear (**γ** is between -0.254 and 0.195), and hence, those risk factors with $p<0.25$ in univariable logistic regression were subjected to the multivariable analysis.

The odds of acquiring *Nematode* infection by calves in Arsi Negelle and Hawassa were 3.8 and 2.8 times higher as compared to Shashemene, respectively (Table 2). Similarly, the likelihood of shedding *Eimeria* oocysts by calves of Arsi Negelle (Adjusted OR=6.2, $p< 0.001$) and Hawassa (Adjusted OR=2.6, $p=0.007$) was significantly different from that of calves in Shashemene (Table 3).

Table- 2: Logistic regression analysis of potential risk factors for GIT *Nematode* infection in calves, southern Ethiopia.

Variables	Variables level	No. examined	No. (%) positive	Univariable			Multivariable		
				OR	95% CI	p-value	OR	95% CI	p-value
Study area	Shashemene	114	26 (22.8%)	Rf.	-	-	Rf.	-	-
	Hawassa	179	74 (41.3%)	2.4	1.4-4.0	0.001	2.8	1.6-5.0	≤ 0.001
	Arsi Negelle	37	18 (48.6%)	3.2	1.5-7.0	0.003	3.8	1.7-8.7	0.002
Age	0-3 months	142	39 (27.5%)	Rf.	-	-	Rf.	-	-
	4-6 months	113	47 (41.6%)	1.9	1.1-3.2	0. 018	2.2	1.2-3.8	0.007
	7-12 months	75	32 (42.7%)	2.0	1.1-3.6	0.024	2.2	1.1-4.0	0.017
Sex	Female	212	78 (36.8%)	Rf.					
	Male	118	40 (33.9%)	1.1	0.7-1.8	0.599			
Faecal consistency	Normal	148	44 (29.7%)	Rf.	-	-	Rf.	-	-
	Semi-formed	150	56 (37.3%)	1.4	0.9-2.3	0.165	1.6	1.0-2.6	0.076
	Diarrhea	32	18 (56.3%)	3.0	1.4-6.6	0.005	5.7	2.4-13.7	≤ 0.001
Total		330	118 (35.8%)						

OR = Odds ratio, Rf. = Reference

Table- 3: Logistic regression analysis of potential risk factors for *Eimeria* species infection in calves, southern Ethiopia.

Variable	Category	No. examined	No. (%) positive	Univariable			Multivariable		
				OR	95% CI	p-value	OR	95% CI	p-value
Study area	Shashemene	114	14 (12.3%)	Rf.	-	-	Rf.	-	-
	Hawassa	179	42 (23.5%)	2.2	1.1-4.2	0.019	2.6	1.3-5.3	0.007
	Arsi Negelle	37	15 (40.5%)	4.9	2.1-11.5	0.000	6.2	2.5-15.7	≤ 0.001
Age	0-3 months	142	24 (16.9%)	Rf.	-	-	Rf.	-	-
	4-6 months	113	32 (28.3%)	1.9	1.1-3.6	0. 030	2.3	1.2-4.4	0.010
	7-12 months	75	15 (20.0%)	1.2	0.6-2.5	0.572	2.3	0.6-2.7	0.527
Sex	Female	212	48 (22.6%)	1.2					
	Male	118	23 (19.5%)	Rf.	0.7-2.1	0.505	-	-	-
Faecal consistency	Normal	148	22 (14.9%)	Rf.	-	-	Rf.	-	-
	Semi-formed	150	38 (25.3%)	2.0	1.1-3.5	0.026	2.1	1.2-3.9	0.016
	Diarrhea	32	11 (34.4%)	3.0	1.3-7.1	0.012	5.3	2.0-13.6	0.001
Total		330	71 (21.5%)						

Based on their morphological characteristics of their eggs (i.e. when examined under 10X

and/or 40X microscopic magnification) four major groups of gastrointestinal nematode parasites were identified (Table 4).

Table- 4: Types of parasites identified based on morphology of their eggs/oocyst

Group of parasites	Proportion (%)	Std. Err	95% CI
Strongyles	20.3%	0.02	16.3-25.0
Trichuris	4.2%	0.01	2.5-7.1
Ascaris	16.3%	0.02	12.7-20.8
Eimeria	21.5%	0.02	17.4-26.3

Among the different reproductive disorders, abortion and retained fetal membrane showed statistically significant association ($p<0.05$) with uterine infection that was expressed either in the form of endometritis or metritis (Table 4).

Table-4. Association of uterine infection with the other reproductive disorders of cows as a predisposing factor

Predisposing factors	Number of cows	Cows with uterine infection	Cows without uterine infection	¡ ^{2}	p-value
RFM	11	7(63.6%)	4(36.4%)	11.9	0.001
Abortion	6	5(83.3%)	1(16.7%)	13.11	0.000
Dystocia	3	1(33.3%)	2(66.7%)	0.16	0.688
Hypocalcemia	3	1(33.3%)	2(66.7%)	0.16	0.688

RFM=Retained Fetal Membrane

DISCUSSION

Calves are vital members of the dairy farms and represent the future replacement stock, and they deserve special attention and great care of health (Chang'a et al., 2010). The overall prevalence of gastrointestinal parasitic infection was 43.9 %, of which *Nematode* and *Eimeria* species infections were accounted for 35.8% and 21.5%, respectively. The prevalence of *Nematode* species observed during this study was in a general agreement with the report from the West Hararghe zone (Tulu and Lelisa, 2016; Kemal and Terefe, 2013). The multivariable logistic regression analysis showed that among the potential risk factors considered in the study areas age and the study areas were found significantly associated with infection of calves both by *Nematode* and *Eimeria* species (Table 2 and 3). The variation between the study areas might be due to the differences in the prevailing management factors in the areas (Constable et al., 2017). The prevalence of *Nematode* species infection increases as the age of the calves increases. Similarly, Tulu and Lelisa (2016) reported that as the age of calves increased, the exposure time to the infective stage of larvae and oocysts also increased. Relatively the lower *Eimeria* infection during the first three months of age was due to the effect of colostral

antibodies from infected cows (Fiege et al., 1992). Again the prevalence of *Eimeria* species infection declined after 7 months of age probably as a result of immunity development to re-infection by the same species of *Eimeria* (Senger et al., 1959). Cross protection between species does not occur, and hence, undoubtedly the calves might be infected by other species of *Eimeria* (Bangoura and Bardsley, 2020). The proportion of both *Nematode* (OR=5.7, p< 0.05) and *Eimeria* species (OR=5.3, P< 0.05) infection was significantly higher in diarrheic calves than calves with normal faeces consistency. In dairy farms diarrhea was most frequently observed disorder in various parts (Tamrat et al., 2020; Żychlińska-Buczek et al., 2015; Megersa et al., 2009; Wudu et al., 2008). It is known that some *Nematodes* species and *Eimeria* species known to damage the intestinal epithelial cells leading to inflammation and cause diarrhea (Constable et al., 1017; Ramadan et al., 2015).

In conclusion, gastrointestinal parasitic infections are highly prevalent in the study areas. This study identified that study area, age of the calves and faecal consistency were significantly associated with the prevalence of *Nematode* and *Eimeria* species infection of calves. Therefore, it is advisable to introduce strategic interventions that include regular treatment of the herd including the calves.

CONFLICT OF INTEREST: There is no financial or other relationship that might lead to a conflict of interest.

CONSENT TO PARTICIPATE: Informed consent was obtained from all participants involved in the study.

AUTHORS CONTRIBUTIONS: All authors agreed with the content and to submit for publication. Contributions of each author is as follows: MA data collection; KA design of work, data analysis and comment on draft; EZG design of work, data analysis and comment on draft; VDMLP design and comment on draft; DS design of work, data analysis and draft preparation.

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Effects of Twelve-Week Aerobic Exercise on Selected Health-Related Physical Fitness Variables on Gonji Preparatory School Male Students

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KEYWORDS:

Aerobic fitness**;**

Body composition;

Cardiovascular endurance

Research article

ABSTRACT

This study aimed to examine the impact of a 12-week aerobic exercise program on health-related physical fitness variables among grade eleven male students at Gonji Preparatory School. The study design was experimental method. Initially, 242 students aged from 18 to 22 years were purposively selected, but only 108 students fulfilled inclusion criteria of the study. From these, 51 students declined to participate and 57 were willing to participate. For ease of management, only 30 students were selected from these willing groups based on simple random sampling technique,which were then grouped equally into control and experimental groups. Experimental group was exposed to aerobic exercises for 40 - 60 minute a day for 3 days a week during 12-week. Both study groups were exposed to 40 minute per week in school regular physical education class during 12-week. Study groups had taken pre-test and post-test measurements. Paired t-test and independent t-test were used for data analysis. The level of significant was set at $p<0.05$. Statistically significant difference have been detected between the pre-test and post-test values on experimental group in body composition ($t=-3.571$, $p<0.05$ and cardio-respiratory fitness ($t=-4.258$, $p<0.05$), but control group in body composition ($t=-1.786$, $p>0.05$ and cardio-respiratory fitness ($t=-0.091$, $p>0.05$) registered no statistically significant difference. The result obtained from experimental group indicated that there were significant differences observed in body composition and cardio-respiratory fitness, but not on control group. Based on the current finding, a 12-week moderate aerobic exercise program for 40 - 60 minute a day for 3 days a week has positive effect on the improvement of physical fitness, but not improvement 40 minute school regular physical education class, so that it needs additional time for physical education class for grade 11 male students in preparatory schools.

INTRODUCTION

Physical fitness is the biggest potentiality of the human beings. It cannot be bought; it can only be achieved through day to day physical activity (Bharath and Mukesh, 2011). Regular physical exercise and fitness are critically important for the health and welfare of people of all categories, whether they regularly participate in exercise (usually referred as sport) or some type of moderate health-enhancing physical activities. Even among frail adults and very old adults, mobility and functioning can be

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improved through physical activity (Butler *et al.*, 1998). Correctly performed progressive exercise increases the level of fitness and improves health. It also creates a sense of wellbeing, produce greater energy and reduce the risk of developing many diseases. Exercise makes improvements on the body systems over and above normal day to day activities and as a result, the systems adapt anatomically and physiologically (Rosser, 2001).

Aerobic exercise stimulates the cardiovascular and respiratory systems, as well as major muscle groups, resulting in improved physical and mental well-being. Consistent engagement in aerobic activities promotes notable physiological changes. Specifically, aerobic workouts increase blood flow to various tissues, encourage blood vessel angiogenesis (sprouting of new vessels), and optimize oxygen transport, leading to more efficient nutrient delivery to muscles and waste removal, allowing for sustained activity with less fatigue (Shahana *et al*., 2010).

Physical education in schools builds students' competence and confidence, enabling them to participate in a variety of physical activities that play a central role in their lives, both within and beyond the school environment. A well-designed physical education curriculum allows all students to enjoy and excel in diverse forms of physical activity. The time allocated to physical education in the majority of schools has declined with a consequent increase in time allocation for other academic subjects (Hillman *et al*., 2008). Unfortunately, many schools have reduced physical education opportunities in order to dedicate more class time to meet these academic standards (Lavall, 1984).

Similarly, the Federal Democratic Republic of Ethiopian, the Ministry of Education has been developed a physical education curriculum in secondary and preparatory schools with a one-day class schedule per week for 40 minutes long for both theoretical and practical sessions. The allocation of periods for secondary, junior and preparatory schools have been limited compared with other country class schedules to ensure and develop student's optimal physical fitness. In California,schools serving grades 7–12 are required to provide a minimum of 400 minutes of health physical education (i.e sport) instruction over every 10 day period (source:(http://www.cde.ca.gov/ci/cr/cf/documents/, Accessed on June 12, 2019)

The objective of teaching physical education curriculum designed by Federal Democratic Republic of Ethiopian Ministry of Education was intended to develop and maintain all aspects of personality such as physical, mental and social wellbeing of students. But, the question is it possible within 40 minutes per week class schedule? According to American College of Sports Medicine, (2009) participation in at least 30 minutes of moderate physical activity per day carried out 3 days a week will yield significant health benefits. On the other hand, Thomas *et al*. (2004) stated that an appropriate frequency for aerobic exercise is 3-5 time per week and total workout time should be able 20-60 minute depending on the intensity of the activity. World health organization (2006)suggests that one should take at least 10,000 walking step counts per day for health promotion. In Gonji preparatory school, male students particularly show high motivation to participate in physical education class, the time allocated for physical education period allocated is one period per week for 40 minute it might be limit them further progression and intensity of

exercise. This trend might be made students developing poor fitness levels against expected norms in each grade level. Based on the period allocated for grade eleven students physical education class and its effectiveness on physical fitness variables of students the researcher conducted this research to fulfilled gap investigate the effect of twelve-week aerobic exercise training on selected health-related physical fitness variables of body composition, cardio-respiratory fitness, skeletal strength, and muscular endurance. Finally, the researchers hypothesized an experimental group's of body composition and cardio-respiratory fitness would have significant differences following exercise interventions compare with control groups.

Thus, this study was undertaken with the objective of investigating the effects of aerobic exercise training on selected health-related physical fitness parameters in Gonji preparatory school grade eleven male students.

MATERIALS AND METHODS

Description of the study area

The study was conducted at Gonji preparatory school by involving grade eleven male students. Gonji Kolela Woreda is located in West Gojjam Zone, Amhara National Regional State. The administrative center of West Gojjam is Finoteselam; it is also the administrative center of Gonji kolela Woreda, which lies 72 km South-east of Baihr Dar the Amhara regional state capital.

Sampling method and Strategy

For this study, 242 grade eleven male students were selected purposively from the target population. Based on inclusion criteria only 108 students fulfilled the criteria, of which 51 students declined to participate and 57 were volunteer to participate in the study. However, to manage the study properly, only 30 students were selected by simple random sampling technique from 57 volunteers. Then the study subjects (n=30) were randomly assigned into equal experimental and control groups (n = 15) respectively. The age of these students assigned in the two groups (n = 30) ranges from 18 to 22 years. All students selected to participate in the study were with good health condition.

Study design and methodology

Exercise training protocol

The necessary data were collected pre-test and post-test interventions from experimental and control groups. The training period lasted for 12-week.Study participants were exercised for three nonconsecutive days per week i.e. Monday, Wednesday and Friday morning for 40 - 60 minute, at 50-74% Hr max moderate intensity. During each training session, six different exercises were performed in aerobic training; aerobic dance, walking, jogging, running, rope jumping and minor game of football. To control the intensity of the exercise, first the researcher calculated training heart rate of each student by using Karvonen's formula for aerobic using the maximum heart rate to calculate a training threshold and listed down on paper then counted their heart rate for 15 seconds between the training (Costill *et al.*, 2008).

Harvard Step Test

Step test was designed to measure cardiovascular fitness or endurance by using a 51 cm high bench or box watch for timing minute. The step test works on the rationale that individuals with a high level of cardio-respiratory fitness will have a lower heart rate during recovery from three minutes of standardized exercise than less conditioned individuals. The lower heart rate after the test will be an indicator of being fitter (Brouha *et al*., 1943).

Procedure:-The test subject repeatedly steps onto and off of a platform in a cycle of two seconds. The height of the platform is 51 centimeters for men. The participant must maintain a stepping rate of 30 steps per minute for five minutes or until reaching exhaustion. A metronome is used to ensure the correct pace. Exhaustion is defined as the inability to sustain the stepping rate for 15 seconds. Upon completing the test, the participant immediately sits down, and heartbeats are recorded at intervals of 1 to 1.5 minutes, 2 to 2.5 minutes, and 3 to 3.5 minutes.

Scoring:- the results were recorded as time until exhaustion in seconds (t_c) and total heartbeats counted (h_b). It is plotted into a simple fitness index equation: $t_c x 100/h_b$ x 2 (Brouha *et al*., 1943).

Body Mass Index

Body Mass Index (BMI) is a calculation used to estimate body fat based on a person's height and weight, applicable to both men and women. The purpose of BMI is to determine the ideal body weight in relation to body fat and lean tissue.

Procedure:-Measured the student's height in meters and weight in kilograms.

Scoring:-To determined BMI divided the weight by the height squared: BMI = weight / height^2 (Quetelet, 1835).

Data quality control

To ensure the validity and reliability of the study, standardized testing procedures and measurement instruments were employed. Standardized instruments designed for data collection were used to accurately measure study variables and to assess data collection validity. To ensure the uniformity, reliability, and consistency of measurements, each variable was measured three times on each participant, at the same time of day, and under similar environmental conditions. Measurements were consistently scheduled at the same time throughout the testing period and were taken by the same examiner, following instrument calibration before each session.

Ethical consecrations

The study procedures were approved by the Research Ethics Review Committee of Hawassa University, College of Natural and Computational Sciences (RERC/004/20), and written informed consent was obtained from the participants.

The benefits of this research were highlighted to participants. They were assured that their participation in this study is voluntary, and that it is greatly appreciated. Clear awareness was also given to all grade eleven male students that the choice not to be involved in this study was not affect their future career in any way.

Each participant was allocated a number and alphabetical code to ensure that confidentiality and anonymity is maintained. Information sheets, agreement and consent forms have been translated into the national language of Ethiopian in Amharic.

All data will be kept in the possession of the principal research team, and will be destroyed five years after the completion of this study.

Data analysis

The collected data were analyzed using statistical package software for social science (SPSS) version 20. Paired t-test and independent t-test were used for data analysis. The level of significant was set at $p<0.05$.

The characteristics of study participants mean and standard deviation (SD) of age (yr.), height (m), weight (Kg) and maximum heart rate were 19.13±0.74, 1.69± 0.06, 54.39 ± 4.82 and 200.86±0.74, and 19.07±0.88, 1.68± 0.04, and 55.78±3.65 and 200.93±0.88 for the experimental group (EG) and Control group (CG), respectively. These showed that the study participants' characteristics were homogeneous groups.

Experimental and control groups data analyzed within-groups by paired t-test and between-group effects analyzed by independent t-test design were applied during pretest and post-test of exercise interventions'. Experimental and control groups were participated in regular physical education programs aligned with the Ministry of Education school curriculum one period of 40-minute per week. In addition the experimental group engaged 12-week aerobic exercise training for 3 days per week for 40 up to 60 minutes per session.

RESULTS

The results of the study purpose at the effects of aerobic exercise on selected health-related physical fitness parameters in Gonji preparatory school male students are summarized in table 1.

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Table- 1: Paired t-test analysis result of the pre-test and post-test data of the experimental group and control group

Variables (n=30)	Group	Pre-test $\bar{x}$± SD	Post-test $\bar{x}$± SD	t	p
BMI (kg/m^2)	Experimental group	18.97±1.33	18.35±1.10	9.64	0.000*
	Control group	19.77±1.12	19.81±1.14	1.72	0.107
Harvard step test (30 steps/ minute)	Experimental group	104.53±12.55	118.27±12.55	-12.06	0.000*
	Control group	104.13±11.45	103.67±12.41	-0.344	0.736

BMI: Body mass Index, *Significant at $p<0.05$ level

Body mass index (BMI) and Harvard step test pre-test and post-test data of control group revealed that ($t=-1.72$, $p>0.05$) and ($t=-0.344$, $p>0.05$) no statistical significant. On the other hand, experimental group in body mass index pre-test and post-test data ($t = 9.64, p <0.05$) and Harvard step test ($t =-12.06, p < 0.05$) have been found statistical significant.

Table -2: Independent t-test analysis result of the pre-test and post-test data of the experimental group and control group

Variables (n=30)	Group	Pre-test $\bar{x}$± SD	Post-test $\bar{x}$± SD	t	p
BMI (kg/m^2)	Experimental group	18.97±1.33	18.35±1.10	-3.57	0.001
	Control group	18.78±1.12	19.81±1.14	-1.79	0.085
Harvard step test (30 steps/ minute)	Experimental group	104.53±12.55	118.27±12.55	-4.26	0.000
	Control group	104.13±11.45	103.67±12.41	0.091	0.928

*Significant at p<0.05 level

As summarized in table 2, body mass index pre-test and post-test data of the control group (t =-1.79, p > 0.05) and Harvard step test (t =0.091,p > 0.05) have been found no statistical significant. Whereas, in the experimental group the pre-test and post-test body mass index data (t = -3.57, p<0.05) and Harvard step test (t = -4.26, p < 0.05) have been found statistical significant.

DISCUSSION

In this study, a statistical significance reduction in BMI and Harvard step test values has been determined for male students participated in 12 weeks aerobic workout.

When pre-test and post-test values with-in groups experimental group were examined, the difference in the body mass index average before exercise (18.97±1.33) and after exercise (18.35±1.10) was statistically significant (p < 0.05). On the other hand, pre-test and post-test values with-in control group were examined, body mass index average before exercise (19.77±1.12) and after exercise (19.81±1.14) was not statistically significance (p > 0.05). These findings are comparable with the findings of Arslan (2011) who investigated the effect of two exercise protocols (step-up and aerobic dance exercise) on body composition parameters after eight-week exercise. The study participants took part in a step-up and aerobic dance exercise programs for one hour per day, 3 days a week for 8 weeks. After the eight weeks of the step-up and aerobic dance exercise program, it was found that the decrease in the waist body mass index in exercise groups was significant. Similarly, Patricia (2008) tried to examine the effects of a 12-week exercise based training program on aerobic fitness and body composition. Their study found that exercise training significantly improved body mass index of the exercise group, but on the contrary, the body weight of the control group increased significantly at the end of the 12-week exercise intervention program period. Based on the findings of the current study, in parallel with the literature, aerobic exercises program can result a positive effect in body fat percentage.

Following 12-week aerobic exercise training the difference in the Harvard step test average before exercise (104.53 ± 12.55) and after exercise (118.27±12.55) in experimental group was statistically significant(p < 0.05). On the contrary, the difference in the Harvard step test average before exercise (104.13±11.45) and after exercise (103.67±12.41) in the control group was not statistically significant (p > 0.05). In lie with this, Williams and Morton

(1986)also conducted a 12-week aerobic dance exercise protocol. Accordingly, significant improvements were observed in VO_2 max, increased lean body mass and decreased body fat percentage following the 12 weeks exercise intervention. However, the difference of these parameters in the control group were not statistical significant. Mahendran (2009) also conducted similar study on the effects of 12-week aerobic exercises on selected health-related variables of body composition, cardiovascular endurance and muscular endurance. The exercise program protocols were walking, jogging, running and rope skipping at the end of exercise interventions a 12-minutes run test was given for the study participants**.** Mahendran I his finding showed that statistical significant in body composition, cardiovascular endurance and muscular on the study participants of experimental group $p < 0.05$. were observed, but not on control group. It can be can conclude that walking, jogging, running and aerobic dance increase the performance of step test exercise according to the study findings which is parallel to the literature.

CONCLUSION

Based on the major finding of this study, it was conclude that 12-week aerobic exercise training program has significantly improved on student's cardio-respiratory fitness and body composition on the study participants of experimental group. On the contrary, Student's participated in regular physical education class for 40-minute per week assigned as control group has no significant improvement on selected health related physical fitness components of cardio-respiratory fitness and body composition. So that, based on the findings indicated 40-minute physical education period may be limiting the students' performance to improve health-related physical fitness components. Therefore, it is better to revisit the period allocation of regular physical education practical class, i.e. the allocated, 40 minute per week for grade eleven curriculum needs modification to protect the student's health through movement and enhance physically fit, mentally alert, emotional stable and socially interactive citizens.

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Infestation of Ixodidae Ticks in Cattle: Prevalence and Associated Risk Factors in Ambo District, Western Ethiopia

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KEYWORDS:

Ambo district;

Cattle;

Ectoparasites;

Prevalence;

Risk factors;

Ticks

Research article

ABSTRACT

In Ethiopia, ticks cause serious economic loss particularly in ruminants. A cross sectional study was undertaken in Ambo district, Western Ethiopia from October, 2018 to June, 2019 with the major aim of estimating the prevalence, identifying the associated risk factors and the tick species of cattle in the area. From five purposively selected kebeles (the smallest administrative unit of Ethiopia) of the district, a total of 384 cattle were selected by systematic random sampling method. Adult Ixodid ticks were collected from different body parts of infested cattle, preserved in 10% formalin and transported to Ambo University Veterinary Parasitology Laboratory for stereomicroscopic identification to species level. Among 384 cattle examined, 201 (52.34%) cattle were infested with one or two tick species. Higher prevalence of tick infestation was recorded in Degele Gatira kebele (53.25%), followed by Abebe Doyo (50.65%), Gosu Kora (50.65%), Kisose Liban (50.65%) and Senkele Faris (56.59%). The study investigated three genera of Ixodid ticks namely Rhipicephalus (41.7%), Boophilus (0.8%) and Amblyomma (2.60%). Mixed infestations were common including Rh. Boophilus and Amblyomma 24(6.25%) and Rh. Boophilus and Rhipicephalus 4(1.04%). The study identified four species of ticks; namely *Rh. (Bo.) decoloratus* 109 (28.40%), *Rhipicephalus (Boophilus) annulatus* 43(11.20%), *Amblyomma vareigatum* 3(0.80%) and *Rhipicephalus evertsi evertsi* 11(2.90%). The difference in tick infestation was statistically insignificant (P >0.05) between different age groups and kebeles but statistically significant (P <0.05) among sex groups, breeds and different body condition scores (P <0.05). In conclusion, this study indicated high prevalence of tick infestation and identified most important ticks that can transmit various livestock diseases. Proper tick eradication campaign should be conducted to decrease the tick burden in the study area, and concomitantly reduce tick-borne diseases and associated economic losses.

INTRODUCTION

Ethiopia has an enormous and diverse livestock population that plays an important role in the economy and livelihoods of farmers and pastoralists (Akande *et al*., 2010). The country has 65 million cattle, 40 million sheep, 51 million goats, 8 million camels and 49 million chickens. From the total cattle population, 97.8%, 1.9% and 0.3% cattle are indigenous, hybrid and exotic, respectively (CSA, 2020).

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Despite the large animal population, their productivity is low due to poor nutrition, reproduction insufficiency, management constraints and prevailing livestock diseases (Bekele *et al*., 2010).

Parasitic diseases are among the major problems of domestic animals causing serious economic loss (Shiferaw, 2018). Ectoparasites are organisms which inhibits the skin or outgrowth of the skin of the host for various periods (Hopla *et al*., 1994). In Ethiopia, Ectoparasites in ruminant causes serious economic losses to small holder farmers, the tanning industry and the country as a whole through mortality, decreased production, downgrading and rejection of skin and hide (Peter, 2005). Ectoparasites can live permanently on their host, or they may occupy the host's nest and immediate environment, and visit the body of the host periodically (Gross *et al*., 2005). In either case, there is a close dependency on the host for various life sustaining resources (Gonzalez *et al*., 2004). From the Ectoparasites, ticks are ranked as the most economically important arthropods in tropics including sub-Saharan Africa (Abdela, 2016).

Ticks have adverse effect on livestock in several ways and parasitize a wide range of vertebrate hosts and transmit a wide variety of pathogenic agents than any other group of arthropods (Oliver, 1989; Belew and Mekonnen, 2011). Ticks transmit protozoa, bacterial, rickettsial and viral diseases. Moreover, Ticks down grade hide and skins quality and reduce milk and wool production, reduce productivity and increase susceptibility to the other diseases (de Castro, 1997). Ticks can predispose animals to secondary attacks from other parasites such as screw worm flies and infection by pathogens such as *Dermatophilos congolensis*, the causative agent of streptothricosis (Desta, 2010). There are various cattle tick-borne diseases in Ethiopia such as anaplasmosis, babesiosis, theileriosis (Mekonnen *et al*., 1992) and streptothricosis (Surafel and Amsalu, 2019).

Despite the known or existing challenges and the prevalence of tick-related problems in Ethiopia, there is a clear and notable lack of documented information regarding the specific species and associated risk factors of ticks in cattle within the study area. Therefore, the current study was designed and implemented with the objectives of estimating the prevalence of tick infestation, identifying the existing species of ticks and assessing the potential risk factors associated with the occurrence of hard ticks (Ixoid) in cattle in Ambo district, western Ethiopia.

MATERIALS AND METHODS

Description of the study area

The study was conducted in five kebeles (The smallest administrative unit of Ethiopia) of Ambo district namely Degele Gatra, Abebe Doyo, Gosu Kora, Kisose Liben and Senkele Faris from October, 2018 to June, 2019. Ambo district has a total of 35 kebeles. The area is located at latitude and longitude of 8°59'N, 37° 51'E, respectively and an elevation of 2101m above sea level. Ambo has livestock populations of 145, 371 cattle, 50,152 sheep, 27, 026 goats, 9, 088 horses, 2, 914 donkeys and 256 mules. The area is characterized by bi-modal rainfall with mean annual rainfall of 1129mm per year and annual temperature ranging from 10 to 28^{o}C (CSA, 2007; Firaol *et al*., 2014) .

Study Design and Study population

A cross sectional study was conducted on a total of 384 cattle randomly selected from the population. The study populations were includes both local and exotic breeds of cattle with different ages, sex and body condition cores. Out of the 35 kebeles found in the district, five kebeles were selected purposively for their accessibility and large cattle population. The age of the cattle was estimated based on the description given by Nicholson and Butterworth (1996), and then categorized as young (≤1 year), adult (1-3 years) and old (≥ 3 years). Similarly, based on their body condition scores, the cattle were classified as good, medium and poor.

Sample Size Determination and Sampling Method

The minimum sample size required for this study was determined according to the formula given by Thrusfield and Brown (2018). Accordingly, 95% confidence interval, 5% precision and 50% expected prevalence was used as there was no previous study conducted in the area.

$$\mathrm{N} = \frac{Z^2 * Pexp(1 - Pexp)}{d^2}$$

Where, N= required sample size, Z= confidence interval (95%), Pexp= expected prevalence and d = desired absolute precision. Therefore, the computed sample size was 384.

Collection & laboratory examination of ticks

Animals' body was visually examined for tick infestation and adult ticks were collected by using universal bottle containing 10% formalin. Each sample was correctly labeled (with age, sex, breed, Body condition and kebeles) and transported to Ambo University veterinary Parasitology Laboratory for identification to species level by using stereomicroscopic. Ticks identification was conducted following previous protocol described by Wall and Shearer (2001).

Data analysis

Data collected from the field and the laboratory were entered in to Microsoft Excel spread sheet and coded, and then analyzed using SPSS version 20. Descriptive statistics were used to know the prevalence of tick infestation, and association between the tick infestations and host risk factors (sex, age, breed, body condition score and kebeles) was assessed by Pearson Chi square test.

RESULTS

Out of 384 cattle examined, 201 (52.34%) were found infested with one or more ticks' species. There were statistically significant ($P<0.05$) association between tick infestation and sex, breeds and body condition scores whereas it was statistically insignificant ($P>0.05$) with age groups and kebeles (Table 1).

The study investigated three genera of adult Ixodid ticks; namely Rhipicephalus (41.7%), Boophilus (0.8%), Amblyomma (2.60%). Mixed infestations were common by Rhipicephalus (Boophilus) and Amblyomma 24(6.25%) and Rhipicephalus (Boophilus) and Rhipicephalus 4(1.04%) (Table 2).

Table 1: Relation between tick infestation and risk factors in Ambo district, western Ethiopia

Risk factors		Number examined	Prevalence n (%)	χ^2	p-value
Age	Young (1 year)	66	26(39.40)	1.3	0.515
	Adult (1-3 year)	195	107(54.90)		
	Old (>3 year)	123	63(51.22)		
Sex	Male	190	83(43.70)	11.3	0.001
	Female	194	118(60.62)		
Breed	Local	298	144(48.32)		
	HF	86	57(66.30)	8.6	0.003
BCS	Good	198	79(39.90)		
	Medium	117	60(51.30)		
	Poor	69	62(89.60)	51.2	0.000
Kebele	Degele Gatra	77	41(53.25)		
	Abebe Doyo	77	39(50.65)		
	GosuKora	77	39(50.65)	0.838	0.933
	KisoseLiben	77	39(50.65)		
	SenkeleFaris	76	43(56.60)		

Table 2: Distribution of tick genera in Ambo district, western Ethiopia from October 2018 to June 2019

Genus of ticks	Prevalence (%)
Amblyomma	3 (0.80)
Rhipicephalus (Boophilus)	160 (41.70)
Rhipicephalus	10 (2.60)
Amblyoma & Rhihipicephalus (Boophilus)	24 (6.25)
Rhipicephalus (Boophilus) & Rhipicephalus	4 (1.04)
Total	**201 (52.4)**
Species	
Rh. (B.) annulatus	43 (11.20)
Rh. (B.) decoloratus	109 (28.40)
A. variegatum	3 (0.80)
Rh. e. evertsi	11 (2.90)
Rh. (B.) annulatus & *A. variegatum*	3 (0.80)
Rh. (B.) annulatus & *Rh.(B.) decolratus*	6 (1.60)
Rh. (B.) decoloratus & *Rh. e. evertsi*	2(0.52)
..*Rh. (B.) decoloratus* & *A. variegatum*	21(5.50)
Rh. (B.) annulatus & *Rh. e. evertsi.*	3(0.80)

DISCUSSION

The overall prevalence of tick infestation (52.34%) recorded in the current study is comparable with previous report made by Tadele *et al*. (2018) (51.30%). However, it was far lower than the finding of Dabasa *et al*. (2017) (98.20%) and higher than the report of 33.21% by Surafel and Amsalu (2019). According to Pegram *et al*. (1981), tick activities and prevalence in a given area are affected by rainfall, temperature, altitude and atmospheric relative humidity and management

system including the use of accaricide and other preventive measures, agro-climatic condition and other epidemiological factors.

Cross breed cattle were highly affected by tick infestation compared with local breed cattle. This finding was in line with the result of Belay and Enyew (2016). However, it disagrees with the report of Surafel and Amsalu (2019). The higher prevalence of tick infestation in cross and pure exotic breed animals might be attributed to preimmunity against ectoparasites, which often established through contacts with the parasites at the early stage of their life (Ahmed *et al*., 2012).

The proportion of infestation was higher in adult and old animals as compared to young animals, which was most likely due to outdoor management and long distant mobilization of adult and old animals in search of feed and water as the result the chance of exposure to tick could be higher than that of younger animals (Sutherst and Maywald, 1983). In the current study, female cattle were more infested by tick (60.82%) than male cattle (54.90%). This finding was in line with the report of Shichibi *et al*. (2017) in Masha district. This could be partly explained by the high chance of physiological stress (pregnancy or lactation) which create favorable conditions to tick infestation and other external parasite infestations (Sutherst and Maywald, 1983).

Higher prevalence of tick infestation was recorded in thin cattle compared to medium and good body conditioned animals. This result was comparable with reports of Fanos *et al*. (2012) who conducted similar study in and around Mizan Teferi, Southwestern Ethiopia. However, it contradict with a study conducted in Gozamin Woreda, East Gojjam (Tadele *et al*., 2018). Animals with poor body condition had reduced resistance to tick infestation, lack of enough body potential to build resistance and they exposed to any kind of diseases when grazing on the field (Manan *et al*., 2007). On the other possible scenario, the poor body condition observed in those cattle with tick infestation could be due to the effect of the parasite on the energy balance of the animal.

In this study *Rh. (B.) decolaratus* was most abundant tick species (28.40%). This result was in line with Wasihun and Doda (2013) who reported a prevalence of 30.63% for this tick from Humbo district. In contrast to Amante *et al*. (2014), the current finding was lower. The variations could be due to the difference in the geographic area, climate, altitude and season during tick collection. Furthermore, *Rh. e.evertsi* was the third abundant tick species (6.72%) of the total adult tick collected. This result was slightly in line with the report of Abebe *et al*. (2010) who conducted similar study in Somali region, Ethiopia.

CONCLUSION

Tick infestation is the common problem in the study area that occurs on every other animal. *Rhipicephalus (Boophilus) decoloratus* are the leading genus of ticks affecting mainly exotic and cross breed, female cattle with poor body condition of adult to old age in the study area. Although, the prevalence of ticks was high in the study area, proper policies and strategies are not yet in place to control ticks and other external parasites. Therefore, sustainable tick control program should be introduced in order minimize the prevalence to the lowest level so that tick borne diseases and other tick associated problems can be prevented.

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Landslide Hazard Assessment and Zonation by using Slope Susceptibility Evaluation Parameter (SSEP) Rating Scheme- a Case from Debre Sina, Northern Ethiopia

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KEYWORDS:

Landslide Hazard Zonation;

Slope Susceptibility;

Debre Sina;

Landslide Triggering;

Slope Facet

Research article

ABSTRACT

Rainfall-induced landslides of different types and sizes frequently affect the hilly and mountainous terrains of the highlands of Ethiopia. The principal aim of the proposed research work was intended to prepare a landslide hazard zonation map of the area, particularly for hazardous zones. In this study, the Slope Susceptibility Evaluation Parameter rating scheme has been implemented as a relevant approach to map the landslide hazard of the Debresina area, which has experienced slope failure problems for a long period of time. The geology of the area includes quaternary sediments, ignimbrite, rhyolite, different kinds of basalts, and tuff deposits, which are highly weathered and changed into unconsolidated sediments at some localities. Locally observed geological structures such as joints, dykes, and other discontinuities have a considerable role in the initiation of landslide hazard. As a general methodology, a facet map was prepared from a topographic map (1:50,000) and rating values were assigned to each causative parameter (both intrinsic and external) based on its severity in triggering landslide hazard. The study area was classified in to three hazard classes, of which 25 % of the slopes fall in to a moderate hazard zone, while 58 % and 17 %were found to be high and very high hazard zones, respectively. Authentication of the landslide hazard zonation map with past landslide activities suggests the rationality of the considered leading parameters, the adopted technique, tools, and procedures in developing the study area's landslide hazard map. Furthermore, in order to validate the landslide hazard map prepared during the present study, active landslide activities and potential instability areas, delineated through inventory mapping, were overlaid on it, which yielded promising results.

INTRODUCTION

The earth's surface is always in a dynamic change. These changes are more pronounced in mountainous terrains as a result of different mass wasting processes. One of these mass-wasting processes is landslides (Hansen, 1984). According to Mohammad *et al*. (2012), landslide is a slow to rapid downward motion of unbalanced rock and debris masses because of gravity, whereas Baeza and Corominas (2001), identified landslides occur at a very slow rate, particularly in areas that are very dry and areas that receive sufficient rainfall such that vegetation has stabilized the surface. They may also occur at very high speed, such as in rock slides or landslides, with disastrous consequences, both immediate and delayed, e.g.,

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resulting from the formation of landslide dams (Saro and Biswajeet, 2006). Depending on techniques applied, activities involved, data analysis, scale of study, and data availability, various landslide hazard-mapping approaches were introduced. Barredo *et al*. (2000) divided these methods into inventory, heuristic, statistical, and deterministic approaches. Performing deterministic slope stability analyses demands a considerable amount of time and a deep understanding of both geological and geotechnical factors, coupled with a clear grasp of potential slope failure mechanisms. Besides, such analysis techniques may be suitably applied to small areas, at the scale of a single slope only (Clerici, 2002; Casagli *et al*., 2004; Raghuvanshi *et al*, 2014). McClelland *et al*. (1997) emphasized the heuristic or expert-driven approach, as a method in which a geomorphological expert decides on the type and degree of hazard for each area, using either a direct mapping or indirect mapping approach. This approach is a time consuming and it depends on a large degree on the expertise of the geomorphologist (Barredo *et al*, 2000). The statistical approach compares the spatial distribution of existing landslides in relation to different causative factors (Aleotti and Chowdhury, 1999). These methods are good for assessing the spatial probability but there are problems in evaluating either temporal probability or the effects of future environmental changes (Van Westen *et al*., 2006). The Landslide Hazard Evaluation Factor **(**LHEF) technique has been utilized successfully over the years by many researchers but as proposed by Raghuvanshi *et al*. (2014), its major drawback is that it does not account for external causative factors. Further, it does not predict for anticipated adverse conditions during construction and performance stage rather it offers stability condition for the slopes only for the existing situations prevailed at the slopes during the time of investigation.

In the current study effort is made to overcome the shortcomings of above approaches and thus, a slope susceptibility evaluation parameter (SSEP) rating technique, which encompasses both intrinsic and external parameters, has been implemented. Landslide problem has been causing lots of casualties, economic and social problems to societies especially to those who are living in the mountainous areas. According to Kifle Woldearegay (2013), the hilly and mountainous terrains of the highlands of Ethiopia are frequently affected by rainfall-induced landslides of different types and sizes. According to Gebreslassie (2011), the widespread occurrence of landslides in Ethiopia is largely due to a combination of predisposing factors, including rugged morphology, high topography, and the characteristics of outcropping rocks. The triggering factors are essentially connected with the rainfall regime and to a minor extent with seismicity (Gebreslassie, 2011). According to Asmelash Abay and Barbieri (2012), Debre Sina is located along the southwestern Afar rift margin, and it was frequently affected by landslides in the past few years. It is bounded by different mountains because of which it has experienced rainfall triggered landslides which endangered the life of people and destroyed public and private properties including various infrastructures.

MATERIALS AND METHODS

Description of the study area

Location and climate

The study area, Debre Sina, is situated in Amhara Regional State at a distance of 200 Km toward NNE of Addis Ababa, the capital city of Ethiopia. Geographically, it is bounded between UTM coordinates of 582000-593000 mE; 1080000-1100000 mN (Fig.1). The prevailing climatic condition of the area is "Dega" with mean annual rainfall of 1736 mm/year and temperature varying between 10°C to15°C.

Physiography and the drainage pattern

Physiographically, the study area is located in the Showan highlands, the smallest highlands of the Ethiopian northwestern highlands, which also includes the Tigrean north central massif, South Western highlands of Gojam and Gondar (Leta Alemayehu, 2007). The Showan plateau is bounded by the Ethiopian rift on the eastern and south eastern sides while Abay gorge border it on the north western side. The study area generally is characterized by highly variable topographical features which are a reflection of the past geological and erosion processes. The landscape includes plateaus, steep hill slopes, deeply incised valleys and gorges. The elevation of the study area ranges from 1500 m in the Southern sector to 3100 m in the Northern section.

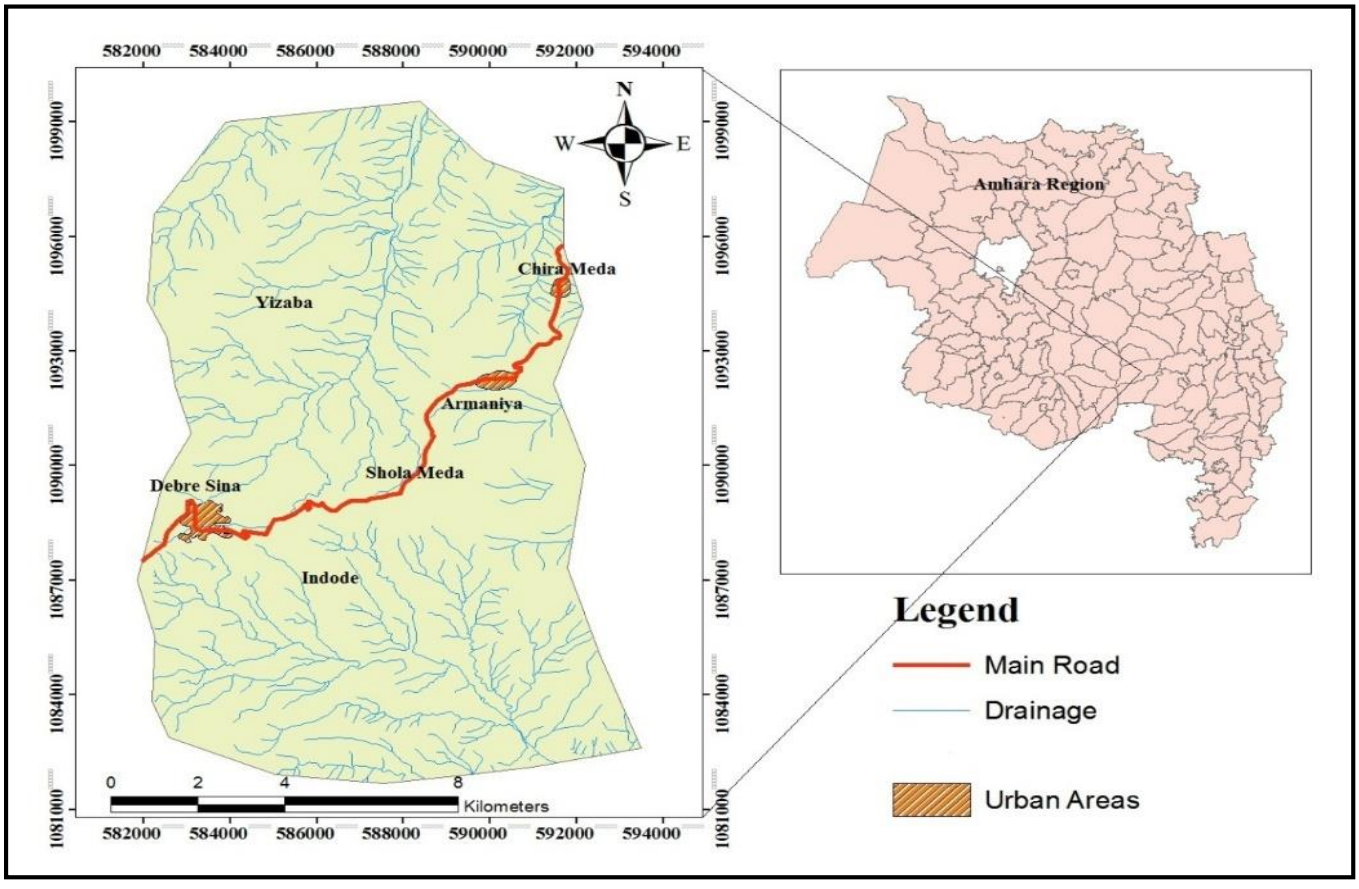

Figure 1: Location map of the study area.

The drainage system of the area includes many small tributaries feeding the main rivers. Most of the tributaries were dry during the present field visit. Majority of them, especially small tributaries, arise from high mountains and join the main rivers at the valley floor. The general drainage pattern of the study area is dendritic type as portrayed in (fig.1).

Geology

The Paleozoic–Mesozoic sediments associated with transgression regression of the sea and Cenozoic volcanic rocks which is directly overlying the Precambrian metamorphic and Mesozoic sedimentary rocks in Ethiopia (Kazmin, 1973). Among these rock units, the geology of the study area and its surroundings can be grouped in to the Cenozoic volcanic rocks (fig.2).According to Astis *et al*. (1997), the Ethiopian volcanics can be related to two main magmatic stages. The first is the Oligocene – Pliocene large fissure eruptions of basalts which build up abundant flood lava sequence known as Ashange and Aiba Basaltic Formations associated with late ignimbrite sheet (AlajiRhyolitic Formations).

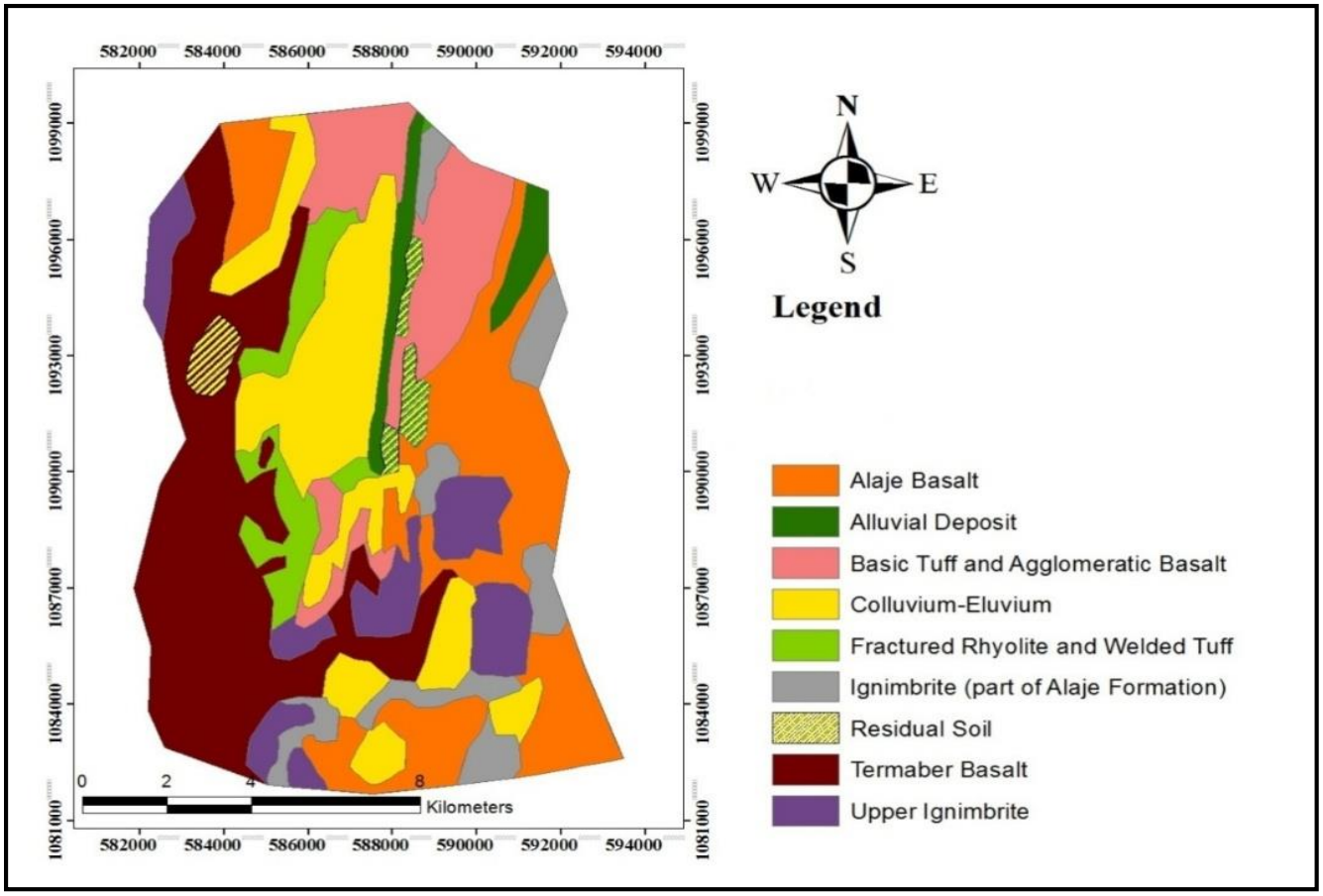

Figure 2: Geological map of the study area.

This magmatic stage ended with the development of large basaltic shield volcanoes, known as the Tarmaber Formation. However in the recent studies about the continental flood basalts of north-western part of Ethiopia, the whole formations were considered as a single unit (Hofman *et al.,* 1997; Pik*et al.,* 1998. Recent classification for continental flood basalt of North western part of Ethiopia was followed as Lower Formation, Upper Formation and the Shield Volcano. Both the Lower and Upper Formation of the continental flood basalt was emplaced 30 my ago within short period of time, less than 1My (Hofmann *et al*., 1997).

The central Ethiopian highlands exhibit a geological structure consisting of Tertiary volcanic rocks capping Mesozoic sedimentary rocks, which are visible only in the deep valleys carved by major rivers. Examples include: Abay Gorge, Jimma Gorge, and Mugher Gorge. According to Mohr and Zenitttin (1988), the Ashangie Formation has been defined by three characteristics: it has experienced a marked dip into the flow sequence of up to 40^{o}; flow thickness averages only about 5m; and individual flows are rarely traceable for more than a few kilometers along strike. Mohr and Zenitttin (1988), highlighted that the Aiba Formation is typically composed entirely of massive flood basaltic flows, with or without intervening agglomerate beds. According to GezahegnYirgu (1997), two major phases of magmatic activity took place, which produced different formations. A first phase was responsible for the eruption of lavas that built thick succession, up to nearly two kilometers, of fissural basalts (known as Ashange and Aiba Basaltic Formation) and later emplacement of a thick series, up to 500 meters, of silicic lavas mainly in the form of ignimbrite sheets (Alaji Rhyolite Formation). The building up of huge shield-like volcanic complexes followed this fissural magmatic stage from central vents with the predominance of basalts over evolved volcanics (Termaber Basalt Formation).

Methodology

Most of the landslide hazard zonation methods are based on the basic assumptions that mass movements are caused by the geological, geomorphic, human induced, etc. factors that can be described through physical parameters, and that the knowledge about these conditions enables drawing conclusions on future landslides (Lang *et al*., 1999). According to Anbalagan (1992), Landslide susceptibility maps can be constructed by using the relation between each landslide and causative factors. Different landslide hazard mapping methodologies in relation to types and scales are portrayed in Table 1.

Table 1: Methods of landslide susceptibility mapping in relation to types and scales.

Types	Techniques	Activities	Characteristics				Scale		
			Direct	Indirect	Qualitative	Quantitativ	1:100,000	1:25,000	1:10,000
Heuristic	Geomorphologic analysis	Use field-expert opinion in zonation	X	X	X		X	X	X
	Qualitative map combination	Use expert-based weight values of parameter maps		X	X	X	X	X	
Statistical	Bivariate statistical analysis	Calculate importance of contributing factor combination		X		X		X	
	Multivariate statistical analysis	Calculate prediction formula from data matrix		X		X		X	
	Probabilistic analysis	Calculate prediction from inventory and time period		X		X	X	X	
Deterministic	Safety factor analysis	Apply hydrological and slope stability models		X		X			X
Inventory	Remote sensing and field investigations	Show locations and characteristics of past landslides	X	X	X			X	

Landslide Hazard Evaluation Factor (LHEF) Rating Scheme

The weight rating system is usually designed in many different ways on the basis of studying the impact of each selected factor, for their importance in inducing the instability. Anbalagan (1992), has suggested a landslide hazard evaluation factor (LHEF) rating system that incorporates all the causative factors as listed in Table 2. The LHEF rating scheme may be more relevant as it is based on an empirical approach using important natural contributing factors of slope instability such as; lithology, structure, slope morphometry, land use and land cover, relative relief and hydro-geological conditions. In this scheme, the external factors including rainfall and seismicity have not been included. The maximum weight for individual factor has further been sub-divided into a number of categories to form a detailed LHEF rating scheme. This scheme can then be used for calculating total estimated hazard (TEHD) for individual facets. The total estimated hazard (TEHD) value indicates the net probability of instability of a slope facet. It is calculated slope facet-wise, because adjoining slope facets may have completely different stability situations. The TEHD value of an individual slope facet is obtained by summing up the ratings of each causative factor, obtained from the LHEF rating scheme for that slope facet. Thus, TEHD value is equal to the sum of ratings of categories of all causative factors. As depicted in Table 2, TEHD values are then arbitrarily categorized into different landslide hazard zones.

Table 2: Maximum LHEF rating for causative factors for macro-zonation.

S.No	Causative Factors	Maximum LHEF Rating
1	Lithology	2
2	Relationship of structural discontinuities with slope	2
3	Slope morphometry	2
4	Relative relief	1
5	Land use and land cover	2
6	Hydrogeological condition	1
	Total	10

The LHEF rating scheme employs an empirical method to evaluate slope instability by considering the individual and combined influences of inherent causative factors. These inherent factors then form the basis for Landslide Hazard Zonation. (LHZ) mapping on macro-zonation approach. Maximum values of rating for each parameter is awarded keeping in mind its estimated significance in resulting slope failure and also to denote overall field circumstances (Table 3).

Table 3. LHZ classes on the basis of Total Estimated Hazard (TEHD)

S.No	TEHD Value	Hazard Class
1	<3.5	Very Low Hazard (VLH)
2	3.5-5.0	Low Hazard (LH)
3	5.1-6.0	Moderate Hazard (MH)
4	6.1-7.5	High Hazard (HH)
5	>7.5	Very High Hazard (VHH)

Slope Stability Susceptibility Evaluation Parameter (SSEP) Rating Scheme

This landslide hazard zonation mapping methodology is a modified technique which is developed by Raghuvanshi *et al.* (2014) and is applicable in large areas demanding rapid slope stability assessment. It mainly relies on field data and produces landslide hazard zonation map by combining both intrinsic and external slope instability triggering parameters. It was developed in order to overcome the shortcomings of Anbalagan (1992) LHEF rating scheme and is found to be suitable to be applied in present study. The SSEP rating technique involves both internal and external activating parameters accountable for slope instability. The slope stability is mainly governed by intrinsic parameters such as; slope geometry, slope material (lithology or soil type), structural

discontinuities, land use and land cover and groundwater (Wang and Niu, 2009). In addition to the factors mentioned, both natural and human-induced external parameters that contribute to slope instability are also taken into account. The primary natural factors identified as triggers for slope instability include seismic activity (Keefer, 2000) and rainfall (Collison *et al*., 2000; Dahal *et al*., 2006). Other natural influences that can lead to slope instability, such as snow and avalanches, wind erosion, permafrost conditions, shoreline processes, and volcanic activity, are not considered in the SSEP for landslide hazard assessments. Manmade activities mainly include constructions and cultivation practices on slopes (Wang and Niu, 2009). Slope Facet is defined as a land unit, which is characterized by uniform slope geometry in terms of slope inclination and slope direction (Anbalagan, 1992). To demarcate the slope facets, topographic maps were utilized. Facet boundaries were delineated using prominent and minor hill ridges, as well as primary and secondary streams, along with other topographical features. For the present study, Debre Sina topo map of 1:50,000 was utilized to delineate slope facets of the study area. Rating values was assigned for each intrinsic and external causative factor based on its severity in landslide initiation and the summation of all causative factors will provide Evaluated Landslide Hazard (ELH). Finally landslide hazard zonation (LHZ) map was prepared based on the facet-wise distribution of ELH values. Table 4 portrays distribution of higher SSEP ratings assigned to each causal factor.

Table 4: Distribution of maximum SSEP ratings assigned to different intrinsic and external factors (Source: Raghuvanshi *et al.*, 2014)

Triggering Parameters		**Maximum Rating**
Intrinsic Parameters		
1. Slope Geometry	Relative Relief	1
	Slope Morphometry	2
2. Slope Material		1
3. Structural Discontinuities		2.5
4. Land use Land cover		1.5
5. Groundwater		2
External Parameters		
1. Seismicity		2
2. Rain Fall		1.5
3. Man-made Activities		1.5
Total		**15**

ELH= Summation of ratings of intrinsic parameters (relative relief + slope morphometry + slope material + structural discontinuity + land use and land cover + groundwater) + Summation of ratings of external parameters (rainfall + seismicity + man-made activities)

RESULTS & DISCUSSION

Preparation of facet map

For convenience and ease assessment of landslide hazard, the study area has been divided into different slope facets which were defined by major or minor hill ridges, primary and secondary streams, and other topographic waves. According to Anbalagan (1992), slope facets are characterized by more or less uniform slope inclination and slope direction. These slope facets were prepared from topographic map of scale 1:50,000 and verified in the field. Slope facet was used as base map to award rating values for landslide hazard triggering parameters (Table 5). The slope facets were usually delimited by ridges breaks in slope, streams, spurs, gullies and rivers etc. The facet maps form the basis for the preparation of thematic maps in general and SSEP mapping in particular and individual facet is the smallest mappable unit. In all 60 facets have been delineated in the study area on the basis of visual interpretation of topographic maps fig. 3a.

Landslide Hazard Triggering Parameters

For landslide hazard zonation, numerical ratings have been assigned to each of the internal and external activating parameters on the basis of their impact towards instability of slope, based on standard SSEP rating table.

Intrinsic Parameters

Intrinsic parameters are considered in hazard mapping because they play a great role in the stability conditions of the slope. These intrinsic parameters are relative relief, slope morphometry, slope material, structural discontinuities, land use and land cover and groundwater (Anbalagan, 1992; Wang and Niu, 2009). Based upon the given conditions for each of these internal parameters they may have an effect over the stability condition of the slope.

Relative Relief

Relative relief is one of the important causative factors which may cause slope instability. It affects the instability condition by increasing the gravitational energy which pulls the slope material down the slope. The relative relief map represents the local relief of maximum height between the ridge top and the valley floor within an individual facet (Anbalagan, 1992). Relative relief map of the study area has been prepared by taking the altitude difference between hill top and valley bottom within each slope facet which was later processed by ArcGIS-10.8 software. In the study area 57% of the facets fall in very high relative relief whereas 22% fall in high relief. The remaining facets (21%) fall in medium and moderate relative relief (fig.3d). This implies that more than half of the study area possesses very high relative relief which renders it susceptible to landslide.

Slope Morphometry

Slope morphometry map of the study area has been designed by calculating the slope angles from topographic map. The ratio of height difference between two points in a given facet to horizontal distance gives decimal value of the slope. By taking the inverse tangent of this value slopes in degrees have been manipulated. These slopes fall in to different slope classes as escarpment/cliff (> 45°), steep slope (36°-45°),

moderately steep slope (26°-35°), gentle slope (16°-25°) and very gentle slope (< 15°). Later, slope morphometry map of the study area has been prepared by using ArcGIS-10.8 software. Accordingly, 42% of the facets experience moderately steep slope (26°-35°) while 33% fall under gentle slopes. The remaining facets possess steep slopes, escarpment and very gentle slope which account for about 10%, 8% and 7%, respectively. Generally, most of the facets have moderately steep slope ranging from 26° to 35°(fig 3e).

Slope Material

The rock sub classes in SSEP rating system are adopted from classification of rocks based on field estimates of strength by observation which is proposed by (Hoek and Bray, 1997). Thus, slope material is classified as very weak rock (1-5 MPa), weak rock (5-25 MPa), medium strong rock (25-50 MPa), strong rock (50-100 MPa), very strong rock (100-250 MPa) and extremely strong rock (>250 MPa). Slope material map of the study area has been prepared from field observation using l:50,000 scale topographic map as base map (fig. 3f). Slope material of the study area is well described by highly weathered and fragmented rock mass that made it difficult to distinguish some rocks from soil during field visit. Ignimbrite, Alaje Basalt and fractured rhyolite are some of the lithologies on which intense weathering was observed. Generally, 38% of the study area is covered by medium strength rocks while colluvium materials cover about 27% of it. Highly weathered materials and weak rocks each comprise 22% and 13%, respectively.

Land Use Land Cover

Land use and land cover pattern is one of the important parameters governing slope stability. Vegetation has major role to resist slope movements, particularly for failures with shallow rupture surfaces. A well spreaded network of root system rises the shearing resistance of the slope material because of natural anchoring of slope materials, particularly for soil slopes. Moreover, a thick vegetation or grass cover reduces the action of weathering and erosion, hence adds to stability of the slopes. On the other hand, barren or sparsely vegetated slopes are usually exposed to weathering and erosion action, thus rendering it vulnerable to failure (Wang and Niu, 2009). Slope instability is also induced because of anthropogenic activities, i.e., urbanization, particularly on higher slope angles ($>30^0$). It not only removes vegetation cover but also adds to the natural weight of the slope as surcharge due to the weight of civil structures. In a hill slope with higher slope angle, buildings are usually located by constructing local cut slopes and flat terraces. With this concept urbanization is broadly classified into three categories (Zubair *et al*., 2012). A sparsely urbanization slope is where construction terraces are located far apart (more than 15 m of horizontal spacing) providing a considerable distance between two terraces along the slope. When we see the areal coverage of land covers in the present study area, bushes and shrubs alone cover 29 % of the study area whereas bare land comprises 23 %. On the other hand heterogeneous agricultural areas, arable land and forest encompass 20 %, 17 % and 11 % of the study area, respectively as shown on fig. 3c. The LULC map of the study area was

prepared from ERDAS 9.2 softer and later verified during field visit.

Groundwater conditions of the study area

The susceptibility of rock/ soil to failure is majorly determined by groundwater of an area. Hydrological characteristics of an area include underground water conditions, saturation state of rock/soil, presence of streams, rivers, and drainage pattern of the area. Water bodies displaced because of presence of interruptions and shallow water-table environments in hilly terrains along with torrential rainfall make the slopes susceptible to instability. According to Murck *et al*. (1996) during the prolonged monsoon phases, increased pore-water pressure creates favorable conditions for deep-seated landslides. In the present study area, groundwater is not uniformly distributed over all facets. Therefore, groundwater investigation has been conducted facet wise. Some facets have small flowing streams whereas others display wet to dry conditions. As fig. 3b depicts, surface terraces of groundwater of the study area portrays dry slopes (28 %), wet (22%), flowing (18 %), damp (18 %) and dripping (14 %), respectively.

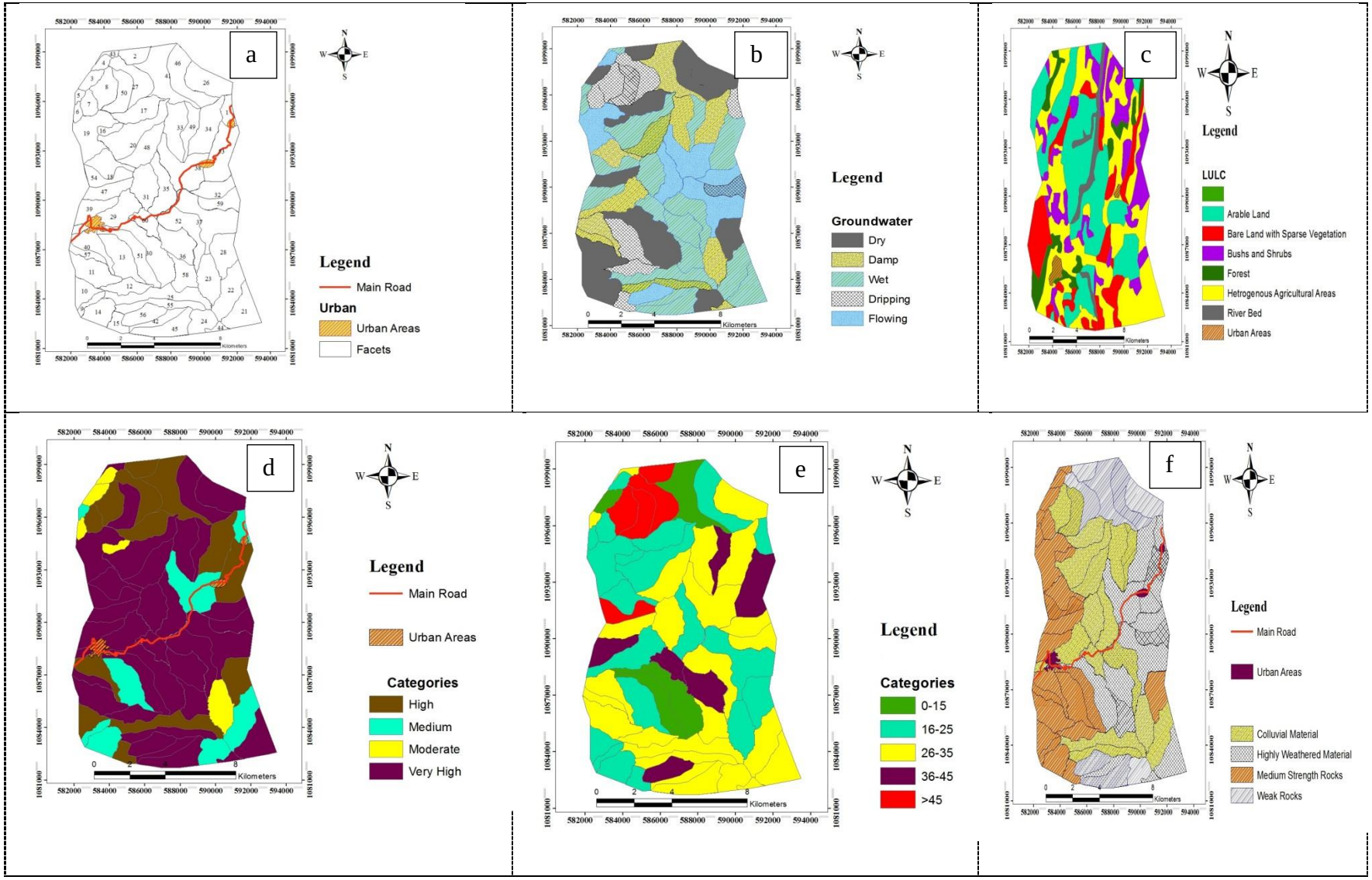

Figure 3: Maps showing slope facets and intrinsic landslide triggering parameters of the study area. (a)Slope facet;(b) groundwater;(c)land use land cover;(d) relative relief;(e) slope morphometry; (f) slope material.

External Landslide Hazard Triggering Parameters

Rain Fall

To assess and see the effect of rainfall to the landslide occurrences of the area, rain fall data for 35 years (1981-2013) was collected from National Meteorology Agency of Ethiopia. It indicates that the maximum, minimum and mean annual rainfall in the study area is 3592.7 mm, 683.6 mm and 1,735.591 mm, respectively. The maximum annual rainfall was recorded in the year 1997, while the minimum in the year 2012. The monthly maximum rainfall is always in the months of July and August for all the recorded data. The study area is one of the areas receiving a high rainfall in the country having a bimodal rainfall nature which possesses alternating dry and rainy seasons. It receives exceptionally peak precipitation in the months of July and August. These two months alone contribute 43% of annual precipitation, which maximizes landslide occurrences. On the other hand months such as; March, April, May and September experience moderate amount of monthly precipitation. Low amount of mean monthly precipitation is recorded in the months of October and November whereas December, January and February are generally regarded as dry months as they receive very low amount of monthly precipitation (fig. 4b)

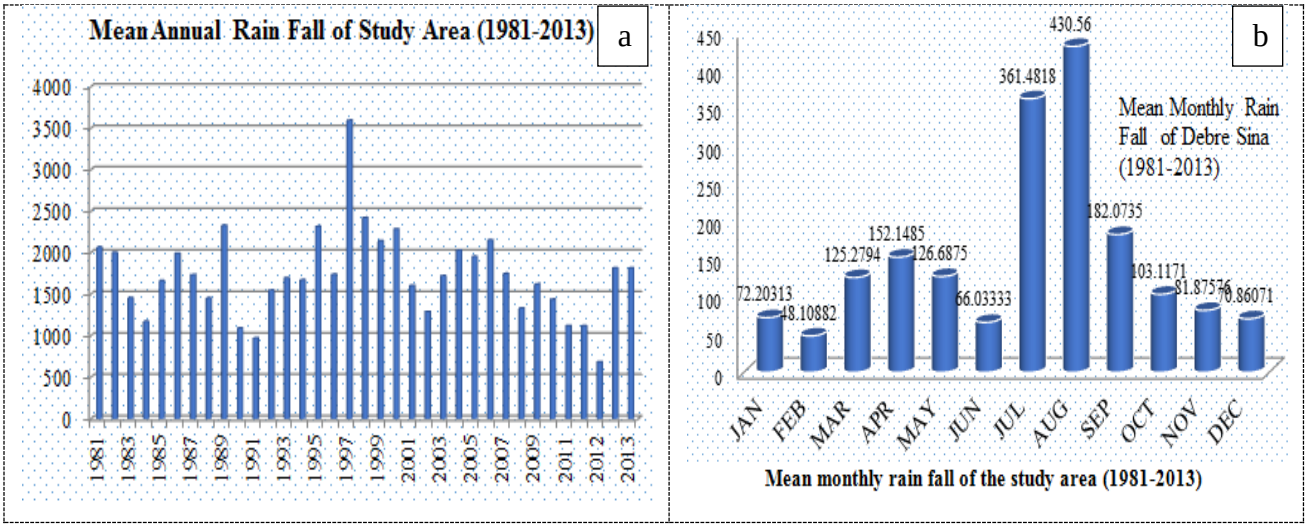

Figure 4: Mean annual and mean monthly rainfall of the study area (1981-2013).

Seismicity

Most of the landslides recorded in the study area happened when the annual rain fall exceeds the long term average rainfall. However, there were lower occurrences of major landslides between the years of 1983 to 1994 where the amounts of annual rainfalls were lower than the long term average except for 1986 and 1989.

The earthquake shocks may be responsible for triggering new landslides and reactivating old landslides. The vibrations due to earthquake may induce instability, particularly in loose and unconsolidated material on steep slopes. The Afar rift margin, where the study area is

situated, is known for its earthquake occurrences. Most of the earthquake ranges from small to medium level (Atalay Ayele, 2007). Although not registered, the occurrences of landslide in association with Afar earthquake in the area are common as evidenced by local dwellers. For example, as obtained from local information, there was a landslide occurrence around the Nibamba Gebriel and Sina Aregawi contemporaneous with the 1961 Kara-Kore earthquake.

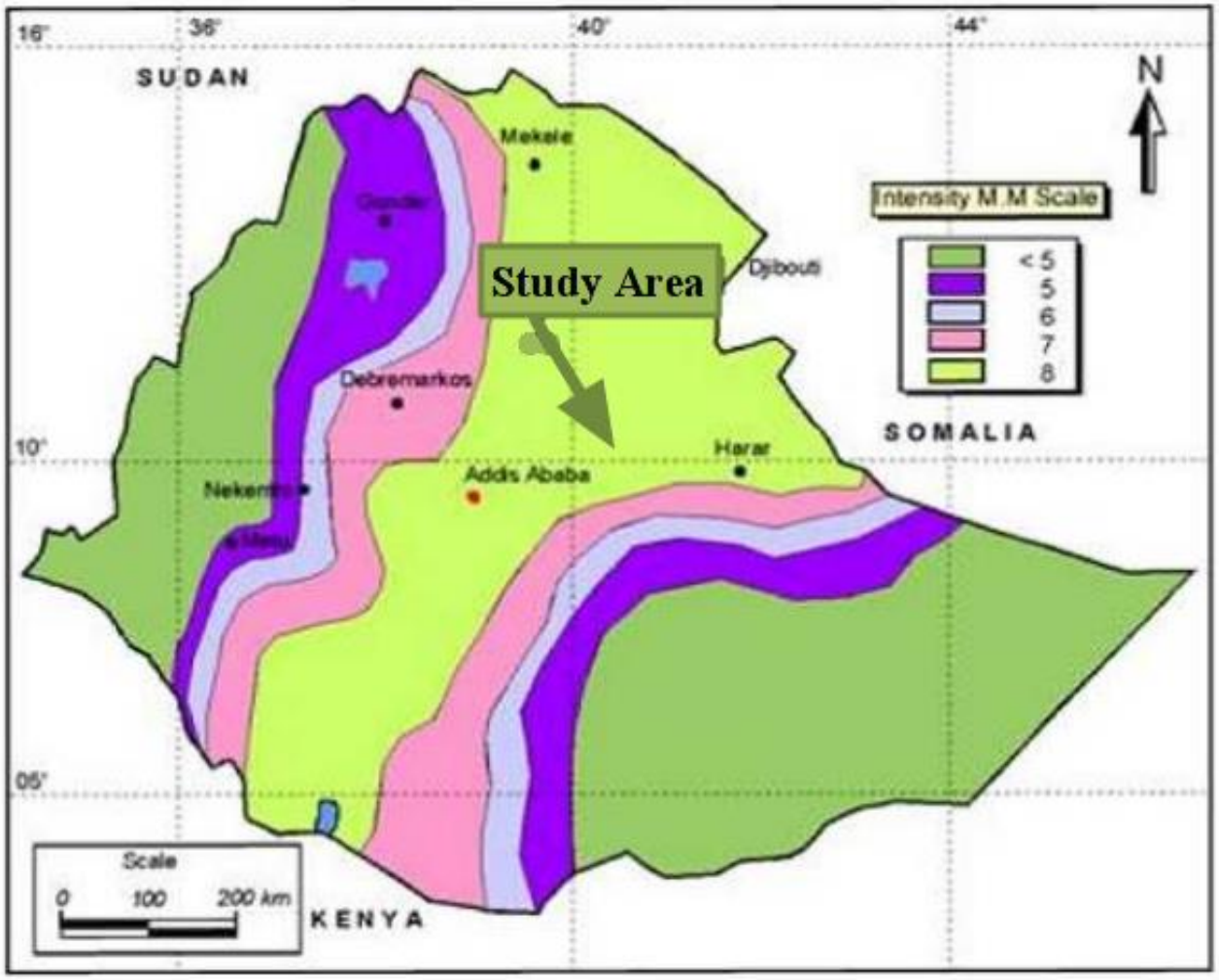

Figure 5: Seismic risk map of Ethiopia (Source: Laike Mariam Asfaw, 1986).

As portrayed above in figure 5, the present study area falls in seismic zone which has an intensity of 8, this zone has a ground acceleration of 0.1- 0.5g. Thus, the rating for ground acceleration of 0.1-0.5g, as per the standard SSEP table is estimated to be 1.5. Accordingly, this rating value has been

distributed to all 60 slope facets in order to generate landslide hazard zonation map of the study area. Earthquake induced landslide is so frequent in most parts of Ethiopia that it needs intensive analysis of causative factors for any landslide including seismic factor.

Table 5: Rating values assigned to each causative parameter in all slope facets

Facets	Relative Relief	Slope Morphometry	Structures	Groundwater	LULC	Slope Material	Man-made Activities	Seismicity	Rain Fall
1	0.6	0.6	1.66	0.6	0.4	0.5	1	1.5	0.75
2	0.8	2	1.86	0	0.4	0.8	1.25	1.5	0.75
3	0.2	0.3	2.31	0	0.75	0.8	1	1.5	0.75
4	0.2	0.6	2.49	2	0.4	0.3	1	1.5	0.75
5	0.6	1	1.82	1	1.5	0.4	0.75	1.5	0.75
6	0.2	0.6	2.5	1	1.5	1	0.75	1.5	0.75
7	0.8	0.6	2.38	1.5	1.2	0.5	0.1	1.5	0.75
8	0.8	2	1.84	1.5	1.5	0.4	0.1	1.5	0.75
9	0.6	0.6	1.58	0	0.4	0.4	0.1	1.5	0.75
10	0.8	0.6	1.88	0	0.75	0.5	0.15	1.5	0.75
11	1	1	2.49	0	1.5	0.4	1.25	1.5	0.75
12	1	1	2.23	1.5	1.5	0.1	1	1.5	0.75
13	0.6	0.6	2	1.5	0.4	0.4	1	1.5	0.75
14	0.6	0.6	1.86	0	0.75	0.8	1	1.5	0.75
15	0.8	1.7	2.5	1.5	1.5	1	1	1.5	0.75
16	0.2	0.6	2.43	2	1.5	1	1.25	1.5	0.75
17	0.8	0.6	1.86	0	0.4	0.3	1	1.5	0.75
18	1	0.6	2.24	0.6	1.2	0.3	0.5	1.5	0.75
19	1	1.7	2.32	2	1.5	1	1	1.5	0.75
20	1	0.6	1.81	0	0.4	1	0.1	1.5	0.75
21	1	1.7	2.5	2	1.5	1	1.25	1.5	0.75
22	0.6	1	1.6	1	0.4	1	0.75	1.5	0.75
23	0.2	0.6	2.11	0.6	1.2	0.8	0.15	1.5	0.75
24	0.6	1	2.13	0	0.4	0.8	0.1	1.5	0.75
25	0.8	1	2.38	1	0.4	0.25	0.75	1.5	0.75
26	1	1	2.5	0	0.4	0.5	0.75	1.5	0.75
27	0.8	2	1.71	2	1.5	1	1	1.5	0.75
28	0.8	0.6	1.94	0	0.4	0.5	0.1	1.5	0.75
29	1	0.6	2.39	0.6	0.75	1	1	1.5	0.75
30	1	0.3	1.78	0	1.5	1	0.1	1.5	0.75

….Continuation of Table 5

Facets	Relative Relief	Slope Morphometry	Structures	Groundwater	LULC	Slope Material	Man-made Activities	Seismicity	Rain Fall
31	1	2	2.32	1	1.5	1	1.25	1.5	0.75
32	1	1	2.16	2	0.4	1	1.25	1.5	0.75
33	1	1	1.6	0.6	0.75	0.5	1	1.5	0.75
34	0.8	1	2.45	0.6	1.2	0.8	0.75	1.5	0.75
35	1	0.6	1.62	2	0.4	0.1	1.25	1.5	0.75
36	1	1.7	2.46	2	1.5	0.4	1	1.5	0.75
37	1	0.6	2.17	2	1.5	0.8	0.75	1.5	0.75
38	0.6	1	2.5	2	1.5	1	1.25	1.5	0.75
39	1	1.7	1.69	1	0.4	0.8	0.1	1.5	0.75
40	0.8	1	2.22	0	0.4	0.8	0.1	1.5	0.75
41	0.8	0.3	2.48	0.6	0.75	0.8	0.75	1.5	0.75
42	1	1	2.03	1	0.4	1	0.15	1.5	0.75
43	1	1	1.94	1	1.5	0.5	1	1.5	0.75
44	1	1.7	2.48	1.5	1.5	1	1.25	1.5	0.75
45	1	1	1.55	0.6	0.4	0.8	0.1	1.5	0.75
46	1	0.6	1.7	0	1.2	0.5	1	1.5	0.75
47	1	1	1.64	0	0.75	1	0.1	1.5	0.75
48	1	1	1.83	0.6	1.2	0.5	0.75	1.5	0.75
49	1	1.7	2	1	1.2	1	0.1	1.5	0.75
50	1	2	2.48	1.5	0.75	0.8	1.25	1.5	0.75
51	1	0.3	2.24	0	0.75	1	1	1.5	0.75
52	1	1	2.5	1	1.2	1	1	1.5	0.75
53	0.8	1.7	1.98	1	1.5	0.5	0.75	1.5	0.75
54	1	2	2.33	1	1.5	0.5	0.75	1.5	0.75
55	1	1	1.84	0.6	1.2	0.8	1	1.5	0.75
56	1	1.7	2.4	2	1.5	1	1	1.5	0.75
57	1	1	2.39	0.6	1.5	0.4	1.25	1.5	0.75
58	1	1	1.98	0	1.2	0.4	0.1	1.5	0.75
59	1	1	2.08	1.5	0.75	1	1	1.5	0.75
60	1	1.7	2.08	1	1.2	0.4	1	1.5	0.75

Estimation of Evaluated Landslide Hazard (ELH)

The evaluated landslide hazard indicates the net likelihood of instability and has been calculated facet-wise. The ELH of an individual facet was obtained by adding the ratings of the individual causative factors obtained from the SSEP rating scheme. Evaluated Landslide Hazard is estimated as summation of ratings of intrinsic

and external parameters. On the basis of evaluated landslide hazard (ELH), three categories of landslide hazard zones have been identified for the present study area (fig.6) viz., moderate hazard (MH), high hazard (HH) and very high hazard (VHH). These zones are distributed in accordance with the geology and geomorphology of the area. Areal coverage of moderate hazard is 25 % whereas those of high hazard and very high hazard are 58 % and 17 %, respectively. These figures indicate that 75 % of the study area is very susceptible to landslide hazard

Moderate Hazard Zone

Moderate hazard zone represents relatively safe areas for construction and various infrastructural activities. It covers 25 % of the study area and out of 60 slope facets 15 fall in moderate hazard zone. Moderate hazard zones are commonly distributed in Northern, Central and Southern parts of the study area. Chira Meda area falls in this zone. Even if this zone is not totally suitable, it should not be avoided because it has less probability of landslide occurrence as compared to others.

High Hazard Zone

The maximum area of the study area is covered by high hazard zone which accounts about 58 % of the study area. This zone represents high susceptibility to landslide hazard as compared to moderate hazard zone. Some of the inventoried landslides are known to occur in this zone. High hazard zone is mostly dispersed in Northern, Eastern and Southern parts of the study area. Out of 60 slope facets, 35 are categorized under this zone. Part of the town Debre Sina and Armania also fall in High hazard zone. Those slopes falling in this zone should be partially avoided or detailed study on larger scale (1:1000) should be done to evaluate the status of stability of these slopes. Suitable control measures should also be identified before taking up constructions in order to minimize related geo-environmental hazards.

Very High Hazard Zone

This zone represents totally unsuitable areas for constructions and settlement as well as agricultural activities. It covers the least area coverage and accounts 17 % of the study area. Because of very high susceptibility of landslide occurrence in very high hazard zone, it is not advisable and should be totally avoided. About 10 facets of the study area have been identified to be very susceptible to landslide hazard. Among these, very high hazard zones are located in North-Western, Central and South-Eastern part of the study area. Part of town Armania also falls in this zone.

Validation of SSEP Results

The results obtained in present study correlated with the past landslide events recorded in the study area. Thus, the final Landslide Hazard Zonation map has been checked against the inventoried landslides of the study area for its validity. Landslide inventory map of the study area has been prepared by integrating field observation and GPS data collection with some ideas obtained by interviewing local people living around the study area. Most of the inventory landslides are concentrated in high and very high hazard zones. Out of 36 landslide inventories prepared during the field visit, 22 (61 %) of them fall in high hazard zone while

the remaining 14 (39 %) fall in very high hazard zone. The methodology followed during the present study relates intrinsic and external landslide triggering parameters to landslide occurrences. It has produced the results that match to past landslides. Thus, Slope Stability Evaluation Parameter (SSEP) rating scheme is found to be suitable methodology in landslide hazard zonation as it validated with the past landslide hazard events.

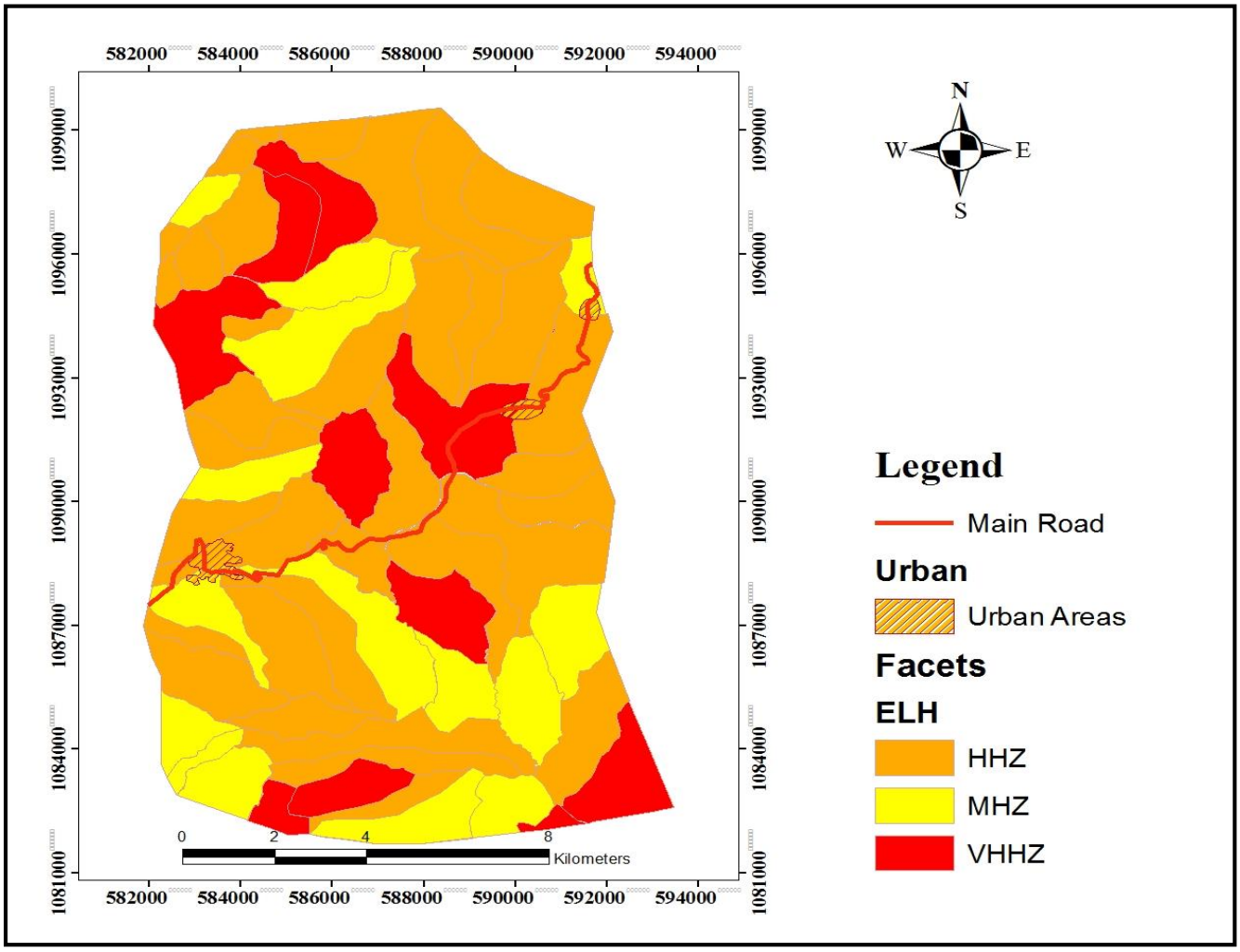

Figure 6: A map showing Evaluated landslide hazard of the study area.

CONCLUSIONS

The present study area has been affected by landslide hazard which devastated both public as well as private properties including infrastructures. It also threatened the life of people and animals living around the study area. Landslide hazard and fatalities have been reported in the study area for a long period of time. Several landslide hazard assessment approaches are available based on the kind of data input, study area size, data availability, kind of topography, etc., each of these approaches has its own benefits and shortcomings. Concerning slope susceptibility in the present study area, areas covered with

bare land, shrub and urban classes are more vulnerable to landslides, as compared to vegetation cover and forest classes which disfavor landslides. North, Northeast and West facing slopes are favorable to landslides, whereas South, Southwest and West orientation disfavor slope failure. Moreover, slopes inclined at greater than 25° angle have strong susceptibility to landslides. Distance to streams also has strong relations with landslide occurrence because areas close to streams prove to be highly prone to slope instability suggesting that slope undercutting by stream is an important process. Most of the recent landslides observed during field visit and delineated through inventory mapping fall into high and very high hazard classes suggesting the reliability of the SSEP rating scheme in delineating landslide prone areas of mountainous terrains. This approach is found to be more effective as it heavily depends on realistic field data andhelps to map landslides in large areas in a short period.

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Assessment of Vegetation in Murchison Falls National Park Five Years after the Completion of Oil and Gas Exploration

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KEYWORDS:

Biodiversity hotspot;

Ecological restoration;

Plant species diversity;

Uganda

Research article

ABSTRACT

Uganda discovered petroleum deposits in commercially viable quantities in 2006. Most areas such as Murchison Falls National Park (MFNP) where petroleum has been discovered overlap with wildlife and nature conservation with high biodiversity and sensitive ecosystems. This study sought to study the vegetation frequency index, relative abundance and diversity in former oil pads five years after the completion of oil and gas exploration in MFNP. We counted all observed plant species following a systematic random sampling technique using a (1mx1m) quadrat for herbs, (5mx5m) quadrat for shrubs, and (10mx10m) quadrat for trees. Data was collected using a 60m line transect to record the identified plant species. The study used a total of eight quadrats per transect and the total number of transects were 32. A quadrat was placed every after 7m along the line transect in and outside the oil pads. Each transect begun from the center (placard) of the oil pad going in directions of center to north, center to south, center to east, and center to west. This was carried out for purposes of replication and the same procedure was carried out for the control area. The same procedure was conducted at a frequency of wet (4^{th}-30^{th} April 2019) and dry (1^{st}-30^{th} June 2019) seasons. The counted data was later transformed and analyzed using t-statistical tests and chi- square tests in SPSS version 20 software. The study recorded uniform and non-uniform plant species and the mean vegetation diversity of 1.9±0.06 in oil pads and 1.71±0.12 in control areas. The study identified 31 different plant species, and among these, seven plant species were recorded in oil pads, eight in control areas. The results of vegetation relative abundance and diversity between oil pads and control areas were generally similar. However, the study observed some plant species such as Desert date (*Balanites aegyptiaca*) in control areas that were completely absent in oil pads. Further studies focusing on edaphic assessments, soil chemical, and biological analysis to better understand the impacts of oil exploration in the protected area are recommended.

INTRODUCTION

Oil was first discovered in western Uganda in the 1870s, but commercially viable oil was only confirmed in 2006 (Rwakakamba and Lukwago, 2013). Approximately 2.5 billion barrels of commercially viable oil of $2 billion worth in annual revenue for twenty years (Shepherd,

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2013) was discovered under the Ugandan portion of the Albertine Rift in 2006. This would make Uganda the fifth largest oil producer in Africa (Vokes, 2012). The government of Uganda went ahead in the early 2000s and licensed the exploration of oil prospects in the country. The government made agreements with oil companies which include Dominion Uganda Ltd, Tullow Oil plc, Heritage Oil and Gas Ltd and Neptune Petroleum Uganda Limited (NEMA, 2009). These companies discovered oil quantities in the Albertine Rift and along the boundary of Uganda and Democratic Republic of Congo (DRC). Uganda hosts a number of protected areas including the Queen Elizabeth National Park, Rwenzori Mountains National Park (both are World Heritage Sites), Kibaale, Semlikiand Murchison Falls National Parks, plus Toro-Semliki and Kabwoya wildlife reserves (USAID, 2007). Seven of the ten national parks and over 20 forest reserves are located in the Albertine Rift. The Albertine Rift provides ecosystem services such as tourism, water systems through lakes, rivers and wetlands. It also supports people by providing a source of livelihoods via forests, wetlands, minerals and fertile soils.

Global economic development and demand for energy have led to an expansion in oil and gas exploration, and oil and gas reserves in many cases overlap with protected areas and biodiversity Hot spots (Harfoot *et al*., 2018). For example, the Albertine Rift is a known hotspot of mammals, birds and plant species in Uganda. The wildlife law in Uganda allows exploration and extraction of oil under protected areas, provided that the impacts to the environment are minimized and where possible the natural habitat is restored after extraction. Initial drilling was promising, and it expanded from the Kabwoya Wildlife Reserve to other sites around Lake Albert including Murchison Falls National Park (MFNP). Uganda, Gabon and the Democratic Republic of the Congo are some of the African regions where oil exploration has occurred in protected areas (Coghlan, 2014; Dowhaniuk *et al*., 2018).

Human activities in a national park can lead to habitat loss from an increasing and expanding human population which is the greatest threat to a wide diversity of species (Brooks *et al*., 2002). Further causes of habitat loss can be recreation and transportation which may have an array of immediate and long-term impacts on species within wilderness parks (Trombulak and Frissell, 2000). Kityo (2011) also noted that other potential impacts due to increased human presence and traffic would include increased incidents of road kills, soil spills (an oil or fuel spill) on site which would result into an ecological disaster, destroying wildlife grazing rangelands and wildlife. Clearing of vegetation along seismic lines and pipelines can fragment habitat and alter predator–prey interactions (Borasin *et al*., 2002). Construction of drill pads, new roads and fences results into habitat loss and exacerbates fragmentation (UWA, 2012). Additionally, improved access to remote areas can increase poaching and the oil spills can have devastating effects on entire ecosystems (Johnson, 2007; Rwakakamba *et al*., 2014). Northrup and Wittemyer (2013) pointed out energy development impacts on wildlife as pollution, removal of vegetation for roads and oil pads, increased poacher access, altered animal migration and foraging habits. Oil and natural gas development poses heavy threats and dangers towards environmental conservation and the health and safety of the earth's biodiversity (Ericson, 2014). Increased road

traffic due to mining can also threaten protected areas due to increased access to biodiverse regions (Laurance *et al*., 2009), causing drastic change to land cover due to large human migration into areas with low human population density (Wilkie and Carpenter, 1999; Wilkie *et al*., 2000; Laurance *et al*., 2014).

From an ecological perspective, development can cause large-scale and novel alterations to ecosystems, resulting in habitat loss and fragmentation (Leu *et al*., 2008; McDonald *et al*., 2009) that strongly impact terrestrial wildlife populations and their ecosystems. The most important and large-scale cause of habitat fragmentation is the expansion and intensification of human land use (Burgess and Sharpe, 1981). Habitat fragmentation has three major components, namely loss of the original habitat, reduction in habitat patch size, and increasing isolation of habitat patches, all of which contribute to a decline in biological diversity within the original habitat (Wilcox and Murphy, 1985).

Oil extraction has shown to put biodiversity conservation at risk, as exemplified in the Niger Delta, where oil spills and gas flaring have damaged biodiversity, destroyed mangrove forests, contaminated beaches, coated birds, endangered fish hatcheries, and disrupted food webs (Ugochukwu and Ertel 2008).Human disturbances from oil and gas activities affect wildlife at different levels. It may affect the structure, composition, and distribution of wildlife populations on a landscape level (Wassenaar, 2005; Vistnes and Nellemann, 2008). Various studies have indicated that wildlife displacement is a result of disturbance. For example, in the US state of Virginia, reclaimed coal mines had fewer salamanders (Corrozino, 2009). In the state of Montana, elk continued to avoid a drill pad even after drilling was completed (Dyke and Klein, 1996). The state of California registered lower bird species richness and abundance four years after the restoration of flood control structures (Pattern and Rotenberry, 1998). Wyoming State in the US experienced the displacement of elks for 2 weeks during the seismic surveys (Gillin, 1989). Land-use changes and degradation of ecosystems by humans are the biggest global threats to biodiversity and ecosystem services (Foley *et al*., 2005; Hooper *et al*., 2012).

Oil exploration and production has various phases ranging from seismic surveys, exploratory drilling which confirms the existence or absence and quantities of hydrocarbon reservoirs. This is followed by appraisal drilling whose intention is to know if the reservoir is economically viable for development. This is followed by development and production, and the final stage is decommissioning (Kasimbazi, 2012). In some cases, this is followed by restoring the site to environmentally sound conditions. It is achieved by implementing measures to motivate site re-vegetation and constant monitoring of the site after closure. For the case of MFNP, all drill pads and pad access roads north of the Nile were restored upon completion of appraisal drilling in early 2014 (Fuda, 2018). Restoration involved removal of all equipment and murram (a laterite soil used for building roads in East Africa) at the site, scarification of subsoil, reinstatement of topsoil and translocation of native grasses from nearby areas to the decommissioned access road and pad footprint (Total E&P Uganda, 2013). There was no reforestation of native trees or shrubs, which caused in restored sites being more profoundly

dominated by grasses, in relative to surrounding areas. Thus this study sought to assess the status of vegetation of the former oil pads post exploration stage. We were able to achieve that by studying the vegetation composition in former oil pads by comparing it with sites that are presumed to have never gone through anthropogenic disturbances.

MATERIALS AND METHODS

Study Area

Murchison Falls National Park (MFNP) is located in the northwestern region of Uganda and the study area is in the northern part of the park which is the main tourism circuit area. The study sites were located in Exploration Area 1 and they included Jobi 4 with a coordinate of 2 º20'09.5"N, 31 º29'52.4"E and Jobi East 7 having a coordinate of 2º20'45.4" N, 31º32'26.8" E (Figure 1). The study area consists mainly of mosaic grassland, dense borassus woodland, open borassus woodland; open woodland, wooded grassland and bush/shrub. The park's topography is rolling, reaching a maximum elevation of 1,291 m at Rabongo Hill in the south east of the park, and the lowest elevation of 619 m at Lake Albert on the rift valley floor in the west. The park is hot with mean minimum temperature of 22°C and maxima of 29°C all year round. The eastern part of the park is wetter than the western part; Chobe to the East receives around 1,500 mm whilst Paraa receives about 1,100 mm per year. Murchison Falls National Park has two rainy seasons, from mid-March to mid-June, and from August to November (UWA 2001). The two exploration sites were drilled and restored by replanting of vegetation at different time periods (Table 1). Control areas were outside the selected oil pads within the same location. Restoration involved removal of all equipment and murram (a laterite soil used for building roads in East Africa) at the site, scarification of subsoil, reinstatement of topsoil and translocation of native grasses from nearby areas to the decommissioned access road and pad footprint (Total & Uganda, 2013). There was no replanting of native trees or shrubs, which caused in restored sites being more heavily dominated by grasses, in relative to surrounding areas

Table 1: Time period of exploration and restoration of the study sites

Exploration Site	Drilled	Restoration completed by
Jobi 4	March- April 2013	June 2013
Jobi East 7	July- August 2013	May 2014.

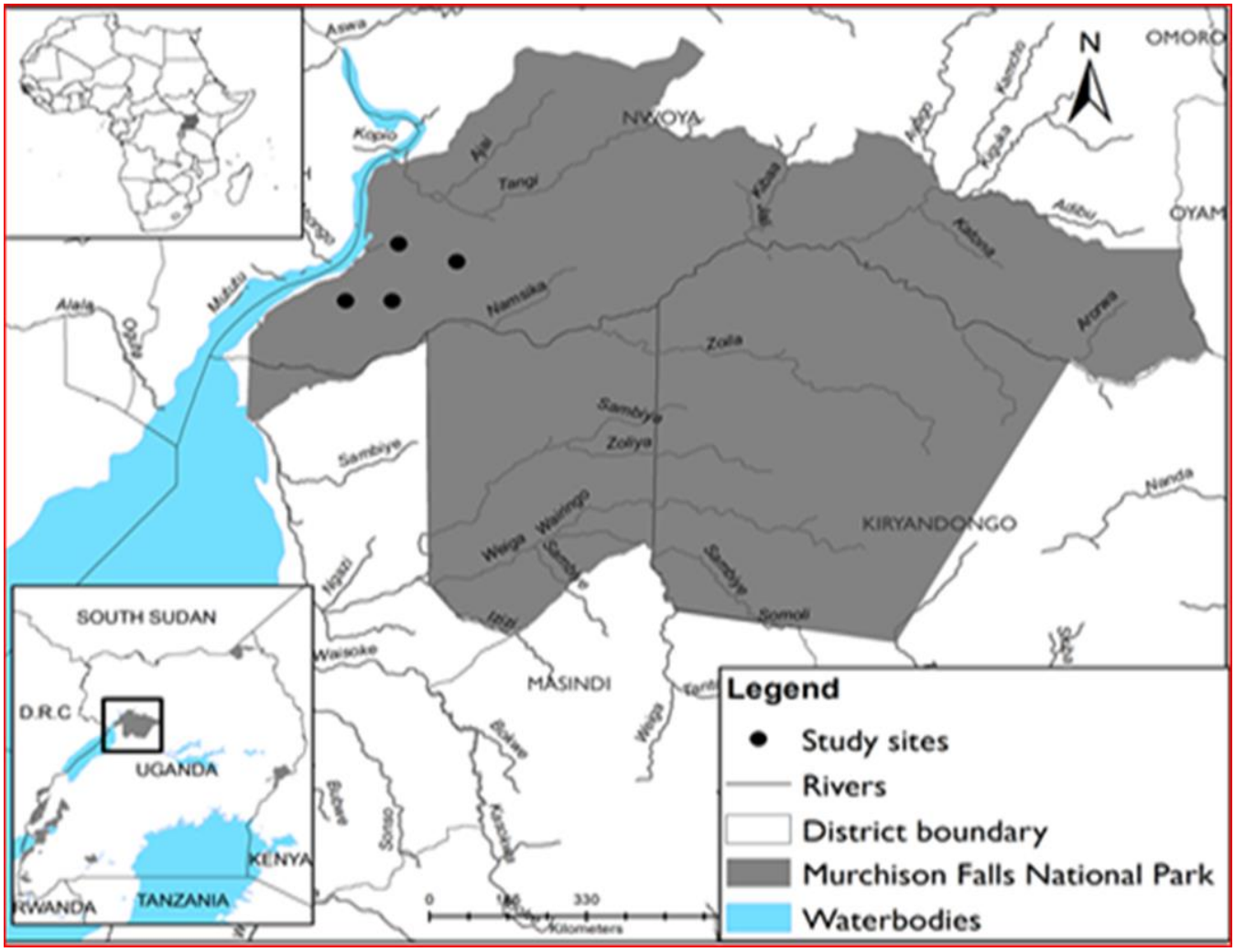

Figure 1: Location of study sites in Murchison Falls National Park in northwest Uganda

Research Design

The study used quantitative research designs which involved purposive sampling to select the exploration sites and control areas. This was on basis of easy accessibility, the cost involved in travelling, time available, and sites must be under the mandate of Uganda Wildlife Authority. The oil pad sites under the study were selected based on the fact that they must be somewhat a habitat to the mammals in the park. The control area sites were selected based on the assumption that they had the same environmental conditions as the oil pads (Jobi 4 and Jobi East 7) and had never gone through any human disturbance. The control areas were located 120m away from the oil pad sites. Plant counts were replicated for both wet (April 2019) and dry (June 2019) seasons in and outside the oil pads. The study conducted replicated counts along transect lines as one of the sampling principles to ensure that difference in encounter rate (number of objects detected per unit survey effort) can be sufficiently estimated. All transect lines were replicated following similar randomization scheme to give all locations in the study area a known, non-zero probability of being covered by a transect (Figure 2). The

study used a dichotomous key to identify the plants during the study. Identification of the plants was made at the sites without carrying samples to herbarium because it would be tedious. Moreover, the research permit issued to us to conduct research in a protected area does not permit carrying plant species outside the park. One of the research assistants involved during data collection was a qualified botanist experienced in plant identification, which made plant identification easy.

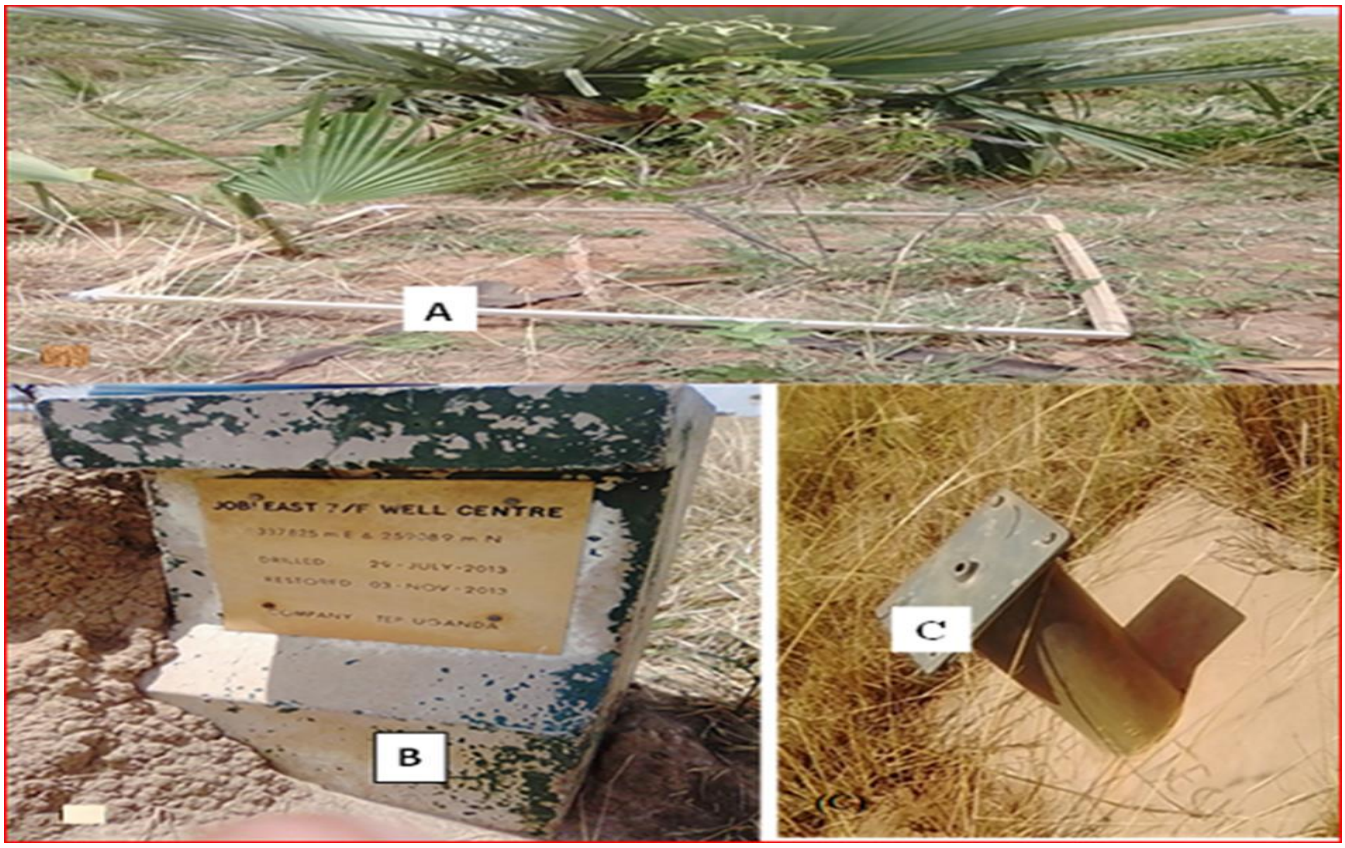

Figure 2:(A) is the 1x1m quadrat used to count plants along a transect, (B) is the placard bearing the oil pad name, time of drilling and restoration, (C) is the borehole that once supplied water to the oil pad camp.

Data Collection

Plant species counts were conducted in and outside the former oil pad sites using observation and recording method. A systematic random sampling technique (Greig-Smith, 1983) was followed by using a 1 x 1m quadrat for herbs, 5 x 5m quadrat for shrubs, and (10x10m) quadrat for trees. Data was collected following a 60m line transect to record the identified plant species. A quadrat was placed every after 7m along the line transect in and outside the oil pads. In total 8 quadrats x 4 line transects were followed for the sites under the study. Each transect begun from the center (placard) of the oil pad going in directions of center to north, center to south, center to east, and center to west. This was carried out for the purposes of replication in order to get the true representation of each site and the same

procedure was carried out for the control area. The same procedure was conducted at a frequency of wet (4th-30th April 2019) and dry (1st-30th June 2019) seasons. It should be noted that the study intentionally measured vegetation frequency index, vegetation relative abundance and vegetation diversity but did not put in to account the relative cover of the observed plant species due to the limited time and resources that were available for the study. The study was primarily concerned with the uniformity and composition of the plant communities as a whole not the nature of plants and coverage across the sites under the study.

Data Analysis

Vegetation Frequency Index

The vegetation frequency index was determined using Equation 1. The obtained frequency indices were analyzed using Raunkier's law of frequency (1962), which is often used to study the homogeneity or uniformity of plant species in an area.

$$FI = \left\{\frac{No. of\ units\ in\ which\ the\ species\ occured}{Total\ no. of\ units\ studied}\right\} x\ 100 \ldots\ldots (1)$$

This law of frequency assumes bimodality occurrences to describe vegetation abundance per unit area, which assumes that species are, either present or absent. In Raunkiaer's law, species are categorized in levels/classes based on frequency as: level A (0-20%); B (21-40%); C (41-60%;) D (61-80%); and E (80-100%). The normal frequency ratio is valuable in several kinds of studies in testing the homogeneity of the vegetation in a given area.

Frequency levels are interpreted as A>B<C>D<E; In general, the higher class E has greater homogeneity/uniformity of the vegetation. The most essential point being that class E should be larger than class D with greater number of species in class E than in D. Class A means the plant species under study are very scarce, B means occasional presence, C means infrequent presence, D means frequent presence and E means abundant or very numerous presences of the plant species under the study.

Vegetation Relative Abundance

The vegetation relative abundance (RA) was determined by employing Equation 2, where A refers to the observed individual plant species.

$$RA = \left\{\frac{Total\ no. of\ species\ A}{Total\ no. of\ individual\ of\ all\ species\ recorded} x\ 100\right\} (2)$$

However, the study compiled mean vegetation abundance of each plant species observed to compare the mean values using t statistical tests. Mean vegetation relative abundance (μ) was computed by summing up the total number of each plant species (x) observed divided by the total number of quadrats used in the study (Equation 3).

$$\mu = \frac{Sum\ of\ plant\ species\ x}{Total\ number\ of\ quadrats} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

All data sorting and computing was conducted using Microsoft excel sheets before being transferred to SPSS software for further t-statistical tests.

Vegetation Diversity

Vegetation diversity was computed using Shannon Weiner diversity index (H) that was determined by Equation (4). The corresponding

H Max values and equitability values were calculated as well as to help make scientific conclusions of the collected data. Calculations were determined using Microsoft Word Excel 2010 before exporting it to SPSS version 20 for t - statistical analysis. Vegetation relative abundance and diversity between oil pads and control areas were analyzed using t statistical tests in SPSS version 20 at p=0.05 significance level.

$$H = \sum_{i=1}^{s} p_i \ln p_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

In the Shannon index, p is the proportion (n/N); of individuals of one particular species present (n) divided by the total number of individuals present (N), **ln** is the natural logarism, Σ is the sum of the calculations, and **s** is the number of species. H max values are determined when each group has the same frequency referred to as maximum diversity possible [log(x)].

Shannon equitability value or Evenness (E) was also determined using Equation (5).

$$E = \frac{H}{Hmax} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where H= Shannon-Weiner diversity index, H_{max} = ln(s) and S = total number of species in the sample.

RESULTS

Vegetation frequency index per transect

The frequency index analysis from the study shows that some plant species are more uniform than others (Table 2). The plant species that were observed to be uniform in both oil pads and control areas include Thatching grass (*Hyparrhenia hirta*), Cat's tail drop seed (*Sporobolus pyramidalis*), Nut grass (*Cyperus rotundus*) and Wandering jew (*Commelina benghalensis*). Plant species which are more uniform in oil pads than control areas include Garden signal grass (*Urochloa panicoides*), Hippo grass (*Vossia cuspidate*), Creeping wood-sorrel (*Oxalis corniculata*), Star grass (*Cynodon dactylon*), Goats weed (*Ageratum conyzoides*), Devil horsewhip (*Achyranthes aspera*), Pickerel weed (*Pontederia cantata*), Tick berry (*Lantana camara*), Wait a bit thorn (*Acacia mellifera*), White thorn acacia tree (*Vachellia constricta*), and Candle bush (*Senna alata*). However, some plant species were recorded to be less uniform in oil pads than control areas and they include Feathered chloris (*Chloris virgate*), Bur bristled grass (*Setaria verticillata*), Desert date (Balanites aegyptiaca), Hoket horn (*Arisonia abyssinica*), Garden pink-sorrel (*Oxalis latifolia*), Borassus palm tree (*Palmyra palm*), Edible canna (*Canna eduls*), Guatemala (*Tripsacum laxum*), Sticking weed (*Acacia okidetalia*), Treedax daisy (*Tridax procumbens*), and Whistling acacia (*Acacia hoki*). Other recorded plant species in the study had similar uniformity in oil pads and control areas and they include Finger grass (*Digitaria eriantha*), Fibrous drop seed (*Sporobolus stafianus*), Nandi grass (*Cetera ancient*), Wild canny lilly flower (*Canna indical*), and Baboon apple (*Annona glabra*).

Table 2: Frequency Index, Frequency Classes, and Vegetation Relative Abundance of the observed plant species per transect in oil pads and control areas.

Observed Plant Species	Scientific Name	OP-FI	FC	CA-FI	FC	OP-VRA	CA-VRA	*Sig. Value*
Thatching grass	*Hyparrhenia hirta*	100	E	87.5	E	103.8±30.6	169.6±47.8	*
Cat's tail drop seed	*Sporobolus pyramidalis*	100	E	87.5	E	95.8±20.1	148.1±41.8	*
Nut grass	*Cyperus rotundus*	100	E	100	E	42.3±9.8	95.5±20.0	*
Wandering jew	*Commelina benghalensis*	100	E	100	E	48.6±10.2	58±8.5	*
Feathered chloris	*Chloris virgata*	12.5	A	50	C	9.8±4.9	57.5±28.1	*
Bur bristled grass	*Setaria verticillata*	0	A	12.5	A	0±0	0.75±0.74	***
Desert date	*Balanites aegyptiaca*	0	A	37.5	B	0±0	9.8±8.9	***
Hoket horn	*Arisonia abyssinica*	0	A	12.5	A	0±0	2.8±2.7	**
Candle bush	*Senna alata*	12.5	A	0	A	4.1±4.1	0±0	***
Garden signal grass	*Urochloa panicoides*	50	C	0	A	1.4±1.4	0±0	**
Hippo grass	*Vossia cuspidata*	50	C	0	A	7.8±3.1	0±0	***
Creeping wood-sorrel	*Oxalis corniculata*	50	C	37.5	B	18.6±11.6	14.6±8.0	NS
Finger grass	*Digitaria eriantha*	50	C	50	C	17.4±8.9	9.8±4.0	NS
Garden pink-sorrel	*Oxalis latifolia*	50	C	75	D	15.3±8.4	9.8±4.5	NS
Star grass	*Cynodon dactylon*	87.5	E	75	D	14.5±5.5	13.4±4.2	NS
Fibrous drop seed	*Sporobolus stafianus*	25	B	37.5	B	11.1±8.9	14.1±10.4	NS
Whitethorn acacia tree	*Vachellia constricta*	37.5	B	12.5	A	0.9±0.4	0.9±0.9	NS
Baboon apple	*Annona glabra*	25	B	12.5	A	0.9±0.6	10.6±10.6	NS
Borassus palm tree	*Palmyra palm*	12.5	A	50	C	0.3±0.2	2.6±1.5	NS
Goats weed	*Ageratum conyzoides*	62.5	D	25	B	8±3.7	0.9±0.7	NS
Nandi grass	*Cetera ancient*	12.5	A	12.5	A	0.6±0.6	1.5±1.5	NS
Wild canny lilly flower	*Canna indical*	50	C	50	C	4.6±2.1	5.5±2.2	NS
Devil horsewhip	*Achyranthes aspera*	12.5	A	0	A	0.3±0.2	0±0	NS
Edible canna	*Canna eduls*	0	A	12.5	A	0±0	0.4±0.4	NS
Guatemala	*Tripsacum laxum*	0	A	12.5	A	0±0	0.3±0.2	NS
Pickerel weed	*Pontederia cantata*	12.5	A	0	A	2.8±2.7	0±0	NS
Sticking weed	*Acacia okidetalia*	0	A	12.5	A	0±0	0.1±0.1	NS
Tick berry	*Lantana camara*	12.5	A	0	A	2.9±2.9	0±0	NS
Treedax daisy	*Tridax procumbens*	0	A	12.5	A	0±0	2±1.9	NS
Wait a bit thorn	*Acacia mellifera*	37.5	B	0	A	0.8±0.4	0±0	NS
Whistling acacia	*Acacia hoki*	0	A	25	B	0±0	3±2.0	NS

*OP = Oil Pads, CA = Control Areas, FI = Vegetation Frequency Index / Percentage Frequency, FC = Raunkiaer's Frequency Classes, A = (0-20%), B = (21-40%), C = (41-60%), D = (61-80%), E = (81-100%), Raunkiaer's Formula A>B>C<D<E, OP-VRA = Oil Pad Vegetation Relative Abundance, CA-VRA = Control Area Vegetation Relative Abundance, Sig.Value = Significant Value, NS= Non Significant difference, *(p<0.05), **(p<0.01), ***(p<0.001), Total number of quadrats per transect= 8, Total number of transects in oil pads = 16, Total number of transects in control areas = 16*

Vegetation relative abundance per transect

The vegetation relative abundance in oil pads has no significant difference from the vegetation relative abundance in control areas (t= -1.946, d.f=30, p=0.061). However, the results show that there were some plant species that were significantly more abundant in control areas than in the oil pads (Table 2) which include Thatching grass (*Hyparrhenia hirta*), Cat's tail drop seed (*Sporobolus pyramidalis*), Nut grass (*Cyperus rotundus*), Wandering Jew (*Commelina benghalensis*), Feathered chloris (*Chloris virgate*), Bur bristled grass (*Setaria verticillata*), Desert date (*Balanites aegyptiaca*), and Hoket horn (*Arisonia abyssinica).* On the other hand, some recorded plant species were more significantly abundant in oil pads than control areas and they include Candle bush (*Senna alata*), Garden signal grass (*Urochloa panicoides*), and Hippo grass (*Vossia cuspidata*).

Table 3: Plant species recorded per transect in oil pads and control areas

Species Common Name	Scientific Name	Type of Plant	Oil Pads	Control Areas
Baboon apple	*Annonaglabra*	Shrub	+	+
Borassus palm tree	*Palmyra palm*	Tree	+	+
Bur bristled grass	*Seteriaverticullata*	Grass	-	+
Candle bush	*Sennaalata*	Tree	+	-
Cat's tail drop seed	*Sporoboluspyramidalis*	Grass	+	+
Creeping wood-sorrel	*Oxalis corniculata*	Grass	+	+
Desert date	*Balanites aegyptiaca*	Shrub	-	+
Devil horsewhip	*Achyranthesaspera*	Shrub	+	-
Edible canna	*Canna eduls*	Shrub	-	+
Feathered chloris	*Chlorisvirgata*	Grass	+	+
Fibrous drop seed	*Sporobolusstafianus*	Grass	+	+
Finger grass	*Digitariaeriantha*	Grass	+	+
Garden Pink-sorrel	*Oxalis latifolia*	Grass	+	+
Garden signal grass	*Urochbapanicoides*	Grass	+	-
Goatsweed	*Ageratum conyzoides*	Grass	+	+
Guntamala	*Tribsacumlaxom*	Grass	-	+
Hippo grass	*Vossiacuspidata)*	Grass	+	-
Hokes horn	*Harrisoniaabyssinica*	Grass	-	+
Nandi grass	*Cetera ancient*	Grass	+	+
Nut grass	*Cyperusrotundus*	Grass	+	+
Pickerel weed	*Pontederia cantata*	Grass	+	-
Star grass	*Cynodondactylon*	Grass	+	+
Sticking weed	*Acacia okidetalia*	Grass	-	+
Thatching grass	*HyparrheniaHirta*	Grass	+	+
Tick berry	*Lantana Camara*	Grass	+	-
Treedax daisy	*Tridaxprocumbens*	Grass	-	+
Wait a bit thorn	*Acacia mellifera*	Shrub	+	-
Wandering jew	*Commelinabenghalensis*	Grass	+	+
Whitethorn acacia tree	*Vachelliaconstricta*	Tree	+	+
Whistling acacia	*Acacia hoki*	Tree	-	+
Wild canna lilly flower	*Canna indica*l	Shrub	+	+
Total number of plant species present			**23**	**24**

+ = Plant species present, - = Plant species absent, OP = Oil Pads, CA = Control Areas, Total number of quadrats per transect= 8, Total number of transects in oil pads = 16, Total number of transects in control areas = 16

The study also recorded a non-significant difference in the vegetation relative abundance of some plant species between oil pads and control areas which include Creeping wood-sorrel (*Oxalis corniculata*), Finger grass (*Digitaria eriantha*), Garden Pink-sorrel (*Oxalis latifolia*), Star Grass (*Cynodon dactylon*), Fibrous drop seed (*Sporobolus stafianus*), Whitethorn acacia tree (*Vachellia constricta*), Baboon apple (*Annona glabra*), Borassus palm tree (*Palmyra palm*), Goats weed (*Ageratum conyzoides)*, Nandi grass (*Cetera ancient)*, Wild canny lilly flower (*Canna indical*), Devil horsewhip (*Achyranthes aspera*), Edible canna (*Canna eduls*), Guatemala (*Tripsacum laxum*), Pickerel weed (*Pontederia cantata*), Sticking weed (*Acacia okidetalia*), Tick berry (*Lantana camara*), Treedax daisy (*Tridax procumbens*), Wait a bit thorn (*Acacia mellifera*), and Whistling acacia (*Acacia hoki*).

Observed plant species per transect

A total of 16 various grass plant species, 4 shrub plant species and 3 tree species were recorded in oil pads whilst a total number of 17 grasses, 4 shrubs, and 3 trees were recorded in control areas. Some of the observed plant species were recorded in both oil pads and control areas, while others were in either of the two sites (Table 3). However, the total number of plant species recorded in oil pads were not significantly different from the ones recorded in control areas (χ^2= 8.29, d.f=1, p > 0.05).

Vegetation diversity per transect

The results of Shannon Weiner vegetation index per transect at both oil pads and control areas are presented in table 4. The results show a relatively higher mean vegetation diversity per transect at oil pads (1.9±0.058) compared to at control areas (1.71±0.120). The study results show a non-significant difference in the vegetation diversity between the former oil pads and control areas (t= 2.114, d.f =7, p=0.072). This indicates that there are no habitat variations post oil and gas exploration. The results indicate a non-significant difference between the vegetation species equitability between oil pads and control areas (t = 2.118, d.f=7, p =0.072). The mean equitability of vegetation per transect in oil pads and control areas is 0.80±0.014 and 0.75±0.029, respectively

Table 4: Vegetation diversity at oil pads and control areas

OPT	*H value*	*H max*	*E value*	CAT	*H value*	*H max*	*E value*
Jobi4 ET	2.05	2.48	0.83	CA1 ET	1.83	2.20	0.83
Jobi4 ST	2.16	2.56	0.84	CA1 ST	2.47	2.71	0.91
Jobi4 WT	1.89	2.40	0.79	CA1 WT	1.42	1.95	0.73
Jobi4 NT	1.78	2.20	0.81	CA1 NT	1.38	2.08	0.66
JE7 ST	1.61	2.20	0.73	CA2 ST	1.63	2.30	0.71
JE7 WT	1.93	2.40	0.81	CA2 WT	1.63	2.20	0.74
JE7 NT	1.91	2.48	0.77	CA2 NT	1.60	2.40	0.67
JE7 ET	1.86	2.20	0.85	CA2 ET	1.72	2.20	0.78

OPT=Oil Pad Transect, CAT=Control Area Transect, JE7 = Jobi East 7, H value- Shannon Weiner vegetation index, H max= Maximum species', E value= Species' equitability. ET=East transect, ST= South transect, WT= West transect, NT= North transect, CA1= Control area 1, CA2= Control area 2,Total number of quadrats per transect= 8, Total number of transects in oil pads = 16, Total number of transects in control areas = 16

DISCUSSION

Frequency Index (FI) of vegetation

Results from the vegetation frequency index were analyzed by Raunkiaer's law of frequency (1962) recorded the uniformity or non-uniformity of plant species in the study area. Uniform vegetation signified stable community whilst non-uniformity may suggest a disturbed vegetation community. The study recorded a number of plant species which were more uniform in control areas than in oil pads. This may suggest that these plant species are more abundant in control areas than oil pads. However, it should be noted that distribution of frequencies "depends on the number of quadrats, the size of the quadrats, and on the Index of Diversity of the population." Unless all of these factors are considered, the distribution of frequencies in classes is not meaningful (Williams, 1950). Another challenge with this methodology of vegetation assessment is that the dissemination of species in the frequency classes differs with the size of sample. The results are highly influenced by the composition of the total population in terms of numbers of individuals per species.

Vegetation Relative Abundance

The study recorded a non-significant difference in the vegetation relative abundance between oil pads and control areas. The findings are not in line with Lee *et al*. (2013) who suggested that species richness and total vegetation cover (Fiori and Zalba, 2003) may decrease in response to road construction and natural resource extraction. The results reveal that the plant communities have been able to recover from the human disturbances caused by oil exploration. This is not in line with the report by Forbes *et al*. (2001), which suggested that there is a general slow recovery of plant communities from human disturbances, and other physical impacts of development for decades or centuries.

Some of the recorded plant species were more abundant in control areas than former oil pads. The findings are similar to those of Simmers and Galatowitsch (2010) which suggest that, in semi-arid environments, habitats heavily disturbed by anthropogenic activities often have lower species richness compared with undisturbed areas. However, the timeline for recovery may vary by taxa and level of disturbance (Nichols and Nichols, 2003; Walker and Moral 2003). This could be an explanation why some plant species were abundant in oil pads than control areas. Encounters of more abundant plant species in former oil pads is contrary to the findings by Prinsloo *et al*. (2011) which suggested that oil and gas development leads to decrease in vegetation cover. The study recorded some plant species which were more abundant in former oil pads than control areas and this is similar to Larson *et al*. (2001), whose findings indicate that reclaimed sites tend to have a higher abundance of species. This is because reclamation introduces new plants and offers moist and humid soil-water which are better conditions than reference sites. This causes the reclaimed oil pads to have greater richness and higher abundance of the introduced plants.

Vegetation diversity

The study recorded a non-significant difference in the vegetation diversity between oil pads and control areas. This is similar to Lupardus *et al*.

(2020) whose findings did not detect significant differences in species richness of recovering grasslands between reference and reclaimed well pads. However, the current study findings of no significant difference were contrary to findings by Edwards *et al*. (2014) which noted that mining infrastructure fragments and degrades natural habitat through the creation of roads. Another study conducted by Cui *et al*. (2009) and Janz *et al*. (2019) found out that disturbances can have immediate and persistent or long-lasting effects with slow recovery times on vegetation. The results are also contrary to UNEP (1997), Epstein and Selber (2002), Kumpula *et al*. (2011), OGP/IPIECA (2011) and Kamara *et al*. (2019) whose findings indicated that natural resource extraction of oil and gas exploration had well documented impacts on wildlife as well as vegetation. The fact that the vegetation diversity in oil pads is similar to that in control areas is a good indicator that the habitats for mammals has been fully restored.

CONCLUSIONS

In general, the results of the current study revealed that the vegetation at the former oil pads has been fully restored. The oil exploration has not generally changed vegetation in the protected area. The oil pads are recovering at a steady rate given there is no observable difference of the vegetation relative abundance and diversity between oil pads and control areas. Based on these findings, oil companies should always do baseline studies before any development activities are carried out. The findings can serve as a benchmark for restoration once oil activities are complete. Moreover, further research studies are recommended in the former oil pads about edaphic assessments, soil chemical, and biological properties analysis. The studies would provide information to better understand if exploration altered the quality of soil in any way and also provide better guidance for further development phases of oil and gas in the park.

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Author Contributions

HA, CKT and WT conceived and designed the study; HA and KT conducted the research; HA and WT analyzed the data; HA and CKT wrote the paper. All the authors (HA, CKT, WT and KT) reviewed and approved the paper for submission.

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Analysing COVID-19 Verified, Recuperate and Death Cases in Ethiopia Using ARIMA Models

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KEYWORDS:

COVID-19 Cases;

Days;

Autoregressive Integrated Moving Average

Research article

ABSTRACT

Applying a successful prediction of the confirmed, recovered and deaths is supposed to be the basic requirement to successfully control the dissemination rate of diseases. Time series models have widely been considered as the suitable methods to forecast the confirmed, recovered and deaths because of the virus. The objective of this research is to apply the Autoregressive Integrated Moving Average (ARIMA) modelling approach for projecting COVID-19 confirmed, recovered and deaths cases in Ethiopia. Over strict tracks of all phase of Box-Jenkins strategy, ARIMA (1,1,1), ARIMA (16,1,2) and ARIMA (0,1,1) models for confirmed case, recovered and death case, respectively were selected as the most appropriate models for predicting corona virus cases of Ethiopia. Using these models, a predictions of five month a heads future situation of COVID-19 confirmed case, recovered and death case (Jan 3, 2021 to May 3, 2021) has made. The results showed that in the coming five months from Jan 3, 2020 to May 3, 2021, the number of COVID-19 confirmed, recuperated and deaths cases in Ethiopia may reach up to 320,597; 168,912 and 4438, respectively. By and large, the size of the corona virus distribution was increased from time to time in the past ten month, until 3rd Jan, 2021, and it is anticipated to continue faster than before for the coming 5-months, until the end of May, 2021, in Ethiopia and more rapidly than before while the peak will remain unknown yet. Therefore, an effective execution of the precautionary measures and a rigorous compliance by circumventing carelessness with the rules such as prohibiting public congregations, travel restrictions, social distancing, and strict use of personal protection measures may improve the dissemination rates of the virus. Further, through updating more new data with constant reconsideration of predictive model provide useful and more accurate prediction

INTRODUCTION

The primary event of corona virus (COVID-19) eruption was informed on December 31, 2019 in Wuhan and then, it has been put across the universal deadly disease owning harsh new type of hazard to individual vigour and life in a continues way. According to World Health Organization (2020), more than 135,045 COVID-19 cases, 2,083 deaths, and 121,594 recoveries have been reported in Ethiopia and 101,483,628 COCID-19 cases, 2,185,413 deaths and 73,386,329 recoveries and 25,908,918 active cases among these 25,801,597(99.6%) in

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mild condition and 110,289(0.4%) series or critical cases and 73,386,329 (97%) are recovered and 2,185,413(3%) are dead across the globe during the study period (WHO, 2020). The quantity of COVID-19 cases rapidly goes up in mid-January, and the infection quickly blowout beyond China's boundaries. As of this research, it has extended to 219 countries all over the globe (WHO, 2019**).** Despite broadening COVID-19 influences, there are key public health questions. How many individuals will be diseased? How does the condition vary day by day? How many individuals will die? These inquiries could be re-joined by predicting the possible futures of this contagion via time series models. However, broadly used time series models and tools do not essentially have high forecasting precision, particularly for medical researches (Huppert and Katriel, 2013). By fitting models and creating precision forecasting unfailingly may improve community health judgment-making (Yonar *et al*., 2020**).**

On March 13, 2020**,** the Federal Ministry of Health has confirmed a corona virus disease (COVID-19) index case in Addis Ababa, Ethiopia. The case, which was publicized on the 13th of March 2020, is the first one (index case) to be reported in Ethiopia since the beginning of the outbreak in China in December 2019. The case is a 48- year old Japanese man reported to have travelled from Japan to Burkina Faso and then reached in Ethiopia. The person developed symptoms and presented at the health center in Addis Ababa from where the rapid response team (RRT) moved him to the isolation facility in Yeka Kotebe. He was clinically stable, with no serious symptoms. Subsequently, on 16 March 2020, the administration of Ethiopia have been announcing to appliance numerous defensive actions such as emerging community alertness about over all behavior of the infection and its stoppage tools like cleansing of ways and marketplaces, isolation of mistrusted and diseased cases, lockdown of the universities, schools, house of worship, and announcing state of crisis. Ethiopian administration has applied protective measures directly after the infection has been stated the world disease. Yet, the spread has continued quick for the reason that supreme of the individuals have been carelessness in certain of defensive actions such as public distancing and mass assembly. On the other, populace movement through the border from the next-door nations like Sudan, Djibouti, Kenya and Somalia has a lion part for the current movement of quick spread of infection in Ethiopia. Accordingly, COVID-19 spread would get thoughtful in Ethiopia, and its coming movement is also likely to depend directly or indirectly on the spread of COVID-19 within and outside of all those neighboring African countries.

Investigating the trends and predicting the coming indices of the infection in Ethiopia must be accompanied in order to put in a place operative monitoring policies. Though the spread mechanisms of the infection is not totally recognized, the number of new cases are harshly growing, and the effects of inhibition should be assessed on numerical data where numerical investigation is extra significant.

Actually, several states in the world up to now have functional data-driven statistical models alike Autoregressive Integrated Moving Average (ARIMA) for forecasting of future movements of the communicable infection. Subsequently, to model the exponential growing rate of the virus, Yichi *et al*. (2020) and Gupta and Pal (2020) conducted their study using a

linear based time series model, Auto Regressive Moving Average (ARIMA family) model. Time series forecasting models like ARIMA is the ordinary method which gives clothed forecasts on time series data in fast time (Hyndman *et al*, 2008). This method of investigation has been extensively functional, for its consistency and rapid application by numerous stakeholders. Hence the objective of this work is to put on the Autoregressive Integrated Moving Average (ARIMA) modelling approach for predicting corona virus (COVID-19) confirmed cases, recovered and deaths in Ethiopia to empower the community health organizations to conduct trust worthy day-to-day prediction and to arise with appropriate intervention policies, deliver direct and long-term route of the illness and play role to the body of knowledge in epidemiologic study method.

MATERIALS AND METHODS

Study Area

The research was carried out in Ethiopia, where the virus quickly spread and disturbing. According to the UN population estimates, whole population of the country is 114,963,836 peoples.

Research data

The everyday time series data of COVID-19 of Ethiopia from 13 March 2020 to January 3, 2021 were gathered from the official website of Johns Hopkins university (2020): https://goto.now/AWY0o. SPSS Version 20 statistical software was functional to achieve statistical data investigation on the confirmed, recovered and deaths case of COVID-19 datasets.

Technique of data study

Time series analysis aims to tell consistent and expressive statistics and use this information to forecast upcoming values of the series**.** Time series models try to predict the upcoming values by investigating the former and present. It contemplates past data and tries to arise some procedure which will clarify those existences and forecast upcoming values. The distinct feature of time series analysis is consecutive observations are typically dependent and that the investigation must take methods to classify the designs which characteristically happen in the data. Based on this detail, amongst time series methods, this research applied ARIMA model in order to evaluate the upcoming movement situation of COVID-19 in Ethiopia.

Auto Regressive Integrated Moving Average (ARIMA) modelling

It is the other most regularly used time series models as it considers varying movements, periodic fluctuations and random disturbances in the time series. It also appropriate for all types of data, containing non-stationary data, which is if there is no systematic change in mean (no trend), no systematic change in variance and periodic variations has removed (Box and Jenkins, 1976). In practice, most of the time series are non-stationary and Wei, 2006 commends eliminating any non-stationary sources of variation in time series data. In most case, common method for attaining stationary is to put on consistent differencing and log transformation to the original time series (x_t). If differencing a time series d times results in a stationary series, then that original series is said to follow an Autoregressive Integrated Moving

Average (ARIMA) process, denoted as ARIMA (p, d, q) and can be written as:

$$\varphi(\beta)\nabla^d X_t = \theta(\beta)W_t$$

Where:

Autoregressive operator can be expressed as: $\varphi(\beta) = 1 - \varphi\beta - \varphi_2\beta^2 - ... - \varphi_p\beta^p$

Moving average operator

$$\theta(\beta) = 1 + \theta_1\beta + ... + \theta_p\beta$$

Differencing operator $(\nabla^d) = (1-\beta)^d$ it is the expression of d^{th} consecutive differencing so as to make series stationary. W_t is a Gaussian white noise series with mean zero and variance $(\delta_w{}^2)$.

Testing for stationary: Before emerging a Box-Jenkins modelling process, it is significant to verify whether the data under study encounters basic suppositions such as series stationary. A time series is well-thought-out as stationary if its statistical properties such as mean and variance are constant over time (Box and Jenkins, 1976). Many testing procedures for stationary are planned in the literature. In this research, correlogram test were functional for testing whether the series is stationary.

The correlogram test: It is one way to characterize a series with respect to its reliance over time. It usually recognized as sample autocorrelation function (ACF), which is plot of sample ACF coefficient against observation difference in time (lag). As indicated in (Box and Jenkins, 1976) if the sample ACF decays very slowly in non-seasonal and seasonal lag snit indicates that differencing is wanted and an insinuation for series non-stationary.

Constructing ARIMA model: As planned by (Granger and Newbold, 1986) method, in order to construct ARIMA model for a specific time series data, must follow four phases: Model identification, estimation of model parameters, Diagnostic checking for the identified model, Application of the model (forecasting).

Model Identification: With this phase, the amount of differencing compulsory attaining stationary and the order of both the seasonal and non-seasonal AR and MA operators are determined. The autocorrelations function (ACF) and the partial autocorrelation functions (PACF) are the two most valuable tools in any attempt at time series model identification (Shumway and Stoffer, 2010)**.** To determine the number of differencing (d), non-seasonal autoregressive (p) and moving average (q) parameters, the guideline specified in (Lehmann and Rode, 2001) are used. Therefore, if PACF Cuts off after lags q and ACF tail off, then ARIMA (0, d, q) model is identified. If ACF cut off after lag p and PACF tail off, ARIMA (p, d, 0) model is acquired. Finally, if both ACF and PACF tail off, then the recognized model will be ARIMA (p, d, q).

Parameter Estimation: After selecting the most suitable ARIMA model, the parameters are estimated by Maximum Likelihood Estimation.

Diagnostic Checking: it deals with the residual assumptions in order to decide whether the residuals from fitted model are independent, constant variance (Lehmann and Rode, 2001).

Visual Analysis: It is a method for investigating plot of the residual over time. If visual reviews of the plot tell that they are haphazardly distributed over time, then it is a residual independence (Lehmann and Rode, 2001).

Residual Autocorrelation Function (RACF): With this test, to say that residual follows a white noise process, roughly 95% of the autocorrelation coefficient should fall within the range of ±1.96/squ(n) (Grasselli *et al*, 2020).

If the nominated model is insufficient, the three-step model building process with other model is typically repeated many times until a satisfactory model obtained. The final model selected can then be used for forecast determinations (Box and Jenkins, 1976).

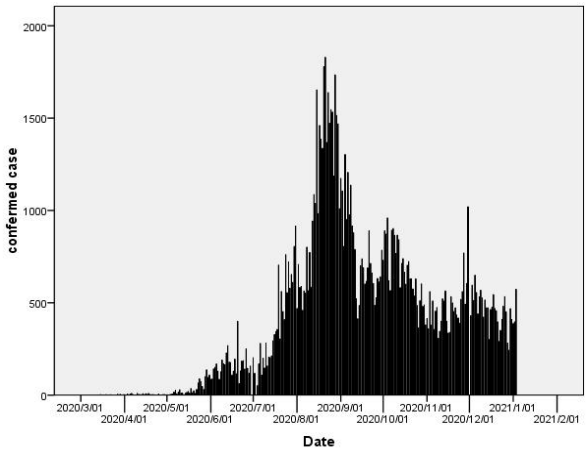

Figure 1: Distribution of confirmed cases of covid-19 in Ethiopia(Mar 3, 2020- Jan 3, 2021)

Predicting: It is last phase in time series modelling, the aim is to forecast future values of a time series, $Xt + m, m = 1,2,\ldots$ based on the data collected to the present, $X = \{Xt, Xt - 1, \ldots, Xl\}$.

$$X_{t+m} = \phi_1 X_{t+m-1} + \ldots + \phi_{p+d} X_{t+m-p-d} - \theta_1 W_{t+m-1} - \ldots - \theta_q W_{t+m-q}$$

RESULTS

Descriptive analysis results

The first confirmed case of the COVID-19 in Ethiopia (the index case) is described on 13 March 2020 with one infected foreigner. Then after, the administration of Ethiopia has without delay in use different measures to put off and manage the infection, but the case has been expontially increasing and widely distributing until Sep 1, 2020. From Aug 01, 2020 to Oct 01, 2020 large number of people are infected by the virus and the number of infection shows slight decline until the study period Jan 3, 2021 (Fig.1). Similarly, the first recovered cases reported on Jun 01, 2020 and the recovery cases increased parallel with the confirmed cases. There was a large number recovery cases during December 1, 2020 to January 1, 2021 (Fig 2).

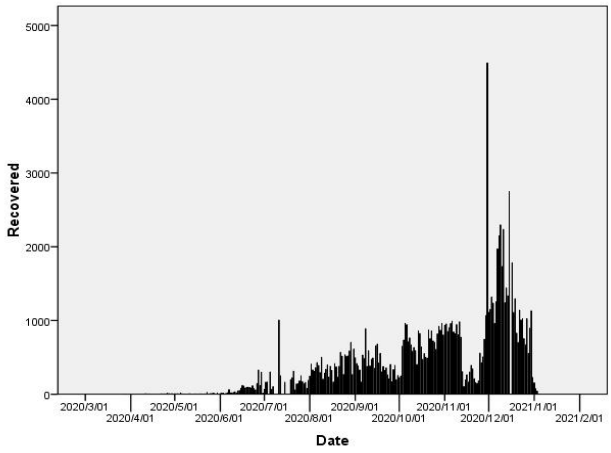

Figure2: Distribution of covid-19 recovered case in Ethiopia (13 Mar, 2020-Jan 3, 2021)

As shown in Fig 3, the first mortality/death case was reported on April 2, 2020. The number of deaths was increasing with the increase of the number of confirmed cases. High number of deaths in Ethiopia was reported during Aug 03, 2020 – Oct 1, 2020. As shown on Fig 4, the

confirmed numbers of cases are increasing and the recovery case is also more increasing parallel to the confirmed cases.

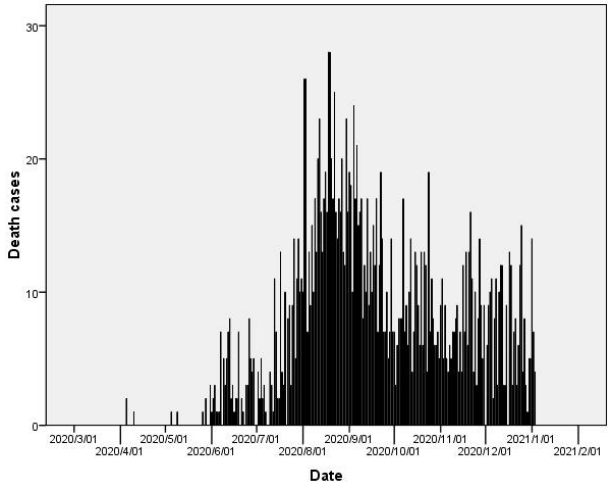

Figure 3: Distribution of death cases in Ethiopia (Mar 3, 2020-Jan3, 2021)

The number of death cases is also increasing but interestingly the recovery cases (green line) is very closed to confirmed cases (blue line) but the death (yellow line) is going away from the confirmed cases (blue line), that is, the death cases are not increasing in the same level as confirmed cases and the death line is getting flat.

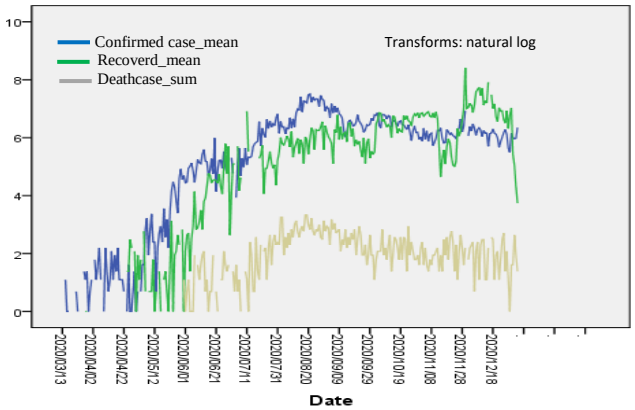

Figure 4: Covid-19 confirmed, recovered and death cases in Ethiopia (Mar 3, 2020-Jan3, 2021).

Results from ARIMA modelling of COVID-19 case

Result in testing stationary: The first step in every time series investigation containing ARIMA modelling is to see whether the time series is stationary. In this research, time series plot and Autocorrelation Function (ACF) were practical to check the stationary. The pattern of the series of COVID-19 confirmed cases, recovery and death cases shows increasing trend indicating the mean and the variance of the series are not constant throughout time and this shows the process is not stationary and the data need to be differencing and with the one step differencing, d=1, we got stationary data.

Result in model identification for confirmed cases:

From Table 1 ARIMA (1,1,1) and ARIMA (5,1,1) are recommended since they have lest Bayesian Information Criterion (BIC) and highest adjusted R-square, but by B-J methodology, parsimonious models give better

forecast than over-parameterized models. Therefore, ARIMA (1,1,1) is selected.

Table 1: Tentative models

Confirmed cases	ARIMA(1,1,1)	ARIMA(1,1,2)	ARIMA(5,1,1)	ARIMA(5,1,2)
Adj R square	88.9	88.9	89.3	89.3
BIC	9.855	9.877	9.911	9.933

Result in model identification for recovered case:

From Table2 ARIMA (15,1,1) and ARIMA(1,1,2) are selected but by B-J methodology , ARIMA (1,1,2) is the best model to forecast the confirmed cases. But residual ACF and PACF are not flat, that is lags 16 and 15 are very significant indicating there is white noise in the series and we should re estimate the model by adding AR(16) in the model. Thus the appropriate model to forecast recovery case is ARIMA (16, 1, 2).

Table 2: Tentative models

Recovered cases	ARIMA(1,1,1)	ARIMA(1,1,2)	ARIMA(15,1,1)	ARIMA(15,1,2)
Adjusted R square	60.4	60.6	66.1	66.4
BIC	11.614	11.631	11.775	11.788

Result in model identification for death case:

From auto and partial auto correlation plot a candidate MA(q) models were recommended. That is ARIMA (0,1,1) models is recommended.

Result in model diagnosis: According to (Box and Jenkins, 1976), all the models that accepted and satisfied all residual tests and the parameters meaningfully vary from zero must be included and nominated as candidate model for forecast. Residuals ACF and partial ACF plot for confirmed, recovered and death cases, all the lags are inside the 95% confidence interval showing there is no problem of white nose so the models are ready for use of prediction.

Table 3: ARIMA models & coefficients for best selected model.

COVID-19 cases	Model	BIC	R-squared	MAPE	Coefficient	P value
Confirmed case	ARIMA(1,1,1)	9.855	.889	0.309	$\hat{\phi}_1$=-0.233	0.016
					$\hat{\theta}$ = 0.417	0.00
Recovered case	ARIMA(16,1,2)	11.732	0.69	0.439	$\hat{\phi}_1$ =0.257	0.00
					$\hat{\phi}_2$ =0.230	0.00
					$\hat{\phi}_3$ =0.129	0.034
					$\hat{\phi}_6$ =0.185	0.003
					$\hat{\phi}_{15}$ =-0.330	0.00
					$\hat{\theta}$ = 0.998	0.00
Deaths cases	ARIMA(0,1,1)	2.649	0.679	0.407	$\hat{\theta}$ = 0.801	0.00

Predicting precision assessment

If the fitted models achieve well in predicting, the estimate error will be comparatively minor and the Mean Absolute Percentage Error (MAPE) should be close to 5%. From Table 3, it can be witnessed that the accuracy of forecasts measured by the Mean Absolute Percentage Error (MAPE) cast out to be 3.09% for ARIMA (1, 1, 1) model, 4.39% for ARIMA (16, 1, 2) and 4.07% for ARIMA (0, 1, 1) model, which are relatively less than 5%. This implies that those models would perform better in predicting the confirmed, recovery and death cases of COVID-19 well.

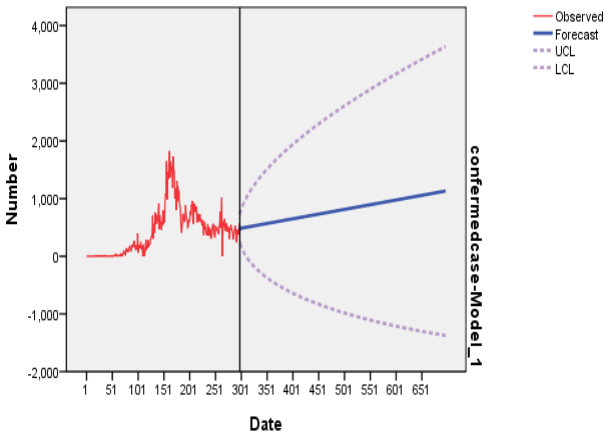

Figure 5: Forecasted value with 95% prediction interval for confirmed cases in Ethiopia

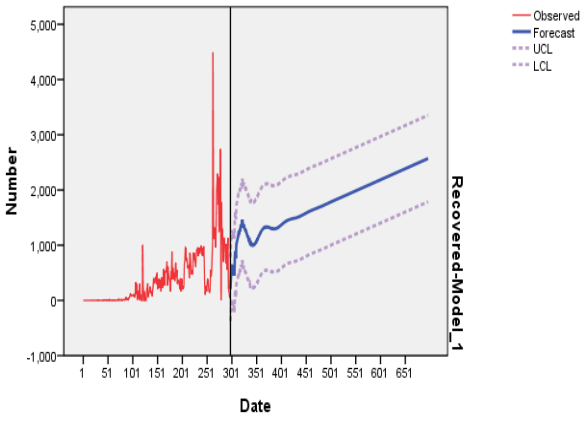

Figure 6: Forecasted value with 95% prediction interval for recovered cases in Ethiopia

Fig 5, Fig 6 and Fig 7 presents prediction of COVID-19 confirmed, recovered and death cases and it gives the direction and tendency of the epidemic and forecasts the likely development of future epidemics. The Figs shows, a forecasts of five month a heads future situation of COVID-19 confirmed case, recovered and death case (Jan 3, 2021 to May 3, 2021). Infected cases, recovered and death cases are expected to considerably increase in the coming five months. By the end of May 3, 2021, cumulative confirmed, recovered and death cases across Ethiopia, will reach 320,597, 168,912 and 4438 respectively.

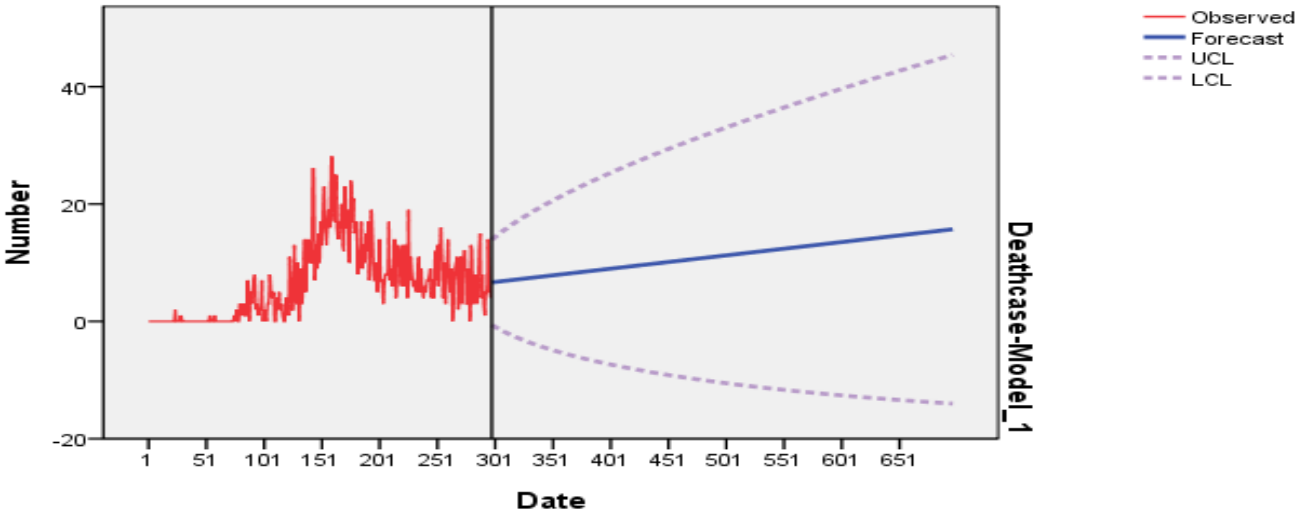

Figure 7: Forecasting value with 95% prediction interval for deaths case in Ethiopia

DISCUSSION

It is crucial to generate consistent and appropriate forecasting model that can assistance health system administrations and other stakeholders to prevent the extra blowout of COVID-19. Time series forecasting models is the statistical method which provides a clothed forecast and has been extensively practical for trend of communicable sickness in rapid time (Fanelli and Piazza 2020). ARIMA models are predictive technique that offers a good forecast and has been widely used for the rapid trend of infectious diseases (Holt, 1957, Hyndman *et al*, 2008, Shumway and Stoffer, 2010).

Over strict follows of all phase of Box-Jenkins strategy, ARIMA (1,1,1), ARIMA (16,1,2) and ARIMA (0,1,1) models for confirmed case, recovered and death case respectively were selected as the best models for predicting COVID-19 cases of Ethiopia. Time series analysis of COVID-19 provides the direction and movement of the epidemic and forecasts the probable progress of upcoming epidemics. Using these models, a forecasts of five month a heads future situation of COVID-19 confirmed case, recovered and death case (Jan 3, 2021 to May 3, 2021) has made. In diverse area, a lot of numeric researches have been showed to forecast new case of COVID-19 case using ARIMA model (Gupta and Pal, 2020; Li *et al*.,

2020, Yonar *et al*., 2020; Zhan *et al*., 2020) which are consistent with this research. In line with the current study, Li *et al*. (2020) and Das (2020) also used ARIMA model to predicting COVID-19 epidemic in India and China, respectively and showed that the infected case were increasing.

COVID-19 cases reported in the country is assumed to exceed 160,585 in the five months of 2021. At the end of May, inline projected cumulative infections across Ethiopia to hit 156,610 on average (Hyndman *et al*, 2008), while the real value until 19 May was just 189,137 cases and 1352 deaths (Yonar *et al*., 2020). This means that the number of people who are corona-virus-positive in Ethiopia can increase more than predicted (Hyndman *et al*, 2008). However, in this analysis, the cumulative confirmed, cumulative recovered and cumulative death forecast cases on May 3, 2021, are 320,597, 168,912 and 4438, respectively. Similar to the predicted values in this study, variation of pandemics in Ethiopia in the first five months has been shown to increase (Hyndman *et al*, 2008). The scholars disprove the effect of geographical difference and temperature in reducing the distribution of COVID-19 (Granger and Newbold, 1986). The COVID-19 pandemic has caused significant global social and economic disruption. While pre-protective strategies are crucial in managing the spread of COVID-19, this study does not evaluate their impact due to the unavailability of exposure data

CONCLUSIONS

Since the study shows the increase in the number of deaths and confirmed cases in Ethiopia, more attention should be given to the control and prevention of Covid-19. Without the implementation of effective infection control measures by the Government of Ethiopia, the COVID-19 situation is expected to deteriorate, leading to greater consequences for the nation. Consequently, this study advocates for the development and enforcement of sustainable pandemic control strategies. Utilizing the ARIMA model allows for forecasting the future spread of COVID-19 based on existing data, which will assist institutions in formulating appropriate policies.

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