UNIVERSITY FOR DEVELOPMENT STUDIES

SEASONAL VARIATION IN FORAGE AVAILABILTY AND GRAZING BEHAVIOUR OF CATTLE IN SELECTED PERI-URBAN AREAS IN THE NORTHERN REGION OF GHANA

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BY

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THIS THESIS IS SUBMITTED TO THE DEPARTMENT OF ANIMAL SCIENCE, FACULTY OF AGRICULTURE, UNIVERSITY FOR DEVELOPMENT STUDIES, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN ANIMAL SCIENCE

(ANIMAL PRODUCTION)

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DECLARATION

This is to affirm that this thesis has been authored by me and has neither been submitted for a degree nor any aspect published by another person elsewhere. All cited literature in the text has been well referenced and any assistance received in writing the thesis have been duly acknowledged.

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ABSTRACT

A research involving six cattle herds was carried out to determine the effect of season: intermediate, peak rains and dry seasons, on characteristics of grazing lands and grazing behaviour within peri-urban areas of three selected districts, namely: Tamale Metropolis, Savelugu Municipality and Sagnarigu District in the Northen Region of Ghana. The effect of management style, that is, Fulani and Non –Fulani management styles on grazing behaviour of cattle was also investigated. Two herds each were selected from Tamale Metro, Savelugu Municipal and Sagnarigu District for study. A total of 18 cows constituting 3 per farm were selected for the behavioural studies. Grazing lands were selected based on interaction with farmers, and also, by direct observation, while biomass sampling area was selected within the main grazing zone of the pasture. The parameters measured within grazing fields were plant species, vegetation cover, status of pasture, plant height, nature of grazing fields, biomass estimates and carrying capacity. Behavioural parameters studied were proportions of total grazing time used for feeding, walking, resting, watering and social interaction. Grass (72.8%) was the dominant species group of plant in all three seasons. A greater proportion (P<0.05) of grazing lands were heavily grazed (52.6%). The highest plant height was recorded during the dry season (above 35CM) and the least (below15CM) during the intermediate season (P<0.05). The highest vegetation cover was recorded in the rainy season and the least in the dry season. Conversely, biomass yield was highest (P<0.05) in the dry season (1400 kg/ha) and least in the intermediate season (600 kg/ha). Carrying capacity naturally followed the order of biomass production. Similar proportions of time were spent feeding both in the

intermediate and peak rains. These were, however, higher than the proportion in the dry season. A higher proportion of time was spent walking in the dry season (33.8%) than both intermediate (22.4%) and peak rains (15.2%). A higher proportion of time was spent feeding in non-Fulani (69.3%) than Fulani (61.5%) managed cattle. Conversely, more time was spent walking in Fulani (28.5%) than non-Fulani (18.8%) styled- management. The study concluded that, biomass was highest in the dry season while grass was the most dominant species group on natural grazing lands all year round. Cereal based crop residues formed a greater percentage of the biomass in the dry season. Season and management style had an influence on feeding, walking and resting.

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A very big thanks to my parents, Mr. and Mrs. Samuel Akapali and my Uncle and his wife Mr. and Mrs. Benjamin Alenyorege for their love, care and support; God bless you all.

DEDICATION

I dedicate this thesis to my Uncle, Mr. Benjamin Alenyorege for his unending guidance and support in my Education.

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LIST OF ABBREVIATIONS

AU	Animal Unit
AU-IBAR	African Union Inter-African Bureau of Animal Resource
CC	Carrying Capacity
GSS	Ghana Statistical Service
IPCC	Intergovernmental Panel on Climate Change
MOFA	Ministry Of Food and Agriculture
NABFC	National Anti-Bush Fire Committee
NRC	National Research Council
PNDCL	Provisional National Defence Council Law
PUF	Proper Use Factor
SDSU	South Dakota State University
TLU	Tropical Livestock Unit
UNCCD	United Nations Convention to Combat Desertification
WOCAT	World Overview of Conservation Technologies

CHAPTER ONE

1.0 INTRODUCTION

Ruminant production forms a major part of the people of Northern region, most especially, in the rural and peri-urban areas (Oppong-Anane, 2001). It serves as buffer during the cropping season when there is no much food to depend on (Oppong-Anane, 2001). It is also a form of savings for those who do not want to leave their monies in the banks and an investment to the business minded people.

Sustenance for cattle and small ruminants is almost entirely dependent on grazing of natural pastures and rangelands within the Savannah woodlands, characterized by unimproved pastures and bush fallow, with extreme seasonal variation in quantity and quality (Oppong-Anane,2013). Livestock production system in northern Ghana is constrained by many factors of which feed shortages in terms of quantity and quality during the dry season constitute a major part (Oppong-Anane, 2013). Accessibility of available feed in the wet season is another limitation in some communities in northern Ghana due to the cultivation of arable crops (Awuma, 2012). This feed challenge together with high incidence of diseases and mortality contribute significantly to low livestock productivity.

Ghana is characterized by diverse ecological zones resulting from an interplay of many different interrelated complex factors which include climate, soil types and geological formations. The local climate in Ghana is determined by two air masses that move from opposite directions. One of them comes with hot and dry desert air and moves from the north to south. This type of air comes from Sahara, the north-east and is known as the harmattan. The other wind is from the south Atlantic which is a warm and humid maritime air moving from south to north. Movement of these two air masses accounts for the different climatic seasons in Ghana, a domination of the hot and dry continental air (harmattan) causes a drought period, whiles the occurrence of the warm and humid maritime air brings about the rains (Maribellum, 2013).

The vegetation of Northern region falls within the Guinea Savanna zone. This type of vegetation presents an enabling environment for ruminant production (Oppong-Anane, 2001). Considering the fact that it is basically grassland, providing a vast natural range land for grazing animals, explains why most of Ghana`s ruminants are produced in this part of the country.

Many of the animals reared in northern Ghana, however, survive mainly on left over straw during the dry season (Konlan *et al*., 2014). Such a situation has long been recognized to result in cyclic body weight gain in the rainy season and weight loss in the dry season (Annor *et al*., 2007). These have made feed for livestock the main constraint to improved productivity in smallholder systems.

1.1 Justification

Man has always relied on livestock for quite a substantial portion of not only his protein needs but also, general food needs for survival. It is also a major economic activity for most animal farmers all over the world. Grazing forms a substantial portion of animal production since it is the only way of converting the energy in grasslands vegetation into energy source that can directly be utilised by man (Fatur, 2009).

Both plants and animals form part of the ecosystem on which mankind relies on for his needs. There is, however, not much understanding with regards to the interaction between plants and animals within the ecosystem. This lack of proper understanding of interactions between plants and animals in the field has hindered maximum use and benefits of graze lands. More so the erratic rainfall pattern, particularly, around the guinea savanna ecological zone and as a result of several decades of abuse through over grazing, improper land clearing practices, bush fires, deforestation practices as well as the impact of invasive weeds, has given rise to a visible decline in the quantity and quality of rangeland forage and a consequent threat to the carrying capacity of such range (Nyamekye, 2010).

Every morning, animals especially cattle are taken to so called grazing fields for grazing without a second look at such fields to ascertain whether it will really be able to provide the animal its daily feed requirement. Animals will mostly walk long distances in search of good pasture which may or may not prove fruitful. This problem even becomes more worrying during the dry season when most of the fields are burnt leaving bare ground. Even in the rainy season, there is this problem of crop farmers in an attempt to protect their crops, deny these animals access to natural forage chasing animals here there, thereby reducing the animal’s access to good grazing material. A more worrying issue is the recent trend of continuous accusations and counter accusations between crop farmers and Fulani herdsmen over farm destructions and resultant confrontations which has on some occasions resulted in loss of human lives.

Range management practices are mostly plant biased and most of the interventions may not consider animal type or feeding behaviour. This situation may lead to shortcomings in the range management process. Ideally, decisions concerning interventions and grazing management planning and related issues should take into account the plant-animal interactions in the ecological system in order to help attain sustainable range management without ignoring other important environmental and social dimensions of the process (Fatur, 2009). An understanding of the components of the ecosystem including plants and animals and their dynamic interplay is key in coming out with strategies for managing natural rangelands.

A complete investigation of plant/animal interaction during the various seasons of the year is therefore important for proper setting of range management interventions. Also, an understanding of feeding behaviour of animal leads to adaption of good management practices that leads to maximum use of the existing ecosystem to increase animal production. The ability of grazing fields to meet the animals pasture requirements will be of great benefit since most farmers do not practice feed supplementation.

1.2 Objective of study

The main objective of the study was to investigate plant/animal (cattle) interaction within the grazing fields with the following specific objectives:

1. To document the effect of seasonal changes on the vegetation attributes of grazing fields within the peri-urban area of Northern Region.
2. To determine the effect of seasonal changes on grazing behaviour of cattle.
3. To determine the effect of grazeland management system on the grazing behaviour of cattle.

Hypothesis

1. Vegetation attributes of grazing fields in the peri-urban area will change with changing season.
2. Grazing behaviour in cattle will change with changing season.
3. Grazing behaviour is influenced by management system.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Graze lands

Graze lands are lands that are accessible to animals for grazing. These may include lands not under any form of cultivation, farm lands that have been left free after harvest and also lands that have been artificially prepared for grazing purposes (Holechek *et al.,* 2004). These graze lands may be protected or unprotected. In Ghana all members of the community are at liberty to graze their animals on any farmland after crop harvest, and grazing land (natural pasture) is generally communally owned (Oppong-Anane, 2001). World Overview of Conservative Technologies (2008) also defined grazing land as land used for animal production e.g. natural or semi- natural grasslands, open woodlands, improved or planted pastures. These may therefore include non-grasslands. Grazing lands represent both a source of animal feed and a key element in biodiversity protection (Milne *et al*., 2015).

More than half of the world's land surface is grazed (Milne *et al*., 2015) and just under one third (31%) is grassland (including grasslands, shrub lands and savannah) (Milne *et al*., 2015). It has been stated that the nature of these grazelands ecosystems is controlled by past and prevailing climatic conditions as well as characteristics of the geological substrate and their interactions (Risser, 1984).

2.1.1 Graze land management

Graze land Management is the manipulation of graze land components to obtain the maximum combination of goods and services for society on sustained basis. Range management has two basic components: The first is protecting and enhancing the soil vegetation complex while the second involves maintaining or improving the output of consumable range products, such as red meat, fibre, wood, water and wildlife (Holechek *et al.*, 2004).

Controlled grazing management practice is seen to be useful in conditions of poor vegetation cover, overgrazing and degraded soils, and is considered as the best sustainable land management practice that can restore degraded rangelands as it enhances the vigour of mature perennial grasses (AU-IBAR, 2012*).* Rotational grazing is a management system based on the subdivision of the grazing area into a number of enclosures and the successive grazing of these paddocks by animals in a rotation so that not all the area is grazed simultaneously (Milne *et al*., 2015). The main principles of rotational grazing are: firstly, to control the frequency at which pasture is grazed. Secondly, control the intensity at which the pasture plants are grazed by controlling the number of animals which graze each paddock and their period of occupation. The third principle is to reduce the extent of selective grazing by confining a relatively large number of animals to a small portion of the rangeland (Milne *et al*., 2015). Control of the stocking rate and animal breeds and species are also improved feeding practices that help in reducing degradation of graze lands. Degraded graze lands can also be restored by vegetation management, use of fire, chemical control and re-vegetation of degraded and bare lands, addition of grass species with higher productivity, or carbon allocation to deeper roots, have been shown to increase soil carbon, other land management (e.g. soil and water conservation practices, agro-forestry, fencing, nutrient management, etc.) (Milne *et al*., 2015).

2.2 Soil and climate

All soils are not the same in quality, nor are all soils suitable for intensive grazing use by domestic livestock (Casale, 2009). In general, sandy soils produce the least amount of forage and clayey soils produce the largest quantities under proper management. Soils that have a low inherent fertility are shallow or easily eroded and will require special attention and may only produce enough cover to protect the soil and help prevent competition with undesirable weeds and toxic plants (Casale, 2009). Soil quality encompasses the physical, chemical and biological components of the soil and their interrelation (Doran and Parkin 1994; Karlen *et al.* 2001), and is assessed based on its ability to perform those soil functions that are necessary to meet the requirements of the particular land use. For rangelands, these requirements include plant growth (quantity and quality) and community composition to support grazing animals.

The amount of annual rainfall and distribution pattern plays a very important role in determining carrying capacity as the growth pattern of forages follows the rainfall pattern within the different agro-ecological zones (MoFA, 2016). In the Coastal Savannah area, there is a growing season of seven months and a "non-growing" period of five months while in the Guinea Savannah area, the growing season lasts for five months and the "non-growing" period for seven months (MoFA, 2016). Forage production is highly reduced during periods of drought or in years when most of the rainfall occurs at the beginning of the season. Late season rains on the other hand usually produce higher forage yields although it sometimes limit`s the livestock numbers that can safely graze a wet pasture.

Climate also plays an important role when pastures are irrigated. For instance, less water will be needed and applied in favourable rainfall years and more water will be required in low or unfavourable rainfall years. It may not be economically possible or wise to irrigate pastures when water is in short supply in years of drought. Hence livestock herds will need to be adjusted accordingly in order to avoid depleting graze lands (Casale, 2009). Pasture may be more productive if located in cooler and wetter climates (Rust and Trust, 2013) As long as there is sufficient moisture to support grasslands, a reduction in precipitation from high to moderate levels appears to be beneficial for livestock (Seo and Mendelsohn, 2006).

According to Rust and Trust (2013), climate affects livestock directly and indirectly. Direct effects from air temperature, humidity, wind speed and other climatic factors influence animal performance (growth, milk production, wool production and reproduction) (Houghton, 2001). Thornton *et al*. (2007) identified the impact of climate on feed resource as an indirect effect by way of the carrying capacity of rangelands, the buffering ability of ecosystems and their sustainability which in turn has a significant effect on livestock productivity.

2.2.1 Effects of climate on vegetation

In general, climate controls the broad scale distributions of plant species and vegetation cover more than any other factor (Sykes, 2009). While this is true of the present-day climate, past climates still influence current vegetation patterns as a result of generation times for many species, especially trees that can be hundreds of years (Sykes, 2009). Rapid climate change associated with increasing greenhouse gas emissions (IPCC, 2007) influences current and future vegetation patterns. Sykes (2009) showed that spatial patterns of vegetation across southern New England during the postglacial period are a response to the development of a regional climatic gradient. There has been some amount of reviews and meta-analyses on the influence of climate change on phenology. Menzel and Fabian (1999) reported for the period 1959–1993 in Europe that events of spring were occurring earlier at a rate of 1.8 days per decade. By 1971–2000, earlier leafing, flowering and fruiting had increased to 2.5 days per decade with a delay in leaf fall by 0.2 days per decade (Menzel *et al.,* 2006). Fitter and Fitter (2002) reported that first flowering in the United Kingdom advanced by 4.5 days per decade in the 1990s whiles Pen˜uelas *et al*. (2002) reported earlier leafing (3.3 days per decade), earlier flowering (1.2 days per decade), earlier fruiting (3.5 days per decade) and delayed leaf fall (2.7 days per decade) in Spain over the last half of the century. These changes are, however, not consistent across species with an advancement of 14.6 days per decade for *Lippia triphylla* but there was a delay of 7.8 days per decade for *Fraximus angustifolia* (Pen˜ uelas *et al*., 2002).

Data on the effects of climate change on tropical species are relatively scarce. However a study by Colwell *et al*. (2008) explored possible effects of climate change over a tropical elevation gradient using four insect and plant datasets in Costa Rica. They concluded that upslope movements of biota on mountainsides may be compensated as in higher latitudes by species from further down the mountain or the lowlands. Meanwhile, replacements for current tropical lowland species from areas with high temperatures may not be available as current species migrate upwards leading to 'lowland biotic attrition' and biodiversity loss (Sykes, 2009).

Temperature and precipitation are the two leading climatic factors that affect plant establishment, growth, reproduction and ultimately survival through its life cycle, especially when these factors occur rapidly or at extreme rates (Sykes, 2009). Plant productivity is, however, likely to increase in a climate that becomes warmer but has enough soil moisture (Sykes, 2009).

2.3 Plant composition

Managing pastures for attainment and permanent establishment of the most desirable plant species for grazing animals can sometimes take several years to fully materialize (Casale, 2009). Ideally, a combination of early and late maturing annual and perennial grasses and legumes planted in different pastures offers the rancher the most options. Simple mixtures of grasses combined with a legume or two, produces as much or higher quality forage than complex mixtures (Casale, 2009). Simple mixtures also make grazing management much easier, which is vital in keeping up production, desirable plant composition and dense ground cover. In some cases, pastures may need to be established from scratch or reestablished depending on previous land uses, existing plant composition, amount of unwanted plants and overall site condition. Brand new pastures are quite expensive to establish and can take up to a year before they are ready for grazing. Grazing intensity on new or reestablished pastures should be gradual and in tune with a proven grazing system (Casale, 2009).

2.4 Interactions between range plants and animals

A plant animal interaction strongly influences the morphology, behavior and ecology of both plants and animals. This explains why most plants produce brightly coloured flowers, plenty of leaves and also produces diverse toxic compounds just to deter herbivorous animals from feeding on them (Abramson, 2011).

Plant–animal interactions can assume many forms. For example, a plant might change the chemistry of its defensive compounds by way of natural selection as a result of pressure from the long-term effects of herbivores (Abramson, 2011). Also, the physiology of modern herbivores may be restructured differently from that of those that lived several thousand years ago as an adaptation for the detoxification or avoidance of plant defensive chemicals (Abramson, 2011). Other examples of plant–animal interactions include pollination biology, fruit and seed dispersal ecology, herbivory on plants by invertebrates (such as insects) and vertebrates (such as ungulates), ant–plant interactions, the ecology and evolution of carnivorous plants, and community and ecosystem patterns of animal distributions resulting from the availability of plant resources (McGraw, 2010).

2.4.1 Rangeland plant identification and classification

Before using a particular site for grazing purposes, we first of all will need to know the type of plant species found on such grounds, its acceptance by the animal, response to grazing and general continuity (Fatur, 2009)

Grasses form the major species group of plants on graze lands, and are characterized by jointed stems. The stems are normally hollow between the joints (nodes). Leaves are in two rows and over lapping on the stem with parallel veins. They also have a shallow fibrous root system. Grasses are generally the most important and abundant kind of range plants. Forbs are broad-leaved plants with above-ground growth that dies back each year. Most forbs have net veins in the leaves, but a few, such as wild onion, have parallel veins. Broadleaf plants and wild flowers are kinds of forbs (Nichols, *et al*. 1987). Grass-like plants look like grasses, but have solid stems (not hollow) without joints. Stems are often triangular. Veins in the leaves are parallel (Nichols, *et al.* 1987). Sedges and rushes are in this group of plants. Trees and shrubs are plants with stems and have the ability to live for several years. Shrubs have their stems branching from near the base whereas Trees have a definite trunk and are usually bigger than shrubs. Some plants can take on a shrub or tree growth form depending on environmental conditions (Nichols, *et al*. 1987).

2.5 Comparative nutritive value of grasses, forbs and shrubs

The chemical composition of forage changes with physiological age, time of grazing or harvest, variety and species of plant, degree of contamination and plant part. In addition to this, valid nutrient values can only be obtained when the samples analysed is a true representation of the pasture under study. Improper sampling is one of the largest but most overlooked sources of variation in forage analyses (Linn and Martin, 1991).

Pastures and especially natural grasslands are the most economic source of nutrients to feed ruminants because of their ability to digest fibrous feeds. Forage quality can be limited by their botanical composition, but specially, by the interaction between species composition and season of the year

(Silveira et al., 2005). Seasonal fluctuation in forage quality from pastures results both from morphological alterations of plants as function of its phenological evolution and from seasonal replacement of flora species, as occurs in some natural grasslands. This flora can be substantially altered by grazing pressure, soil fertility or introduction (by direct drilling) of exotic species (Nabinger *et al.*, 2009).

Grasses form the major portions of almost all natural grazing fields in the world (Holechek, 1984). This may be as a result of their ability to grow and regrow within a very short period even after grazing. Generally grasses have lower crude protein, phosphorus, lignin and cellulose concentrations than forbs and shrubs (Holechek, 1984). Digestibility of grasses is typically less than forbs and shrubs. At about the same growth stages, cold-season grasses are higher in crude protein, phosphorus, and digestibility and lower in fibre than warm-season grasses. Plant fiber is digested more slowly than the cell contents (Holechek, 1984). The high cellulose (digestible portion of fibre) concentration and high cellulose to lignin (indigestible portion of fibre) ratio makes grasses best suited to large ruminants such as cattle or cecum digesters (horse) that have low nutrient requirements per unit body weight.

Leaves of grasses are nutritionally superior to stems. For this reason short grasses are nutritionally superior to mid and tall grasses, particularly, during dormancy. The high vailability of grasses makes them important to large ruminants that have a total forage requirement (Holechek, 1984).

The main agronomic advantage of forage legumes include: (i) their contribution to the nitrogen (N) economy of agricultural land due to their association with (N) fixing bacteria and (ii) their ability to increase herbage production, herbage feed value and ultimately ruminant production of meat/milk, particularly in areas of low fertilizer N input (Marten *et al*., 1989; Frame *et al*., 1998). An additional benefit of legumes is that the rate of decline in digestibility with advancing maturity is less than for grasses (Dewhurst *et al*., 2009). Leaves of legumes, and particularly white clover, were found to be more favourable for prehension than those of grasses, particularly during the spring heading period (Dewhurst *et al.*, 2009).

Forbs typically have higher levels of crude protein, phosphorus and digestibility, and lower levels of fibre during their active growing stages than grasses or shrubs. Leaves from deciduous shrubs are similar to forbs in nutrient content. When dormant, forbs and deciduous shrubs leaves rank intermediate between grasses and evergreen shrubs in nutritive quality. Because of their low fibre levels, forbs and deciduous shrub leaves break down quickly in the rumen and permit higher intakes than grasses or evergreen shrub leaves during active growth. Forbs and deciduous shrub leaves are critical dietary components to small ruminants such as white-tailed deer and pronghorn that require low fiber diets (Holechek, 1984).

The unfortunate thing, however, is that many forbs are poisonous. For this reason they have often been collectively considered undesirable by range managers (Holechek, 1984).

Evergreen shrub leaves and buds from deciduous shrubs have higher crude protein, phosphorus, carotene (Vitamin A) and digestibility levels, and lower fibre levels than grasses and forbs when forage is dormant. Woody material from shrubs is highly lignified and very low in nutritive value. Therefore, grazing animals are highly selective for leaves, buds, fruits, and young twigs with low lignification. Ruminants with small mouth parts such as goats or pronghorn can select against woody material much better than cattle or elk. However, evergreen shrub leaves do provide an important crude protein, phosphorus, and carotene supplement to cattle and elk on many ranges when grasses are dormant. Animals with small mouth parts that can be highly selective such as goats, deer and pronghorn use these plants most efficiently (Holechek, 1984).

2.6 Graze land degradation

Auberville (1949) used the term desertification to refer to the severe degradation of arid, semiarid, and sub-humid areas of the world due principally to climatic and anthropic factors (UNCCD, 1995; Arnalds, 2000). Desertification was also used by Savory (1999) to refer to the manifested symptom of biodiversity loss in arid and semiarid environments, while Lambin *et a.l* (2009) defined desertification as a reduction in the productive potential of the land.

Rangeland degradations have been attributed to a combination of climatic and anthropic factors (UNCCD, 1995; Geist and Lambin, 2004; Hill, 2006; Lambin *et al.*, 2009) with specific emphasis placed on overgrazing and drought (Bedell, 1998; Puigdefabregas, 1998). While studies in the past repeatedly linked livestock to the degradation of rangelands (Sinclair and Frywell, 1985; Wolfson, 1990), subsequent studies have contradicted this by suggesting that prolonged rest leads to even greater destruction (Seligman and Perevolotsky, 1994; Olaizola et al., 1999; Cummins, 2009; Briske et al., 2008). This suggests that neither climatic nor anthropic factors are to be entirely blamed for arid and semiarid rangeland degradation, but more appropriately have to share that blame (Weber and Horst, 2011).

In a study of the Transjordan plateau, Hills (2006) concluded that climate change was a major factor explaining the disappearance of surface water and changes in vegetation due to increased acidity (Bar-Matthews *et al*., 1999). This could also be linked to a fall in soil-water storage capacity, increased surface runoff, and increased soil surface evaporation, because too few animals were present on the rangelands for too long a period of time (Savory 1999; Weber and Gokhale 2011). A second major factor cited by Hill was human ignorance regarding the consequences of mismanagement (McGovern *et al*. 1988).

2.7 Herbaceous cover assessment

2.7.1 Biomass

According to McKendry (2002), biomass is a term for all organic material that stems from plants (including algae, trees and crops). Biomass is produced by green plants converting sunlight into plant material through photosynthesis, and includes all land- and water-based vegetation, as well as all organic wastes. The term biomass usually refers to the weight of organisms present at the time of measurement (Society for Range Management, 1989). This is important for the estimation of the amount of forage available to animals. Vegetation biomass is important also for assessment of grassland or rangeland condition and for evaluation of new germplasm and cultivars (Mannetje, 2000).

The annual total dry matter (DM) yields are 1,965 and 2,170 kg/ha in the Coastal and Guinea Savannah zones, respectively (MOFA, 2016), and the ligneous species within the natural pastures are estimated to give forage DM yield of 700 to 1,000 kg/ha/annum (MOFA, 2016). Works also done in Sudan gave biomass values of 2.2 ton/ha in open range during early rains and 1.0 ton/ha in the in the dry season (Fatur, 2009).

2.7.2 Ground cover

Ground cover refers to the projection of plants or plant parts on to the soil surface. Measurements of cover are expressed either as the percentage of the soil surface covered by the plants or plant parts or can be broken down into the species or groups of species present (Whalle, and Hardy, 2000). Cover measurements are commonly used to evaluate soil protection, watershed health, rangeland ecological condition, and range trend (Holechek, *et al.* 2004), hence the interests in areal cover which has to do with vertical projection of the plant.

2.7.3 Frequency of species

Frequency is generally used to evaluate distribution of plant species over an area or changes in population of species over time as a result of management. It is mostly used as a measure of range trend (Society for Range Management, 1989) . Sampling for frequency is quite fast and simple to conduct in the field. If one determines density from quadrates, frequency can be calculated from the same data since frequency represents the number of the quadrates in which the species occurs (Holechek, *et al* 2004). Quadrate size plays a very vital role in frequency sampling. A large quadrate will cover many species which will in turn result in many species having high frequencies, while a small quadrate covers less space resulting in smaller frequencies, especially, for less abundant species (Holechek, *et al* 2004). The frequency of a plant species is the percentage or proportion of quadrates in which it is present. It is less tedious and takes little time to measure as compared to measurement of density, particularly, if the plant community is complex and information about a large number of species is required. Moreover, frequency estimates are possible for clonal species where individuals cannot easily be identified. The operator searches each quadrate and records the species that are present. Arbitrary rules must, however, be set as to whether species is counted or not depending on whether it is rooted in the quadrate or any part of the plant is within the boundaries of the quadrate. These rules must be established when planning a survey depending on the objectives (Whalle and Hardy 2000).

2.7.4 Carrying capacity

The carrying capacity of a pasture is the maximum number of animals that the pasture can support throughout the grazing season without being destroyed (Mustafa *et al,* 2000). Carrying capacity takes into consideration, adequacy of forage for grazing animals, whiles still leaving enough residual forage for regrowth the following season. Residual forage also protects soil from erosion and increases the forage yield the following year by improving stand vigour, soil moisture and nutrient cycling. It is for this reason that Darrag (1996) stated that carrying capacity is usually determined by using the proper use factor (PUF) of 50% in which only one half of forage biomass produced is considered as available for grazing.

The carrying capacity for a grazing disposition of a given pasture represents the highest number of Animal Unit months that can be sustained without causing harm to the health of that pasture. Suggested ecologically sustainable stocking rate values in plant community guides are determined from a combination of clipping studies, long-term range land reference area data, estimated production, and historical grazing experience. In order to sustain ecological health and function of the plant community, ecologically sustainable stocking rates are based on standardized biomass allocation and forage requirements of one animal unit (455 kg of dry matter per month). Rose Innes (1977) obtained a carrying capacity value of about 3.2 ha per annum per 317 kg beast (i.e. 3.0 ha per annum for livestock unit of 300 kg live weight) on the western plains of Accra. Fatur, (2009) also obtained carrying capacity values of 1.3 hac/TLU/year in the wet season and 6.0 hac/TLU/year in the dry season.

2.8 Stocking density

Stocking density is the number of animals grazing on a specific unit of land at any one point in time (Allen *et al*, 2011). Of all the management tools, stocking density has been found to have the largest impact on animal performance and forage resources, because it directly influences; animal productivity, forage production, forage quality, long-term plant species composition, plant physiology and profitability of the operation (Thorne and Stevenson, 2007).

Therefore, a proper stocking density is vital to maintain grazing operations under changing conditions, optimize forage and animal performance, and sustain renewable land resources over the long term (Thorne and Stevenson, 2007).

Karen and associates (2004) observed that, cattle stocking density had significant effects on the plant composition, species richness, species diversity, and growth form diversity of plants, with the highest stocking density resulting in highest diversity.

2.9 Tropical feed resources

Livestock production system in northern Ghana is constrained by many factors, of which feed shortages in terms of quantity and quality during the dry season constitute a major part (Oppong-Anane, 2013). Accessibility of available feed in the wet season is another limitation in some communities in northern Ghana due to the cultivation of arable crops (Awuma, 2012). This feed challenge together with high incidences of diseases and mortality contribute significantly to low livestock productivity. Most of the animals in northern Ghana survive mainly on left over straw during the dry season. Such a situation has long been recognized to result in cyclic body weight gain in the rainy season and weight loss in the dry season (Annor *et al*., 2007). These have made feed for livestock the main constraint to improved productivity in smallholder systems.

A study by Konlan *et al*. (2014) found ruminant feed resources to include, crop residues (groundnut haulms, cowpea hay, Pigeon pea residue (leaves and pods), rice straw, sorghum heads, peelings of yam and cassava and maize millet stovers), grazing fields made of naturally grown grasses and legume fodder. Agro-industrial by-products such as corn mill waste flour, brewers' spent grain of sorghum, maize bran and rice bran were also identified. Jayasuriya (2002) reported that feed availability is a function of land use and rainfall pattern, and becomes more available and accessible to ruminant after crops are harvested and animals allowed to graze freely (Annor et al., 2007). In the rainy season, feedstuffs were found to be inaccessible to animals in some communities due to restricted mobility of livestock to prevent damage to crops (MoFA, 2011; Awuma, 2012; Opong-Anane, 2013; Konlan et al. 2014).

Concentrates are traditionally low fibre-high protein feeds, and include oilseed meals and cakes (coconut cake, soybean meal, cotton seed cake, groundnut meal/cake) and animal byproducts (fishmeal, blood meal, feather meal). They are valuable sources of good quality protein for both ruminant and non-ruminant animals (Jayasuriya, 2000). The use of concentrates as a form of supplementation is one way of improving the performance of grazing cattle during periods of scarcity of feed (Asare and Okanta, 2000). The supplements increase the feeding value of the entire diet by direct addition of nutrients over and above supplied by the pasture and other roughages (Asare and Okanta, 2000).

Crop residues are post-harvest roughage materials or plant materials left after the removal of the primary food from the crop plant (Kubkomawa *et al.*, 2015) . Their quality is highly variable depending upon the crop species, seasonal growing conditions, extent of processing and post harvesting or processing treatment. They constitute an important, and often major feed resource available and utilised by smallholder producers in tropical feeding systems. Crop residue has positive balance in filling the feed shortage gap, but technically, they alone cannot meet even maintenance requirement as they are poor in nutrient and nutrient digestibility (Upreti, 2004). It is, therefore, important to improve feeding value of crop residue by treating with appropriate methods, particularly, using 4% agricultural urea (Upreti and Shrestha, 2006). Collecting and transporting straw, however, presents a major challenge to its wide utilization as it is not easy, and definitely not profitable to convey large quantities over long distances in a short time, hence their wide local utilization on production sites (FAO, 2014).

According to Church (1977), Cattle are natural grazers and possess remarkable ability to digest plant carbohydrates that are generally indigestible to most other mammals. Hence the assumption that grazing is the best way to supply nutrients to growing cattle (NRC, 1984). Feed for cattle, and to lesser extent small ruminants, is almost entirely obtained from natural grazing pastures and rangelands within the Savannah woodlands, characterized by unimproved pastures and bush fallow, with extreme seasonal variation in quantity and quality (Oppong-Anane,2013). Seventy percent of the estimated total herbage production of 10,600,000 tonnes of pasture in Ghana comes from natural grass land (Agrovets Consultancy, 1989). There are no lands purposely reserved for grazing in the country, with the exception of fodder banks established in the Afram Plains District under the Afram Plains District Agricultural Development Project (MOFA, 2016). Even though some communities have grazing lands oversown with hardy and nutritious leguminous forages for communal use, it is mainly on state livestock stations that land is reserved for grazing (MOFA, 2016).

2.10 Feeding behaviour of animals

Feeding is mostly triggered by hunger which leaves the animal weak and less active, hence the desire to avert the situation. Intake is influenced primarily by hunger, which is distressing, and by satiety, which is generally pleasurable (Baumont *et al.*, 1989). According to Forbes (1995), ruminants eat the amount of feed which leaves them with the most comfortable feelings. Regulation of feed intake and dietary choices combines short-term control of feeding behaviour related to the body homeostatic regulation, and long-term control that depends on nutritional requirements and body reserves (Faverdin *et al., 1995*). During a main meal, the rate of intake is highest at the beginning and then decreases continuously as satiation proceeds until satiety. Simple exponential models accurately fit cumulative intake during meals in both cows (Faverdin, 1985*)* and sheep (Baumont *et al.*, 1989). Initial rate of intake represents the motivation to eat, and the constant of deceleration of the exponential function the satiation process.

At pasture, the feeding pattern of ruminants is determined by the grazing periods that occur essentially during daylight. In a temperate climate, grazing time is organised into 6 to 8 periods with two main periods at sunrise and sunset. At high temperatures (>25°C), animals adapt their activity to avoid grazing at the hottest times, they start grazing early in the morning, prolong the evening meal and may also graze at night. (Baumont *et al.*, 2000).

Livestock are not all equal in makeup, neither do they use the pasture resource in equal measure. One animal unit (AU) is equivalent to one mature cow weighing up to 1000 pounds. Other livestock equivalents are as follows: one horse = 1.2 AUs, five sheep = 1 AU (6 goats per AU if they are under the age of one year). Horses, sheep and goats can graze plant materials closer to the ground because of the nature of their mouths, tongues and/or teeth. Cattle on the other hand do not like to graze very closely to the ground but can over use a pasture if not properly managed. In general, an animal consumes dry weight forage equivalent to 2 to 3% of its body weight in a day after it is weaned (Casale, 2009).

Cattle will mostly have anything from three to five large meals over the course of a day (Holly, 2011) with the largest meals occurring early in the morning around sunrise and again late in the day around sunset. Overall they usually graze anywhere from six to 11 h every day. They do the bulk of their grazing during daylight hours. Cattle generally do not spend a lot of time grazing at night. The exception to this is when daytime air temperature and humidity levels are high. At that point cattle may graze less during the day and shift their daily grazing activities to include the night when the environmental conditions are less harsh (Holly, 2011).

Among domestic ruminants, camels are classified as browsers, goats as intermediate selective feeders with preference for browse, sheep as non-selective intermediate feeders with preference for grasses and buffalos cattle and donkeys as grazers (Lusigi, 1988).

Most studies done have shown that feeding behaviour is influenced by plant and animal interactions. The animal components include, species, physiological status, previous experience with the vegetation and habitat exploration, whiles the plant component includes, availability, physical and qualitative characteristics of plant biomass (Dicko and Sikena, 1991).

Cattle and sheep have individual maxima for total grazing jaw movement rate, and their apportionment between bites and mastication differ. In sheep, when bite mass increases, the number of bites decreases as the need to masticate increases. In cattle we find a different picture, with many fewer mastications per bite, and as bite mass increases, relatively smaller increases in the proportion of total jaw movements represent (Gibb and Orr, 1997).

Feldt and Schlecht (2016) observed that the average proportion of time spent feeding by cattle was 64 % throughout the year. It was followed by 22 % of time spent walking and 14 % resting time with no significant differences between sites. On average, cattle herds spent 11.0 to 12.9 h d^{-1} on the pasture with significant differences between seasons (Feldt and Schlecht, 2016).

2.10.1 Voluntary feed intake

Butler and Bailey (1973) indicated that voluntary feed intake is the amount eaten during a period of time when the herbage is offered *ad libitum*. Low nutritional quality and high level condensed tannins adversely affects voluntary intake of blackbrush by goats (Provenza *et al*., 1983). Maximizing food intake by the animal is a key component in diets development and feeding strategies for optimizing animal production (Pereira *et al.*, 2003).

Nutrient intake is one of the main limiting factors of ruminant production. The animal`s feed intake capacity depends on several interactive factors in different feeding situations, animal behaviour and environment. Ruminant feed intake prediction is extremely important and difficult, due to the interactions that happen between the animal and the diet. When animals are fed with forage of low quality, the feed intake can be predicted with more precision by factors that describe the physical limit of the ingestion and live weight. In diets of better quality, the ingestion can be predicted by factors that describe physiological demand of the animal. In the investigation of voluntary feed intake in ruminants, it is informative to consider the anatomy of domestic ruminants in relation to the anatomy of all ruminants and the ecological niches occupied by ruminants in the wild (Fisher, 2002). Ruminants do not have uniform digestive tracts. On the contrary, they are highly specialized to process specific diets (Hofmann, 1988; 1998). The ruminant's digestive tract is fit to a particular ecological niche, and ruminants range in specialization from concentrate selectors through intermediate feeders to species adapted to grazing (Fisher, 2002).

Howe and Barry (1988) found goats to have a higher digestive capacity in comparison with sheep when consuming roughages with low nitrogen and high lignin contents. These differences have been attributed to: (a) a special ability of goats to select the morphological parts of the plants with the highest nutritive value (Morand-Fehr *et al*., 1991), this becomes very obvious in the lean season when feed resources are scarce (Bato and Sevilla, 1988); (b) a greater retention time of the digesta in the rumen of goats

(Domingue *et al*., 1991); and (c) interspecies differences in the rumen environment, such as a higher production of microbial protein in goats or a higher number of cellulolytic bacteria in goats than in sheep (Gihad *et al*., 1980).

Efficiency of digestion is elevated with foregut fermentation, but the daily intake of digestible nutrients may be reduced on poor quality feeds because of the relatively slow rate of passage from the rumen even if the diet is otherwise nutritionally balanced (Fisher, 2002). The grazing ruminant efficiently utilizes cellulosic material by fermentation in the rumen but this does not necessarily result in a high intake of nutrients (Van Soest, 1994).

Voluntary intake is an important indicator of the pasture quality and, as a result, is a key factor for predicting the productivity in grazing ruminants (Alcaide *et al*., 1997). The feeding habits of goats and sheep seem to adapt to the available vegetation, although slight differences between them were observed regarding the plant species they selected. The goats selected a diet with a higher protein and lower fiber content than sheep (Rutagwenda *et al*., 1990).

2.10.2 Browsing and browse plants

Browse refers to leaves and soft twigs from shrubs and trees that serve as feed material for ruminants, it also includes flowers and fruits or pods. The concept of browse is a complex matter, having to do with type of plant, animal species, availability and accessibility of forage and the nutritional condition of the animals (Le Houerou, 1980). Browse plants serve as a major feed resource for goats in dry and semi dry parts of the world (Ramfrez *et al*., 1990). For grazing ruminants like cattle, browse plays a complementary role to grasses, especially, during the lean season, as it provides essential protein needs when grasses get scarce (Mangan, 1988).

Browse plants serve a very useful purpose as a source of cheap feed for ruminant production in developing countries, most especially during the dry seasons when herbaceous pasture grasses and legumes are very scarce (Kibon and Orskov 1993). They help in bridging the gap caused by the decline in nutrient values of natural pastures during the dry season, since they are able to retain their green leaves and nutrient content during these seasons. The ability of their foliages to remain green and maintain their protein content makes them potential sources of protein and energy (Olafadehan, 2013). Most smallholder ruminant farmers in developing parts of the world can barely afford concentrates and thus depend almost entirely on browse fodders for feeding their animals (Okunade *et al.*, 2014).

2.10.3 Grazing

Grazing can be defined as the taking in of standing forage, which may include edible grasses and forbs by livestock or wildlife (Holechek, *et al.* 2004). Grazed herbage is the cheapest feed source available for cattle and sheep (Malcolm and Robert, 1997). Grazing when not properly managed can have dire effects on the rangeland, but with good management skills also comes neutral or positive effects. Range managers and land owners will be able to protect and preserve rangeland and plants much better, when they have a better understanding of the effects of grazing and browsing on individual plants and plant populations.

Grazing behaviour of animals can be seen in two folds, intense or search grazing (SDSU, 2007). Intense grazing takes place when there is availability of good quality forage thereby keeping the animal at one feeding station for long with several bites'. Searching behaviour on the other hand, involves the animal taking a few bites from one feeding station and moving on to another, this is mostly as a result of either low quality forage availability or toward the end of a grazing bout (SDSU, 2007).

2.11 Plant defence mechanisms

Plants may largely escape herbivoury if they are imbued with an especially toxic cocktail, although the plants must also have mechanisms for protection from their own toxins. Without defences, plants would be driven to extinction, with the consequent extinction of myriad herbivores, predators, parasites and saprotrophs (Schardi, 2002). .

Chemical defences are very common and well pronounced almost everywhere, playing a very important role in plant survival. Other defensive mechanisms which are also very important but may not always be obvious include, accumulation of tough polymers such as cellulose, lignin, tannins and silicates, which reduce palatability. Also, by minimizing the nutritive value of their tissues, plants may force a herbivore to consume more. This strategy may not seem advantageous, as it actually compels the animal to ingest larger amounts of plant toxins. Thorns, barbs, stings and sticky resins exuded from resin ducts, lactifers, or trichomes physically interfere with herbivory (Schardi, 2002).

Young tender plant shoots found among skeletons of dead stems may be avoided by grazing animals. Some bunchgrasses also accumulate and maintain upright dead stems that can deter grazing – a growth form commonly called a "wolf plant" (Landgraf *et al.*, 1984). Long-term grazing or mowing can make plants decumbent, thus, growing closer to the ground and upturned with a larger number of small shoots containing fewer or smaller leaves (Briske and Richards. 1995).

2.11.1 Plant tolerance to grazing

Grazing tolerance or resistance of a plant has to do with its relative ability to survive and re-grow in a grazed plant community. Resistant plants or species are those which are inherently less damaged than others under comparable environmental conditions (Painter, 1958). The level of resistance is often determined by qualitative or quantitative expression of one or more attributes that gives resistance to the plant (e.g. specific trait approach) (Simms, 1992).

Resistance to grazing can be divided into two components namely; avoidance and tolerance based on the general mechanisms conferring the resistance (Briske, 1986, 1991; Briske and Richards, 1995). Grazing avoidance involves mechanisms that reduce the probability and intensity of grazing, while grazing tolerance is made of mechanisms that promote growth after defoliation. Avoidance mechanisms are made of architectural features, physical deterrents and biochemical compounds which reduce tissue accessibility and palatability. Tolerance mechanisms are composed of the availability and source of residual meristems and physiological processes capable of promoting growth following defoliation (Dahl, 1995).

Grasses respond differently to grazing compared to forbs and shrubs because of where their growing points or meristems are located. They maintain apical and axillary buds near the base of the plant until flowering is initiated. This makes grasses relatively more tolerant to grazing before flowering and allows them to re regrow quickly when grazed in the young leafy stage. On the other hand, forbs and shrubs have axillary buds all along the stem and apical buds at the tips of branches. These meristems are readily available to herbivores and can be removed throughout the plant's life. Some forbs and shrubs have numerous growing points in the root crown at the base of the plant that can produce new shoots or underground runners called rhizomes (Briske, 1991).

2.11.2 Competition among plants and selective grazing

Various plants respond to grazing in different ways but not in isolation, they occur as members of a complex plant community. The nature of plant`s interaction with neighbouring plants will influence how it responds to grazing. The severity of a plant`s defoliation may, therefore, not really matter as compared to competition with its neighbours for limited soil water and nutrients (Mueggler, 1972).

According to Briske and Hendrickson (1998), defoliation may not affect competitive interactions in the short term (less than three years) as strongly in drier regions as in wetter regions. Plants that are not heavily grazed have a better chance of standing the competition as compared to those heavily grazed. In simplest terms, grazing should be applied when the target plant is most palatable to livestock and most susceptible to damage through defoliation. However, this admittedly might be very difficult to observe on vast grazing fields where animals are mostly left to graze on their own (Caldwell *et al*., 1987).

2.12 Grazing and management systems

A successful livestock-based grazing system relies on good pasture condition. Pasture condition refers to the health of plants in an area and whether the soil's nutrients can sustain management practices (Lemus, 2015). Pasture condition depends on species of the plants (legumes or grasses), biomass cover (weed pressure), soil conditions (nutrients, pH, and moisture), yield persistence (annual or perennial), and forage quality (taste, digestibility, and toxicity). Management practices that address these factors can improve pasture productivity (Lemus, 2015).

Management is very key to healthy, productive pastures. A nicely executed pasture management program can lead to improved soil fertility, an extended grazing season, and a more diverse, dense, and persistent pasture ecology (Banhart, 1998). Beef producers should think of themselves as grass producers who are marketing their products to livestock. In other words, livestock producers want to produce high quality forages that can nourish livestock to provide a net return (Lemus, 2015).

Poor pasture management leads to a decrease in animal gains and revenue. To sustain a livestock operation, a well-managed forage system uses several different management techniques. These management practices promote a healthy grass supply and can reduce feeding costs. They also protect natural resources by reducing soil erosion and increasing soil organic matter (Lemus, 2015).

According to Thorne *et al.* (2007), a successful grazing management plan requires a sound understanding of the effect the grazing animal exerts on the range or pasture ecosystem. The grazing animal exerts pressure on the range or pasture ecosystem through consumption and trampling of the plants, and by their movement across the landscape. Separation of this total influence into individual factors increases understanding of the grazing impacts and promotes informed grazing management decisions (Heady and Child, 1994). The goals and objectives of a successful range or pasture management plan are achieved only through two distinct methods of manipulation of the vegetative community: either by altering the grazing factors or through range improvement practices. Range improvement practices include applications of seeds, fertilizers, or other improvements directly to the soil-vegetation complex (Thorne *et al*. 2007).

A grazing animal selects for certain plants or plant parts and consumes them to a particular degree, resulting in a certain grazing intensity (Thorne *et al*. 2007).

This grazing event occurs during a specific season in the growth of the plant and may be repeated. Each of these four factors- selectivity, intensity, season, and frequency (repeated grazing) — influences the growth and reproduction of the grazed plants differently. Inherently then, plant communities are influenced differently. Thus, management of the animals can influence the vegetation of range and pasture systems by manipulating their relationship to the four grazing factors (Thorne *et al*. 2007).

When selecting forage species for seeding or renovating, consider individual requirements (fertility, soil moisture requirements, and winter hardiness). Most producers prefer grasses for forage because grasses yield more per acre. They are also easier to maintain. On the other hand, legumes increase soil fertility, have higher protein levels, and extend the grazing season (Lemus, 2015).

2.12.1 Non Fulani management system

The locals or non-Fulani practice smallholder agro-pastoralism which happens to be the main cattle production system in Ghana, and is mostly geared towards beef production (Oppong-Anane, 2001). It is, however, also linked with milk production system where by milk is shared between the herdsman and the calf, with the surplus going to the market (Okanta, 1992). In this system, farmers whose main occupation is crop cultivation also own livestock. Ownership may be direct, personal and individual, or in the form of trusteeship for family group property held in trust (Oppong-Anane, 2001). Where a large herd is found, the owning family group may be several, varying widely in size and in relationship. It frequently occurs that the apparent owner is not the sole owner, and he is unable either to authorize or approve extensive interventions without consultation with the co-owners (Oppong-Anane, 2001).

The smallholder agro-pastorialism has been described as a function of the type of settlement and distribution of the community, influenced by other factors such as security of danger from predators and cattle thieves and by the availability of quantity and quality of grazing areas Hutchinson (1962). In the compound farming areas, the cattle-owning people live in scattered compounds each surrounded by a farm (Oppong-Anane, 2001). Soon after dawn, each herd is released from the compound and driven through the compound farm by the owning family's children. Herding is, however, by adult members of the family where there are standing crops (Oppong-Anane, 2001).

2.12.2 Fulani herdsmen management system

They are mostly nomadic or semi nomadic herdsmen whose main occupation is rearing of animals, particularly, cattle with an occasional mix of sheep. Fulani pastoralists most often do not have permanent settling places, since their movement is determined by availability of good pasture and water resources. There are, however, a few as in the case of the semi nomads who migrate and return to base eventually (Iro, 1994).

Fulani herdsmen are mainly found in the arid and semi-arid parts of West Africa, but have spread to many parts of the sub region with time, and also as a result of climate change. They are particularly found in high numbers in countries like Nigeria, Niger, Senegal and Cameroon, but form a minority group in these countries (Mikailu, 2016).

They are believed to be the largest semi-nomadic group in the world, and are found across West and Central Africa - from Senegal to the Central African Republic (Mikailu, 2016). Fulani herdsmen are known to engage in both random and planned transhumance movements. The random movements are usually taken by the pure nomads, while the semi nomads take the planned movements. The aim of these types of movements is to access better pasture and find sources of water for their animals (Iro, 1994). Another reason for their movement is to avoid taxes, harmful insects and hostile weather and social environments. A major benefit of the movement for the herdsmen is to maximize the availability of food resources for the cattle and reduce excessive grazing (Iro, 1994).

The nomadic groups spend most of their lives in the bush and are mostly involved in clashes with crop farmers as a result of blames and counter blames of crop destruction by animals, and attack of animals by crop farmers. From 1996 to 2006, about 121 people lost their lives in Bauchi and Gombe states of Nigeria as a result of conflicts between pastoralists and farmers (Abbass, 2012). They herd their animals across vast areas, frequently clashing with farming communities (Mikailu, 2016).

In Ghana, Fulani migrant groups and pastoralist are usually considered strangers and foreigners because of their Senegambian origin (Okello, 2014). As a result, their rights to use the areas termed ancestral lands by indigenous ethnic groups is mostly met with some resistance. Conflicts in some regions in Northern Ghana arise due to cattle destroying the crops of farmers.

The worst ever of these conflicts was in December 2011, when a night raid of a Fulani village in Zamashegu, a farming community in the Gushegu district of the Northern region claimed 30 lives with several injuries. Similarly, more recently, conflicts arose in Agogo, a town located in the

Ashanti Region of Ghana, following the accusation of Fulani Herdsmen of rape, murders and brutalization of farmers who resisted the dominance or destruction of their farm lands (Botchway, 2016).

2.12.3 Movement of grazing animals

Different kinds (species) and classes (heifer, steer, lactating, growing, etc.) of grazing animals utilize range and pasture systems differently. Specifically, the foraging behavior of a given species or class of animal determines how it moves across the landscape and selects different forages. (Thorne, 2009). The distance livestock travel is influenced by many factors including temperature, wind, stage of gestation, and nutritional level of the animal (Malechek and Smith 1976; Ruckebush and Bueno 1978). Previous works have shown that day length may contribute to seasonal animal travel during grazing (Shaw *et al*. 1977).

Grazing animal must maintain water balance or die. Thus thirst is the most influential physiological need determining animal movement and distribution across the landscape (Thorne, 2009). Large ungulates are central place foragers, that is, they have a home range that is centered on water. Cattle and sheep, generally, do not graze beyond 1 mile from water. Consequently, a distance between water sources of greater than 2 miles reduces grazing capacity by 50 percent (Thorne, 2009). The distance cattle walk daily varies both within days and between days on individual farms and is generally related to pasture availability and/or accessibility. Ruminants try to match their feed intake and energy requirements. Distance travelled by grazing cattle is determined by a combination of intrinsic animal characteristics and management decisions. Grazing behaviour under these conditions will be determined, among other factors, by pasture quality/ availability and level of supplementation (SDSU, 2007).

2.13 Bush fires and rangeland management

Burning is an integral component of the cultural values and traditional farming systems of the people of Northern region of Ghana. The effects of bushfire on rural livelihoods and on the ecosystem in Ghana are increasingly becoming extensive and damaging. Unfortunately, it has become very difficult to reduce or completely eliminate bushfires (Nsiah-Gyabaah, 1996). As a result of the occurrence of bush fires only in the dry season, it is treated like many hazardous phenomena which occur occasionally, and only gets attention from the mass media and the general public during the dry season and seem to be forgotten when the risk disappears with the onset of the rains. Consequently, there is very little in the form of published data and information concerning the frequency, intensity, duration and effects of bushfire on the environment and human welfare in Ghana (Nsiah-Gyabaah, 1996). This attitude makes the combating of bush fire a difficult issue.

Ghana government established a National Anti-Bushfire Committee (NABFC) in 1983, which was coordinated by the Environmental Protection Council. The NABFC was mandated to set up guidelines for the operation of regional, district, town and village Anti-Bush Fire Committees and to provide technical support to these committees. The NABFC recommended the setting up of Fire Volunteer Squads in every village. These squards were organized and trained by the fire Service (Akyea, 1987). Training included military drills and rudimentary fire fighting techniques. But after all these trainings, the volunteers were not given any protective clothing or firefighting equipment (Akyea, 1987). The Government also enacted the 1983 Control of Bush Fires Law (PNDCL 46), which bans the setting of fire for any purpose other than the burning of farm slash or the management of forest and game reserves under the authorization of the Chief Conservator of Forests or the Chief Game and Wildlife Officer (Amanor, 2002).

The law specifies that the use of fire must be controlled and confined within the boundaries of the farm, and does not exceed the purposes for which the fire is permitted. The law provides stiff penalties for transgressors. They are liable to pay all the costs of the damages caused by the fire they were responsible for, a fine, or up to five years in prison (Amanor, 2002).

Bush fires are sometimes deliberately caused by foresters in other to maintain or achieve a plant composition which is optimal for a specific management objective. For example, in the Guinea and Sudan Savanna regions, foresters and range managers cause bushfires to promote the growth of forage for livestock. In this instance, fire becomes a good management tool used to facilitate and promote the introduction of new species such as improved forage species into the vegetation. Most herders believe that bush burning improves the acceptability and nutritional value of trees and other species (e.g., grasses) for grazing and browsing (Nsiah-Gyabaah, 1996). Some burning is also done in order to control dangerous animals, insects and pests (Nsiah-Gyabaah, 1996). For example, it is used to destroy or control some diseases, pests and parasites which may include grasshoppers, ticks, locusts, anthrax and tsetse flies, which live and thrive on the vegetation. Fire is sometimes used to create conditions suitable for particular land use systems or to create a habitat for particular species, for recreational purposes or to promote tourism. There are sometimes genuine reasons for burning bush, but if not properly handled, it could be very destructive. Burning in certain seasons of the year can be very destructive not only of vegetation, but also, soil structure and composition, increasing soil erosion (Nsiah-Gyabaah, 1996).

Damage done by fire to the natural pastures is very significant, and is a major contributing factor in the decline in condition of both natural and sown pastures, as well as the greatest constraint to the success of over sowing natural pasture with forage legumes (MOFA, 2016). Uncontrolled bush fire destroys standing hay and crop residues lying in the field, which would otherwise be used by ruminant livestock (MOFA, 2016).

2.14 Palatability of herbage and animal preference

Palatability is a plant characteristic that refers to the relish with which plants or its parts or feed is consumed as stimulated by the sensory impulses of grazing animal (Heath *et al.,* 1985). While preference refers to selection of a plant species by the animal as a feed.

Animal factors such as differential preference for forage species, age, stage of pregnancy, general health and hunger of animal; and plant factors including seasonal availability, degree of maturity, growth stage, phenology, morphological and chemical nature, relative abundance of associated species, accessibility to plants/sites and climate affect palatability (Wahid, 1990; Kababia *et al.,* 1992; Grunwaldt *et al.,* 1994; Nyamangara and Ndlovu, 1995).

It has been frequently observed that sheep generally prefer grasses and forbs more than shrubs; while goats prefer shrubs (Grunwaldt *et al.,* 1994; Wilson *et al.*, 1995). Migongo-Bake and Hansen (1987) reported that in East Africa, sheep feed usually consist of more than 50% grasses during all seasons, while shrub component of their diet tends to increase during dry seasons. Wahid (1990) noted that sheep and goats diet consisted of 53 to 81% shrubs in different rangelands of Balochistan.

Palatability is a complex phenomenon determined by animal, plant and environmental variables. The palatability of forage is determined by its ability to provide stimuli to the orpharyngeal senses of the animal, e.g. taste, colour and texture. Evidence exists that sheep, goats and cattle possess different degrees of sensitivity to palatability factors when a choice of feed is offered (Marten, 1978).

As a result of palatability being defined in terms of plant attributes, it is often called a “plant characteristic”. Palatability is said to influence voluntary intake (Arnold, 1970).

Preference is defined as relative consumption of one plant over another by a specific class of animal when given free choice at a particular time and place (Frost and Ruyle, 1993). Because preference is defined in terms of free choice by an animal, it is often termed an “animal characteristic”. Preference is reserved for selection by the animal, and is essentially behavioural. Relative preference indicates proportional choice among two or more foods (Heady, 1964).

2.14.1 Factors influencing forage palatability

Palatability is the degree to which animals like a food based on its flavour (Burritt, 2011*).* The palatability of a feed is interchangeable with preference for the feed. It is determined by the taste, texture, smell, temperature and appearance of the feed (Burritt, 2011). Marten (1978) partitioned animal factors that influenced palatability into five major categories, namely, the senses, species or breeds, individual variations, previous experience or adaptation, and physiological condition. Animal species difference in selection of forage plants is observed in the greater ability of sheep, compared with cattle, to differentiate between grazed clones of reed canary grass. Both sheep and cattle select reed canary grass clones at least partly on the basis of alkaloid concentration of the grass, both preferring plants having low alkaloids (Marten, 1973). The senses (smell, taste, sight) enable animals to discriminate among foods and provide pleasant or unpleasant feelings associated with eating (Provenza, 1995). Whether or not an animal readily eats a food is not determined by flavour alone, rather it is determined by the experiences associated with eating the food (Provenza, 1995).

Plant factors such as concentrations of sugar or soluble carbohydrates, protein or nitrogen, fibre or cell walls, cellulose, ether extract or fat, individual minerals or total ash, carotene, vitamins, organic acids, tannin, and silica have been found to be highly situation specific, and therefore, cannot be used as a selection criteria (Marten, 1973). Chemical composition is presumably the most important palatability factor (Burrit, 2011).

Natural and induced environmental factors frequently influence plant selection by ruminant animals. Among these are, plant diseases (presence or absence is environment dependent), soil fertility, animal dung, feed additives, climatic variation, and seasonal or diurnal variations (Marten, 1978).

2.14.2 Factors influencing relative preference

Many works have been done on the relationship between chemical composition of plants and their palatability. High positive correlation between protein content and preference by cattle and sheep has been shown (Braghieri *et al., 2003*).

When livestock encounter nutritious or new feed, especially, those with strong flavors, they are unlikely to try them. However, if they continue to eat them because they need additional nutrients or because others are eating them, they are likely to form preferences for those foods (Burritt and Provenza, 1989). Food preferences are not about conscious thought, rather, changes in palatability occur automatically through flavour-feedback interactions. Animals don't need to think about or remember the feedback event. Even when animals are asleep, feedback still changes palatability (Burritt, 2011). When sheep eat a food and then receive a dose of a toxin during deep anaesthesia, they learn to avoid the food because the negative feedback of the toxin (nausea) happens even when the animals are deeply asleep (Provenza *et al*., 1994).

Feeds high in sugars are preferred by cattle (Murphy, 1997). Braghieri *et al*. (2003) reported that high total ether extract also indicates a high preference.

2.15 Factors influencing diet selection

Diet selection is a broad subject matter that cannot be overlooked in animal production. It is common knowledge that grazing animals may be following some general rules during feeding, which most often may be determined by status of the grazing land. Both plants and animals are factors that influence diet selection.

2.15.1 Animal attributes that influence diet selection

Large ruminants ingest feed of potentially lower nutritive value as compared to the smaller ones (Hodgson, 1981). Rumen size relative to body size also differs between different species and this is in part responsible for changes in digestive capability for fibrous grasses, trees and shrubs (Demment and Van Soest, 1985). In gcneral, ruminants with a large body size will digest fibrous foods better because of relatively larger rumens and longer retention times, whilst small ruminants will digest fibrous feeds less well because of shorter retention times and rely on foraging strategies which allow it to ingest a diet with high cell content (Milne, 1991). Foraging strategy, diet selection and digestive ability are linked (Milne, 1991).

The size and shape of the ruminants' mouthparts also affect its ability to select discret food items (Gordon and Illius, 1988). A wide and flat muzzle width is often associated with a low degree of selectivity while feeding, as in cattle, on the other hand, a narrower and more pointed dental arcade is usually related to a high degree of selectivity, as in the goat (Gordon and Illius, 1988).

The selection pattern in utilizing the stubble resource was about the same for sheep and goats but at different percentages. First, residual heads (standing and fallen down) were consumed, followed by leaf and stem components for grazing sheep (Brand *et al*., 2000).

Bartolomé *et al.* (1998) observed that dietary differences were possibly as a result of differences in foraging behavior. Goats are more able to move quickly and freely and feed with their heads raised, while sheep tend to graze with their heads down .This behavioral difference is an advantage for goats in apprehending more attractive but less accessible feed items in the woody vegetation, while sheep prefer the feed items on lower herbaceous vegetation.

Small ruminant diet selection is influenced by many factors. Among these are, available woody and herbaceous species, forage availability and presence of nutritious alternatives, period of grazing, stocking rate, and whether goats and sheep forage as sole rangeland users or together with other animal species (Fatur, 2009).

According to Holecheck *et al*. (2004), browse is an important forage source for goats throughout the year and for sheep during the dry periods when herbage is limited. Defining feeding behaviour along a continuum, rather than categorizing different species of herbivores as grazers, mixed feeders and browsers, is preferred because most animals graze or browse opportunistically (Perez- Barberia *et al*., 2004).

Grazers tend to have wide muzzles, with lower incisors of similar size that project forward in a spatulate fashion (Janis and Ehrhardt, 1988). The greater incisor width of grazers is advantageous in maximizing bite size (affecting harvest rate) of herbivores when feeding on a continuous distribution of grasses (Illius and Gordon, 1987; Janis and Ehrhart, 1988). However, wider muzzles become a disadvantage in the grazer's ability to select the smaller, more nutritious portion of grasses (Janis and Ehrhardt, 1988). Grazing ruminants usually retain the ingesta in the gastrointestinal tract for a longer period of time, and digest fibre more efficiently than browsing ruminants **(**Pérez-Barbería *et al*., 2004; Hummel *et al*., 2006). Grazers, including cattle and horses, primarily, consume grasses and have digestive systems capable of handling large quantities of forages with relatively low nutritional quality (Owen-Smith, 1982). The sheer size of the mouth of these herbivores limits their ability to select individual parts (leaves, twigs) of plants. The large rumen of cattle and the active caecum of horses are well suited to consuming large quantities of low-quality, fibrous forage. They obtain the nutrients they need by consuming a large quantity of low-quality forage (Tu, *et al*. 2001).

In contrast, browsers tend to have a narrower muzzle (Janis and Ehrhardt, 1988) and a relatively larger mouth opening that permits sideways stripping of leaves. Some larger browsers, such as giraffes and black rhinos, have a longer tongue and prehensile lips (Hofmann, 1989). Browsers focus their forage selection on the leaves, flowers, and twigs of woody species (Frost and Mosley, 2015). They typically have a smaller, more pointed mouth than grazers. The narrow muzzle and other dental adaptations of browsers help them select individual plant parts of higher nutritional quality (Frost and Mosley, 2015). In general, the diet of browsing animals is higher in crude protein and more digestible than the diet of grazing animals. Many browse plants, however, contain secondary compounds or toxins that limit their intake by herbivores (Frost and Mosley, 2015). Browsers have developed several physiological characteristics that help them either metabolize or avoid exposure to these compounds (Frost and Mosley, 2015). For example, many species of browsing herbivores have a large liver in relation to their body size, which aids in metabolism of harmful plant toxins. Some browsers are equipped with salivary glands that bind tannins, an anti-quality compound found in some browse plants (Frost and Mosley, 2015).

Intermediate feeders have adaptations of both grazing and browsing. They possess a narrow muzzle and a large rumen relative to body mass, which allows them to graze selectively and still tolerate substantial fibre in their diet (Arnold and Dudzinski. 1978). Sheep are intermediate feeders that possess a relatively small mouth, allowing them to graze relatively close to the ground and to strip leaves or flowers from stems. The diet of intermediate feeders, generally, is dominated by forbs, although they will readily consume grasses when grass plants are succulent or when other forage has limited availability. Plant parts that are tender, succulent and readily visible are usually selected over those that are coarse, dry, and obscure. Compared to cattle, it is more difficult for sheep to graze tall dense stands of forage than short dense stands (Arnold and Dudzinski, 1978).

The best way to control invasive plants is to select the livestock species that most readily feeds on the plant targeted for control. Using more than one species (multi-species grazing) can enhance the benefits (Fatur, 2009) Multi-species grazing uses two or more species to graze the same piece of field, not necessarily at the same time. This has the potential to restore balance to ecosystems by encouraging more even utilization of all forage species, preventing an ecological advantage for one plant species or class of plants (Peischel and Henry, 2006). A good example of multi-species grazing is adding sheep to cattle ranches to check leafy spurge. The sheep graze through a pasture quickly while the spurge is in the yellow bract stage, removing the flower heads and effectively eliminating seed production, while the cattle are turned out for the normal grazing season (Peischel and Henry, 2006).

2.15.2 Other animal factors

Murden and Risenhoover (l993) reported that animals in a high nutritional standing will mostly be more selective, and choose diets differently than animals in poor nutritional state. Goats with low body condition score showed a tendency toward a higher consumption of browse during the rainy season compared to goats with moderate body condition (Mellado *et al*., 2004). The size of an animal has an influence on its feeding behaviour. Animals with low body condition or on a diet poor in nutritional requirements may have reduced tolerance for plant toxins. That is because there is a nutritional "cost" to metabolize a toxic or aversive plant compound (Foley *et al*., 1995).

Herbivores that are Malnourished, generally, eat more than animals with good nourishment. Animals with low body condition may turn to poisonous or less desirable plants to maintain that higher intake when there is scarcity of forage. (Arnold and Birrell, 1977).

Males and females select their diets differently, partly because of size differnces and overall nutrient requirements during reproduction (Grings, *et al*. 2001). Morphological and physiological traits such as growth rate and feed conversion efficiency also contribute to differences in diets (Grings, *et al*. 2001). Males generally have larger stature and muzzle size than females and may have greater energy needs (Grings et al., 2001). It is widely accepted that differences exist in foraging behavior between males and females, but this recognition is still not well understood. However, the sex of the grazing animal should still be considered when selecting animals to achieve specific vegetation management goals.

Animals choose their diets based on nutritional needs, which changes dramatically along its life stages. This knowledge can help with prescribed grazing. For example, some invasive plants with high nutrient content can meet the requirements of lactating females and growing young ones. Studies indicate that sheep grazing leafy spurge wean heavier lambs than their counterparts grazing spurge-free rangeland (Landgraf, *et al.*, 1984). However, not all invasive plants are highly nutritious, and animals must have enough alternative forage to maintain body condition before breeding to meet nutrition needs during gestation and lactation.

2.16 Direct observation of the animal

Direct observation is a widely used procedure both in the past and present when it comes to studies of botanical composition of herbivore diet of grazing animals. Information on this procedure has been reviewed by several workers (Bjugstad *et al*., 1970; Theurer, 1970; Theurer *et al*., 1976). It is a simple procedure that requires minimal use of equipment and easy to use. However, difficulty in species identification and quantification of how much of a plant was consumed are important problems associated with the procedure.

Quantitative information from direct observation has been obtained from the bite-count and feeding minutes approaches (Bjugstad *et al*., 1970). When the feeding minutes approach is employed, time spent grazing each species is quantified and assumed to be proportional to the importance of the species in the diet (Bjugstad *et al*., 1970). The bite-count procedure differs in that number of bites taken from each species, rather than the length of grazing time, is recorded (Reppert, 1960). Free et al. (1971) modified the bite-count approach by quantifying the weight per bite of primary forage species in the diet. Species data were then converted to relative percentages by weight. Holechek *et. al.* (1982) reported small differences between percentage of bites and percentage weight converted from bites for several forage species consumed by cattle.

It is difficult to locate and closely approach wild animals for accurate observation. These problems are, however, minimal or eliminated with tamed animals. However, only one animal can be observed at a particular time even with tamed animals. In addition, it may be difficult to differentiate between mere nibbling and active grazing (Bjugstad *et al*., 1970). Diet selection is a complex behavioural process that is influenced by several factors (Krueger *et al*., 1974). Physiological condition, level of hunger, topography, presence of other animals and past grazing experience all influence the type and amount of individual plant species that are consumed. The use of artificially reared and maintained animals can greatly alter the factors mentioned above. A number of factors influence the accuracy and precision of the direct observation procedure, including the degree of training of the observer, complexity of the plant community present, and/or phenological development of individual plants. Plant identification is not a serious problem on desert rangelands where plants are widely spaced as compared to prairie ranges where plants are close together. Plants become easy to identify as they mature (Holechek *et al*., 1982).

Procedures of sample collection may have some bias effect on the results. Some species may become unidentifiable in the faeces and identification is further complicated by aging of fecal material before sample collection (Scotcher, 1979). Fragmentation may differ between species during digestion so the relative proportion of species appears different (Scotcher, 1979; Vavra and Holechek, 1980).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 The Study Area

The study was conducted at the outskirts of Tamale Metropolis, Savelugu Municipality and Sagnarigu District in the Northern Region of Ghana using six cattle herds. Two of these herds were located in two villages within the Tamale Metropolis (Kalariga and Dalogyili), two within the Savelugu Municipality (Natua Yipala and Kpalung) and two in Sagnarigu District (Gbanyamni and Fuo).

Tamale Metropolis has a total estimated land size of 646.9 sqkm (GSS-2010) and lies between latitude 9º16' and 9º 34' N and longitudes 0º 36' and 0º 57' W (Fig.1). The main soil types in the area are sand, clay and laterite ochrosols. With an elevation of about 180 meters above sea level, the land is generally undulating with a few isolated hills. It has a unimodal rainfall pattern, averaging 1100 mm within 95 days, and average minimum and maximum temperatures of 28 °C and 43 °C, occurring in December and April, respectively. In terms of vegetation, it lies within the savannah woodland zone of the country. The trees in this zone are short scattered wood lots in nature and the major Spp are *Parkia biglobosa*, *Azadirachta indica*, *Acacia Sppecies*, *Khaya senegalensis*, *Adansonia digitata*, *Vitrllaria paradoxa* among others.

Savelugu-Nanton district has a total land area of about 2022.6 sq km with coordinates, 9° 24′ N and 0° 28′ W (Fig.1). The district is located within the

Savanna woodland area with drought resistant trees which hardly shed their leaves completely during the long dry season. Most of these are of economic value and serve as important means of livelihood, especially for women. Notable among these are *Vitellaria paradoxa* and *Parkia biglobosa*. Annual rainfall pattern is erratic at the beginning of the rainy season, starting in April and intensifying as the season advances, raising the average from 600 mm to 1000 mm. The district is characterized by high temperatures with an average of 34 °C. The maximum temperature could rise to as high as 42 °C (April – June) and the minimum as low as 16 °C. The low temperatures are experienced from December to late February, during which the North-East Trade winds (harmattan) occurs.

Sagnarigu district covers a total land size of 200.4 km² and shares boundaries with the Savelugu - Nanton Municipality to the north, Tamale Metropolis to the south and east, Tolon District to the west and Kumbungu District to the north-west (Fig.1). Geographically, the district lies between latitudes 9° 16' and 9° 34' North and longitudes 0° 36' and 0° 57' West. It has a single rainy season, usually stretching from May to October, and this period naturally coincides with the farming activities in the district. Annual rainfall average ranges from 600 mm to 1100 mm, the peak being usually between July and August. The mean day temperatures range from 28 °C (December - mid-April) to about 38 °C (April - June) while the mean night temperatures range from 18 °C (December) to 25 °C (February, March). The district lies within the Savannah Woodland Region characterized by tree savannah vegetation of varying sizes and density. The major types of trees in the district are *Parkia* *biglobosa, Azadirachta indica, Acacia Species, Khaya senegalensis, and Adansonia digitata* among others.

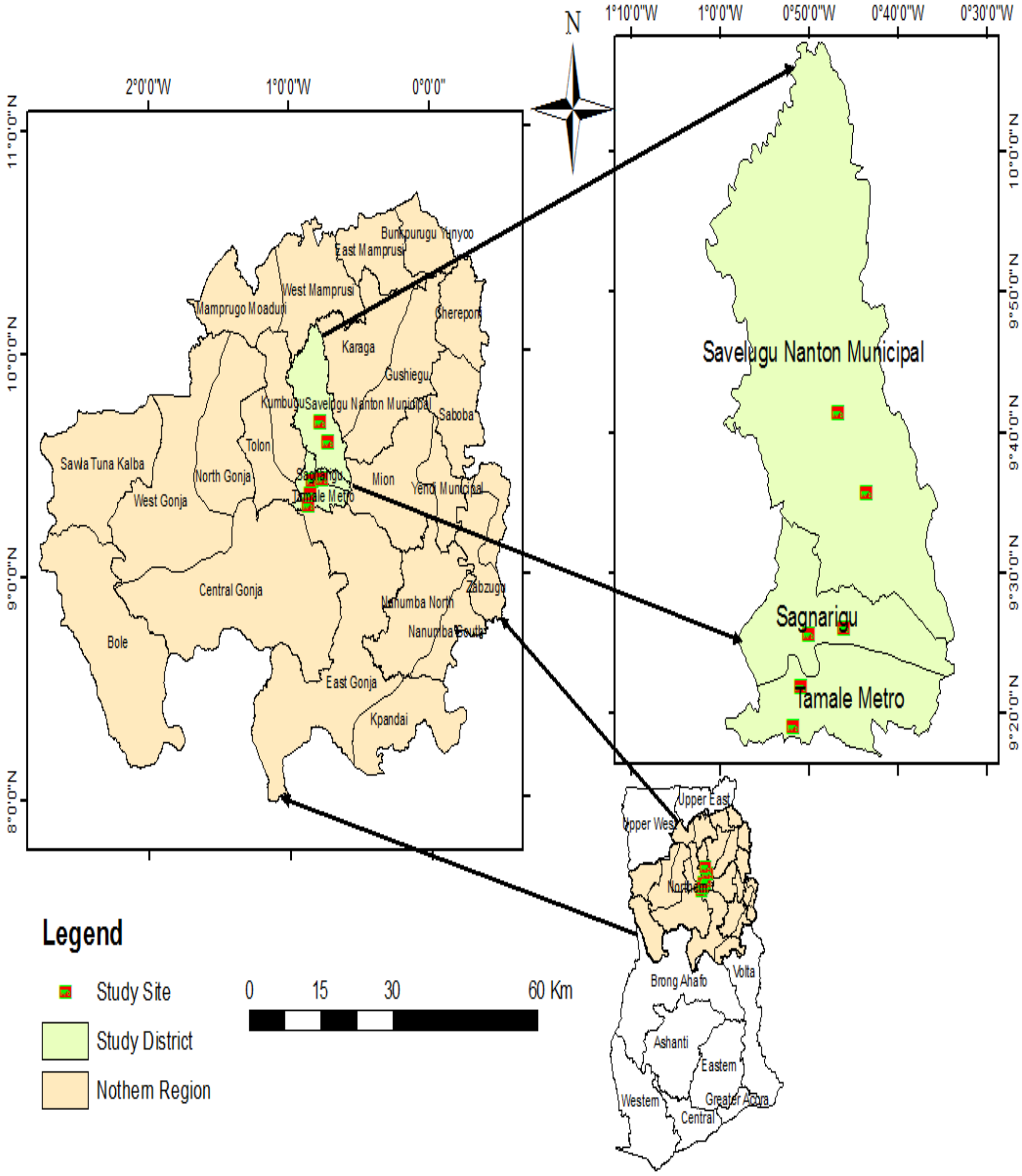

Fig 1: Map showing study sites

3.2 Experimental procedure

3.2.1 Main treatment allocations

Sampling periods were classified into three based on the rainfall pattern within the study area in order to understand the dynamics of vegetation on grazing. The periods included; intermediate (May/June), peak rains (August, September and October) and dry season (January-April). The selected farms were also grouped into Fulani and non-Fulani managed. Information on the age of the herders and kraal location were collected using interviews and observations, respectively.

3.2.2 Vegetation assessments

Graze lands were selected based on interaction with farmers, and also, by direct observation. Biomass sampling area was selected within the main grazing zone of the pasture. A two-step sampling approach was chosen. The first step was to select nine different plots of 10 x 10 m from each grazing land. The second step involved a random selection of four representative vegetation spots (1 x 1m) in each 10 x 10 m plot. The biomass within the 1 m^2 frame was clipped figure 3 and 4 The weight of the harvested samples were measured and recorded, and the dry weight together with the fresh weight used to compute the biomass yield.

The frequency of occurrence of grasses, legume and forbs species was estimated on the grazing lands in each season with the help of quadrats (1 m^2). Rooted specie group within each quadrat were recorded as present or absent. Frequency of occurrence was calculated as number of times a specie group was present in a quadrat divided by the total number of quadrats laid.

Plant height was measured from ground level to the apex of the plant with the aid of a centimetre rule.

Figure 2: Quadrat laid for harvesting

Figure 3: Harvesting of pasture for biomass estimation.

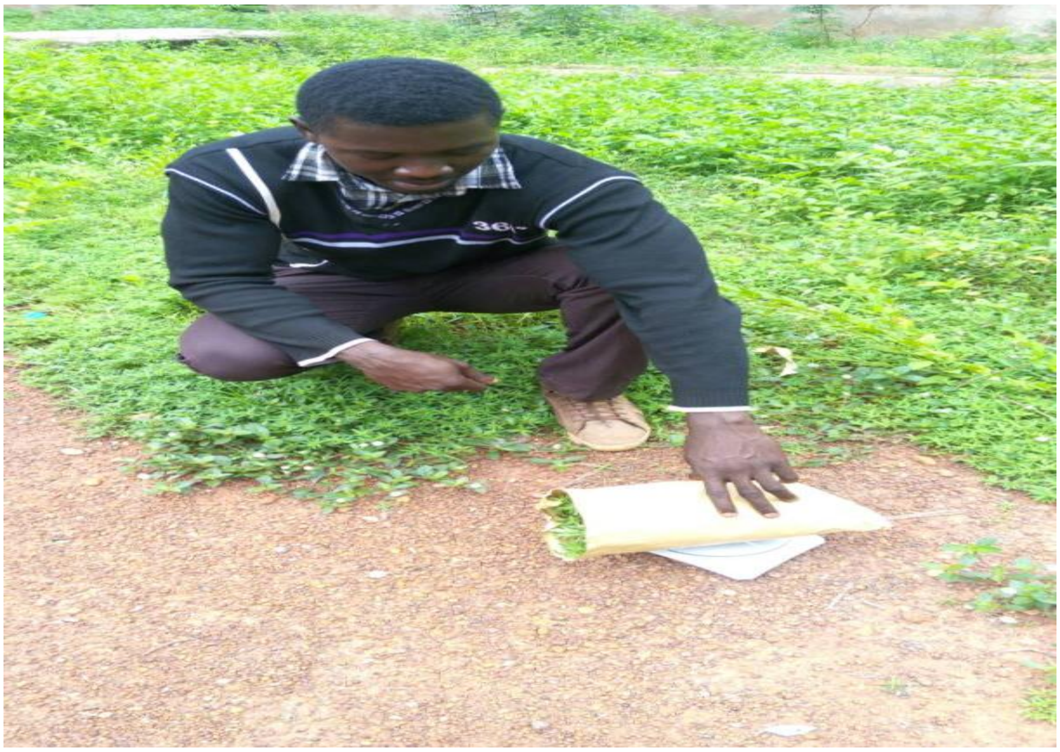

Figure 4: Weighting of sample for biomass estimation.

Vegetation cover was assessed by laying a 0.25 m^2 quadrat and by observation; the area covered by plant shoots and leaves was expressed as a percentage of the quadrat area in line with the procedure of Braun-Blanquet (1964).

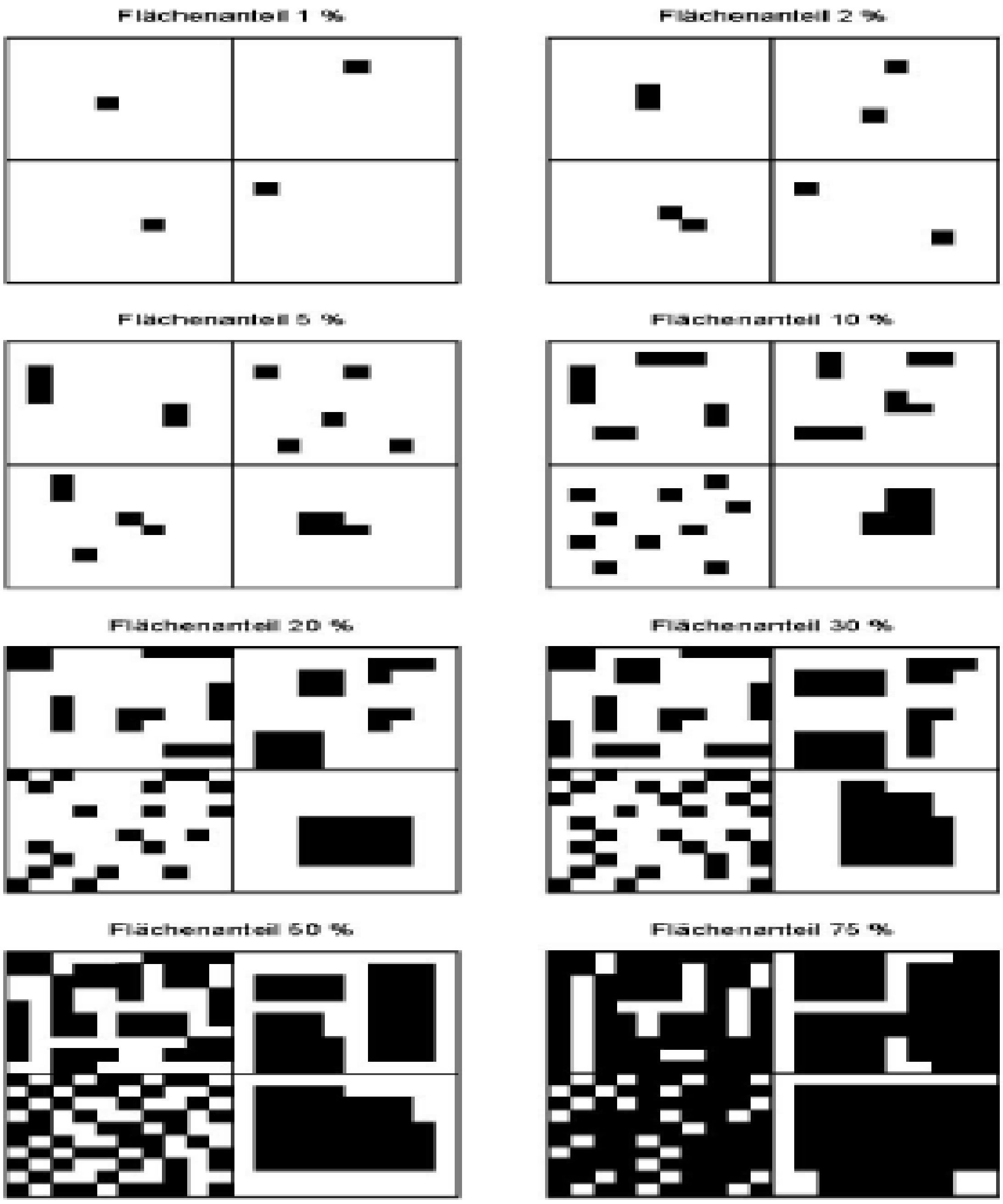

Figure 5: Ground cover classes by Braun-Blanquet (1964).

Carrying capacity was calculated using the proper use factor. According to Mustafa *et al.* (2000), the proper use factor is 0.5. That is half of the forage produced is used for determining the carrying capacity and was calculated according to the daily dry matter requirement of a Tropical Livestock Unit (TLU) which is equivalent to 7.5 kg (Mustafa *et al.*, 2000). Carrying capacity was determined as hectare/ animal unit/ year (ha/Au/Y) according to (FAO, 1980). Carrying capacity was calculated as follows:-

$$Carrying\ Capacity = \frac{Biomass}{tropical\ livestock\ unit\ \left(DM\ requirement / annum\right)}$$

Plants grazed by animals which included naturally growing plants and crop residues were put in three groups namely; grasses (*graminea* family), legumes (*leguminosae* family) and others. Leaf appearance, stems, fruits and roots were used to identify plants into these three main groups.

Stocking density was calculated using the relationship between the numbers of animals expressed as TLU and the specific unit of land being grazed at any one time. One tropical livestock unit (TLU) refers to a hypothetical animal with a live body weight of 250 kg (FAO. 1980). The conversion factor used for the cattle in the study area was 0.7 TLU in accordance to FAO (1980).

3.2.3 Categorization of grazing lands

Grazing lands were categorized into seven main groups, including; fallow on hard pan, maize field, rice field, muddy grounds, gravely grounds, sandy grounds and loose soils. This was done by direct observation of the fields. Below are definitions for the various categories for the purposes of this study.

Fallow on hard pan: These are lands that are not under crop cultivation and have become compacted over time.

Maize farm: Maize fields that are available to animals for feeding after the crops have been harvested, figure 4

Rice farm: Rice fields that are available for grazing after harvesting, figure 4

Muddy grounds: Areas that easily get muddy or flooded during the rainy season and not cultivated.

Sandy grounds: Lands basically made of sandy soils and not cultivated.

Loose soils: This category is basically areas that are neither clay nor sandy in nature (loam) but almost as loose as sandy soil.

Gravely grounds: Lands that are gravely in nature.

Figure 6: Cattle grazing on a maize farm after harvest.

Figure 7: Cattle grazing on harvested rice field.

3.2.4 Observation of animal behaviour during grazing

Species of cattle kept by farmers within the study area were predominantly the West African Short horn, with a few Zebu and Ndama.

The grazing behaviour of 18 cows (3 per farm) was observed. The animals used were aged three years and above. Males were not used for two main reasons, the first being the fact that they mostly run to other herds in search of females for mating purposes, thereby not showing the true movement pattern of the herd under study. Secondly, farmers mostly kept relatively very few bulls (3 to 4) or borrow from other farms for breeding purposes when the need arises, therefore, not enough may be available for observational purposes.

Each of the 18 cows selected was observed for a day, figure 4. Observation (Figure 7) was done continuously between 7:00-9:00 am and 4:30-6:30 pm, depending on the practices of the farm. Each animal was observed continuously for 1minute per 3 minutes, and activities undertaken recorded. The activities were categorised into five main groups as follows; feeding, walking, watering, resting and social interaction (Figure 8). In order to have a true representation of the average behaviour of the herd under study, animals observed were taken from the middle social rank (Mortiz *et al*. 2012).

Figure 8: Observation of animals.

Figure 9: Social interaction between cow and calves.

3.3 Data analysis

Statistical Package for Social Scientists (SPSS, version 20) was used for all data analysis. Type of lands grazed, plant species composition, biomass yield and status of pasture were analysed using chi square test for independence procedure. In case of a significant difference, a pair wise comparison was done by selecting two of the treatments and conducting another chi square test. The data on plant height, biomass yield, carrying capacity and stocking density was checked for normality (Shapiro-Wilk test). As data was not normal, it was transformed (square root) and analysed using the Generalised Linear Model (GLM) procedure, means of the untransformed data are presented in the results section and discussion. For each animal, the total time per day spent on pasture and on different activities was computed by summing up the minutes spent from the time animals were released from the kraal until they returned. The percentage of time spent on each activity was calculated in relation to the total time spent outside the kraal. The data was tested for normality (Shapiro-Wilk test) and found to be non-normal. The data was therefore analyzed using *Kruskal–Wallis* H *test*. Pairwise comparison of season was done by pairing two of the treatments at a time using the Mann-Whitney *U* test.

CHAPTER FOUR

4.0 RESULTS

4.1 Age of herdsmen and kraal locations

There was no limitation on age groups when it comes to herding of animals. The range varied from as young as eight years to sixty years of age. The older age group of twenty and above were mostly Fulani herdsmen, whiles the younger herdsmen (<20 years) were found on local farms or non-fulani farms.

Three of the herds studied were kraaled mostly just by the farmers house overnight, while the other three were kraaled in the bush away from farmers residence. Those farms that had their kraals away from the farmers residence were managed by Fulani herdsmen who go to settle somewhere alone at the outskirts of the village, or even far away in a different village in order to access feed and water resources. One of the farmers kept changing his kraal location from one village to another during the study, searching for better feed and water resources.

4.2 Vegetation attributes

4.2.1 Species groups

Season of the year significantly (X^2= 83.043, df= 4, P<0.001) influenced the occurrence of plant species groups. Grasses (72.8%) formed the dominant species all year round, this was followed by legumes (16.5%) and others (10.8%).

Effects of season on occurrence of plant species groups are shown in Table 1. Grasses were more dominant in the dry season than both the intermediate and peak rainy season. Higher proportions of grasses were also found in the peak rainy season than the intermediate season. Similar proportions of legumes were found during the intermediate and peak rainy season. These proportions were much higher than the proportion found during the dry season. Species other than grasses and legumes were also higher in the intermediate season than the peak rainy season, whiles nothing was recorded in the dry season.

Table 1: Effect of season on the frequency of occurrence of species group of plants, all values in parenthesis are percentages.

Season	Species group (%)			X^2 (5)
	Grass	Legume	Others	
Intermediate	199(61.8)	59(18.3)	64(19.9)	*
Peak rains	313(71.6)	87(19.9)	37(8.5)	*
Dry season	169(95.5)	8(4.5)	0(0)	*
Total	681(72.8)	154(16.5)	101(10.8)	

*X^2 between Intermediate and Peak rains=(X^2=21.029, $P<0.001$), X^2 between Intermediate and Dry season= (X^2=68.955, $P<0.001$), X^2between Peak rains and Dry season= (X^2=43.400, $P<0.001$).

Table 2: Species of plants observed on grazing fields

Common name	Botanical name
Guinea grass	*Panicum maximum*
Gamba grass	*Andropogon gayanus*
Nut grass	*Cyperus rotundus*
Tridax	*Tridax procumbens*
Thatch grass	*Andropogon pseudapricus*
Finger grass	*Chloris pilosa*
Bahama grass	*Cynodon dactylon*
Ditch millet	*Paspalum scrobiculatum*
Bristly foxtail	*Seteria barbata*
Stylo	*Stylosanthes mucronata*
Crowfoot grass	*Dactyloctenium aegyptium*
Feathery lovegrass	*Eragrostis tenella*
African copaiba balsam	*Daniella olivery*
Coffee senna	*Senna occidentalis*
Broom weed	*Sida acuta*
Itch grass	*Rottboellia cochinchinensis*
Speargrass	*Impereta cylindrica*
Loofah gourd	*Luffa cylindrical*
Snake weed	*Euphorbia hirta*
Wild tea bush	*Leucas martinicensis*
Ten o` clock plant	*Portulaca quadifida*
Chinese bur	*Triumfetta rhomboidea*
-	*Pennisetum pedicellatum*
-	*Brachiaria lata*
-	*Acroceras zizaniodes*
-	*Ischaemum rugosum*
-	*Gomphrema celosiodes*

The various plant species identified on the grazing lands are listed in table 2.

4.2.2: Status of grazing lands and Plant height

Status of grazing lands differed significantly ($X^2 = 1.229\times10^{-4}$, $P<0.001$) according to season (Table 3). Most of the fields were found to be heavily grazed at the intermediate season and during the dry season, but moderately grazed in the peak rainy season. Generally, heavily grazed (62.6%) was the predominant status pasture in the study area followed by moderately grazed (36.5%) and burnt (0.9%). About 62% and 96% of grazing lands were heavily grazed in the intermediate and dry seasons, respectively, whiles only about 31% was heavily grazed in the peak rainy season. Burning was, however, only recorded in the dry season and covered about 3% of graze lands.

Table 3: Status of grazing fields on seasonal basis

Season	Status of pasture (%)			X^2
	Heavily grazed	Moderately grazed	Burnt	(5)
Intermediate	110(62.1)	67(37.9)	0(0)	*
Peak rains	43(31.4)	94(68.6)	0(0)	*
Dry season	126(95.5)	2(1.5)	4(3.0)	*
Total	279(62.6)	163(36.5)	4(0.9)	

*X^2 between Intermediate and Peak rains= ($X^2=1.028\times10^{-4}$, $P<0.001$), X^2 between Intermediate and Dry season= ($X^2= 1.126\times10^{-4}$, $P<0.001$), X^2 between Peak rains and Dry season= ($X^2 = 1.405\times10^{-4}$, $P<0.001$).

Plant height differed (P<0.05) on seasonal basis with the dry season having the highest plant height whiles the intermediate season had the least (Figure 10).

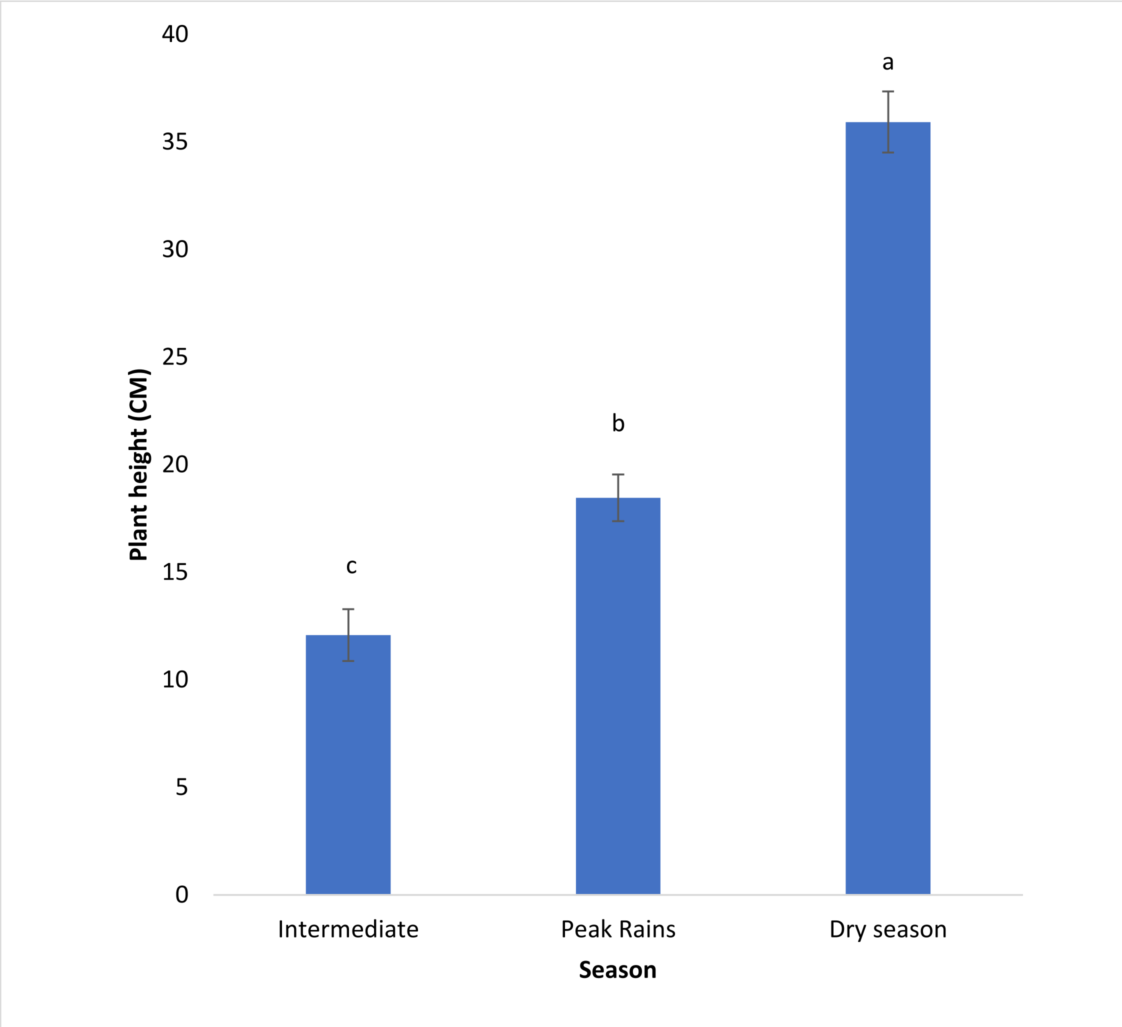

Figure 10: Mean effect of season on plant height

4.2.3 Vegetation cover

Vegetation cover was significantly (X^2=2.454×10^{-2}, df =16, P<0.001) influenced by season. The peak rainy season had the highest vegetation cover with 66% of the grazing lands having a cover of 75% and above. Meanwhile the dry season had the least vegetation cover with 78.6% of the grazing lands having a vegetation cover of 50% and below. Similarly, the intermediate season had 54% of the grounds having 50% cover and below (Table 4).

Table 4 nal effect on vegetation cover

Seas	Vegetation cover (%)									X² (5)
	1	2	5	10	20	30	50	75	100	
Ir	0(0)	5(1.8)	32(11.3)	33(11.7)	16(5.7)	27(9.6)	37(13.1)	80(28.3)	52(18.4)	*
Pl	0(0)	0(0)	0(0)	0(0)	6(1.9)	15(4.7)	88(27.5)	160(50.0)	51(16.0)	*
D	1(0.6)	12(7.1)	28(16.6)	24(14.2)	28(16.6)	21(12.4)	18(10.7)	18(10.7)	19(11.2)	*
To	1(0.1)	17(2.2)	60(7.8)	57(7.4)	50(6.5)	68(8.2)	143(18.5)	258(33.5)	122(15.8)	

*X² b intermediate and peak rains = (X^2=1.236×10⁻², P<0.001), X^2 between Intermediate and Dry season=(X^2 =45.247, P<0.00 tween Peak Rains and Dry season = (X^2 = 2.296×10⁻², P<0.001). Int= intermediate season, PR= peak rainy season and DS= dr n.

4.2.4 Type of grazing fields

Type of grazing fields available to animals during the three seasons are shown in table 5. Season significantly ($X^2 = 1.507\times10^{-4}$, $P<0.001$) influenced the type of grazing fields available to animals. Fallow on hard pan was the mostly available in the intermediate season (48%) than peak rainy (36%) and dry seasons (27%). Similarly muddy grounds were highest in the peak rainy than the intermediate season, while none was recorded in the dry season. Rice fields were mostly available in the dry season (62.6%) than any of the other two seasons. Irrespective of the season of the year, fallow on hard pan was predominantly (38.2%) available and sandy grounds was the least (1.9%).

Table 5: Pe[illegible] e availability of types of grazing fields with respect to season

Season	Type of field (%)							X^2
	[illegible]	MF	RF	MG	SG	LS	GG	(5)
Int	[illegible].0)	0(0)	51(30.2)	16(9.5)	9(5.3)	0(0)	12(7.1)	*
PR	[illegible].5)	0(0)	0(0)	62(31.3)	0(0)	14(7.3)	46(24.0)	*
DS	[illegible].0)	12(10.4)	72(62.6)	0(0)	0(0)	0(0)	0(0)	*
Total	[illegible]8.2)	12(2.5)	123(25.8)	78(16.4)	9(1.9)	14(3.0)	58(12.2)	

*X^2 between [illegible] ediate and Peak rains=(X^2=1.256×10^{-4}, P<0.001), *X^2 between Intermediate and Dry season= (X^2=1.163×10^{-4}, P<0.001), *X^2 between [illegible] ains and Dry season= (X^2=1.600×10^{-4}, P<0.001). FH= fallow on hard pan, MF= maize farm, RF= rice farm, MG= muddy grounds, SG[illegible] grounds, LS= loose soils and GG= gravely grounds

4.2.5: Biomass yield, carrying capacity and stocking density

Biomass productivity for the three seasons differed significantly (Figure.11). The dry season was found to have the highest ($P<0.05$) biomass yield, while the intermediate had the least.

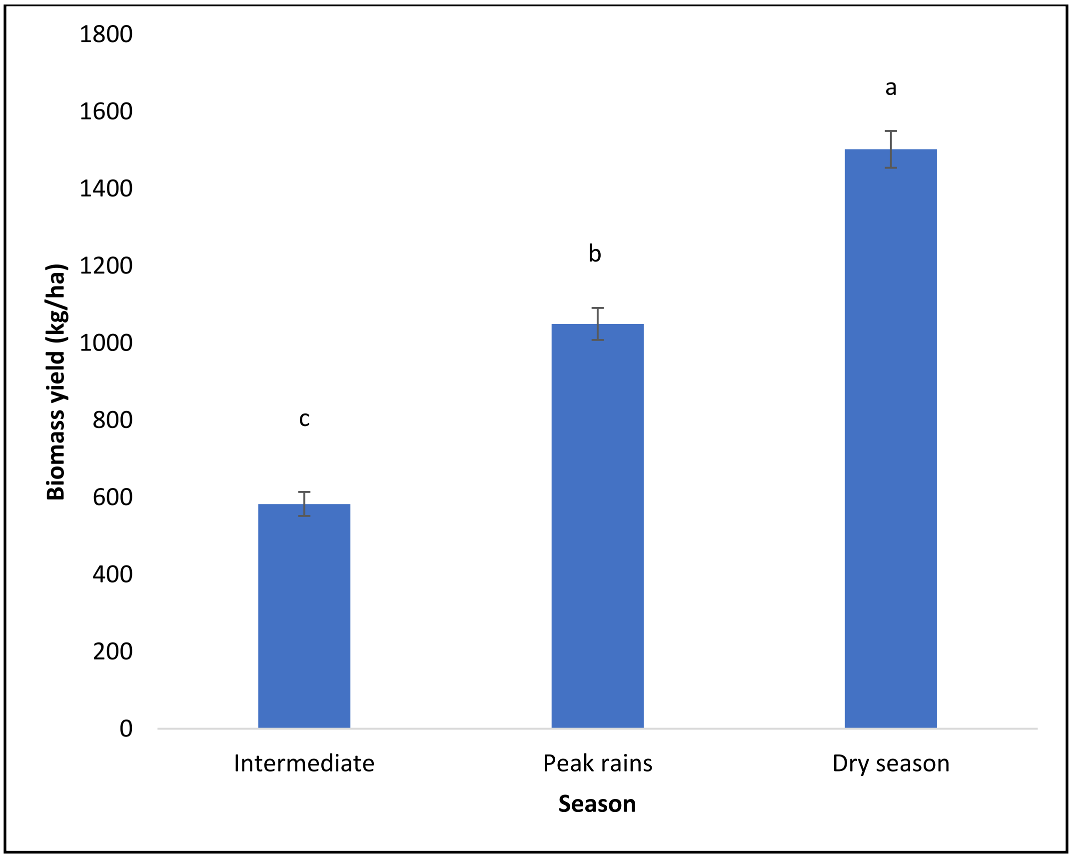

Figure 11: Effect of season on mean biomass yield of grazing lands.

Carrying capacity of fields in the dry season was significantly ($P<0.05$) higher than those in the peak rainy season and intermediate season. Similarly, the carrying capacity during the peak rainy season was much higher ($P<0.05$) than that found in the intermediate season (Figure 12).

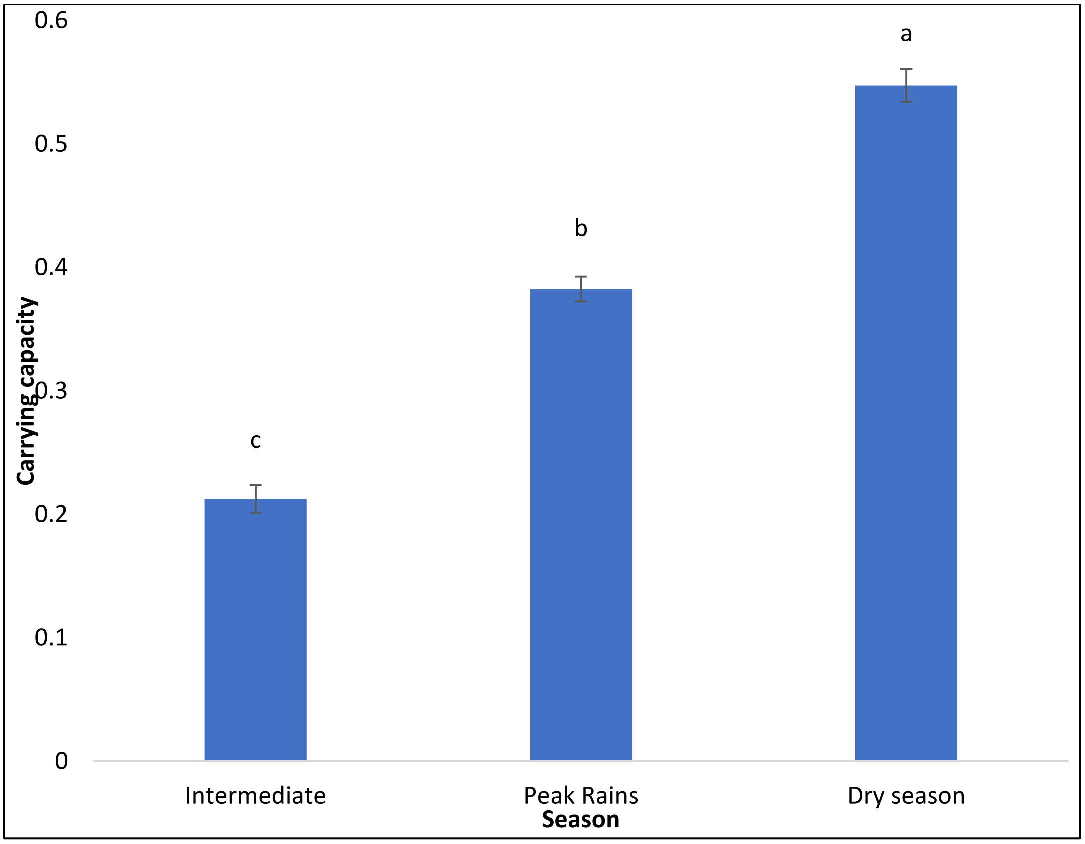

Figure 12: Effect of season on carrying capacity of grazing lands.

Season had a significant effect on stocking density of grazing lands (Figure 13). The stocking density in the intermediate season was significantly higher than the peak rains and dry seasons but there was no difference between peak rains and dry season.

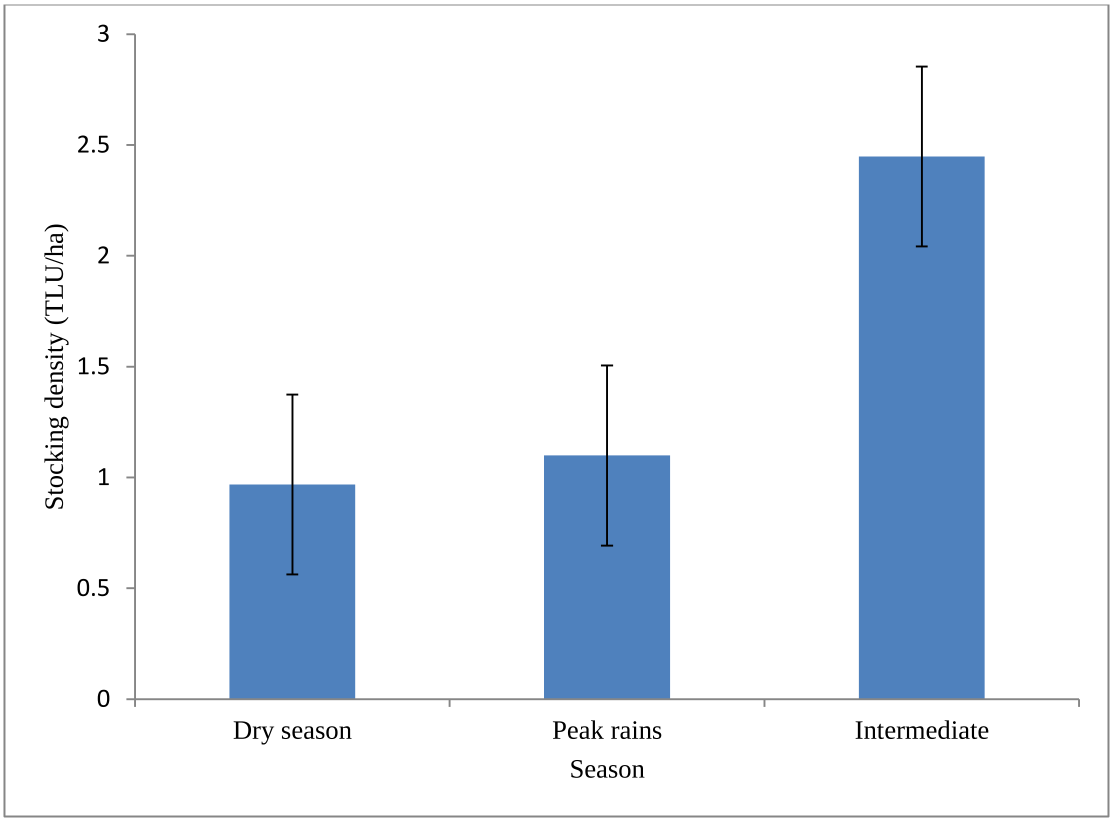

Figure 13: Mean seasonal effect on stocking density

4.3. Seasonal effect on grazing behaviour.

The grazing behaviour of cattle during a seven-hour period is shown in table 6.

Feeding was the most dominant ($P<0.05$) activity undertaken by cattle during each of the three seasons, followed by walking, resting, social interaction and watering. Similar proportions of the animal`s time were spent feeding in both intermediate and peak rainy season, these proportions were much higher than the proportion of time spent feeding in the dry season. Much more time was spent walking in the dry season in search of feed than the intermediate and peak rainy season, the least proportion of time spent walking was recorded in the peak rainy season. Resting was much higher during the peak rainy season than the intermediate and dry season. The intermediate season also recorded a higher resting time than the dry season. Similar proportions of time were spent on watering in each of the three seasons. Social interaction was highest in the peak rainy season and least in the dry season.

Table 6: Effect of season on grazing behaviour of cattle

Season	Behaviour (%)					X^2 (5)
	Feeding	Walking	Resting	Watering	Social interaction	
Intermediate	2402(69.1)	778(22.4)	193(5.6)	34(1.0)	69(2.0)	*
Peak rains	2083(68.3)	464(15.2)	392(12.8)	20(0.7)	93(3.0)	*
Dry season	1773(61.9)	974(33.8)	62(2.2)	27(0.9)	43(1.5)	*
Total	6258(66.5)	2216(23.6)	647(6.9)	81(0.9)	205(2.2)	

*X^2 between Intermediate and Peak rains= (X^2=1.500×10^{-2}, P<0.001), X^2 between Intermediate and Dry season= (X^2= 1.361×10^{-2}, P<0.001), X^2 between Peak rains and Dry season= (X^2 = 4.604×10^{-2}, P<0.001)

4.4 Effect of management on grazing behaviour

Management style significantly (X^2=1.556×10^{-2}, df =4, P<0.001) affected animal behaviour. Non-Fulani herds spent more time feeding than Fulani herds. Conversely, Fulani herds spent more (P<0.05) time walking than non-Fulani herds. Non-Fulani herds rested more during grazing than Fulani herds. Time spent watering and engaging in social interaction did not differ between the two flocks (Table 7).

Table 7: Effect of management style on grazing behaviour of cattle

Management	Behaviour (%)					X^2 (5)
	Feeding	Walking	Resting	Watering	Social interaction	
Non Fulani	3605(69.3)	979(18.8)	465(9.0)	46(0.9)	108(2.1)	*
Fulani	2563(61.5)	1186(28.5)	245(5.9)	36(0.9)	136(3.3)	
Total	6168(65.8)	2165(23.1)	710(7.6)	82(0.9)	224(2.6)	

*X^2 between Non Fulani and Fulani managed animals=(X^2=1.556×10^{-2}, P<0.001).

CHAPTER FIVE

5.0 DISCUSSIONS

5.1. Vegetation attributes

5.1.1 Species groups

The generally high proportions of grass relative to legumes and other species may be attributed to how they respond to grazing because of where their growing points or meristems are located, that is, at the base (Fatur 2009). Additionally, grasses are better able to withstand harsh climatic conditions such as drought and bush fires. The extremely higher proportion of grass (95.5%) in the dry season than peak rains (71.6%) and intermediate seasons (61.8%) is largely due to the fact that animals mostly grazed on harvested farmlands which were covered with residues of rice and maize, and these were categorised as grasses. The relatively lower proportion of grass in the intermediate season is attributable to residual effect of bush burning from later parts of dry season, as most farmers burn the vegetation on their farmlands prior to the planting season as part of their land preparation (Nsiah-Gyabaah, 1996). The higher legume proportions in the peak and intermediate seasons is possibly as a result of favourable conditions enabled by the rainfall, while the lower levels in the dry season could be due to over grazing on the already scanty quantities in the early and peak rainy seasons, as there is usually insufficient pasture for animals to graze during this time of the year (Oppong-Anane, 2013).

Natural pasture grasses are wild, and are usually low yielding and poor in nutrients, as they mostly grow on infertile and erosion degraded soils (Babayemi and Bamikole, 2006). Unfertilized grasses and those grown without a mixture of legumes were described as less nutritive as forage for goats (Bamikole and Babayemi, 2004). This translates into low quality feedstuff for the animals within the study area, as grazing fields were mostly natural pastures, with grasses being the most dominant species group. Ruminants have been known to perform better when feeding on legume monocultures or a mixture of legume and grass, compared with monocultures of grass (Gibb and Orr, 1997). The matter is further compounded in the dry season when the vegetation is all dry. Most grazing fields during this time are burnt leaving animals to walk longer distances gleaning for forage (Nsiah-Gyabaah, 1996). The extremely low levels of legume mean the animals have very limited protein sources since farmers do not do any form of feed supplementation, leaving animals on whatever is available in the field.

5.1.2 Status of pasture

The high percentage of heavily grazed pastures in the early rainy season could be an extended effect from the dry season, but that of the dry season was expected since almost all grasses dry out in this season except for places close to dams or water ways where water was still available. Even then, these areas end up being heavily grazed since a lot of animals end up grazing there after drinking water. A greater portion of these grazing lands, if not all, even end up being burnt during the dry season (Maitima *et al.*, 2009). The peak rainy season on the other hand comes with lots of pasture as only 31% was heavily grazed during this season, with moderately grazed being 69%. This is a normal trend, and is expected since it is the rainy season and almost everywhere is green and animals have lots of options to choose from. Also plants especially grasses are able to re grow fast during this season as the environmental and soil conditions are very favourable for plant growth (Briske, 1991).

5.1.3: Vegetation cover

The vegetation cover in the peak rainy season is much higher than the 41% recorded in northern Sudan by Fatur (2009), which is quiet understandable since Sudan is more of a desert area compared to northern Ghana. Meanwhile, the dry season had about 67% of the fields having 30% cover and below, whiles the remaining 33% was 50% cover and above. This finding is not surprising since plants grow more in numbers and size with increased rains and good soil moisture (Casale, 2009). The early rainy season had almost equal distribution possibly because the rains had just started, initiating plant growth. The dry season had lower ground cover not just because there was no rain during that time, but also because the bushes are always burnt during this season (Nsiah-Gyabaah, 1996). This does not only pose a threat to animal nutrition, but also a source of worry in terms of land degradation. Bare soils are easily eroded by strong wind or rains. A good vegetation cover provides protection to the soil against erosion, and helps keep the moisture content relatively higher. (Holechek, *et al.* 2004). Decayed plant parts also improve the organic matter content of the soil.

5.1.4 Type of grazing fields

All grazing fields were generally close to flat. Fallow on hard pan was the most dominant type of graze field available during the early rains and peak rains but not the dry season. The hard pan nature of the field could be as a result of several years of compaction as animals continue to graze on these same lands year after year (Casale, 2009). Its compacted nature may have also accounted for it being left fallow and not used for crop farming. The type of grazing field during the dry season was mainly rice farm (62.6%). The use of rice and maize farms during the dry season as graze fields conforms to the assertion made by Oppng-Anane (2001) that after harvest, crop residues normally complement standing hay, and in some cases, take the place of natural grasses in the range in providing the bulk of ruminant feed. This residue is, however, left in the field for animals to go feed on. After harvesting annual crops, it is the practice of some communities in the north-west and the north-east of the country to drive their herds from the compounds into the unfarmed areas without any form of herding, where they remain wholly unattended to until the next farming season (Oppong-Anane, 2001). In this study, however, cowboys always herded the animals to the grazing sites and returned them home at dusk. Maize farms were not available in the first two seasons, possibly because such fields had already been cropped, hence inaccessible to animals. The availability of rice fields during the intermediate season is due to the fact that those farms were not yet in use as at the time of study or were just not cropped that year. After fallow on hard pan and rice farms, the next dominant fields available were muddy in nature, and occurred mostly in the peak rainy season. This, however, creates a difficulty most of the time to both cattle and cowboys by way of movement, thereby making grazing in such areas very uncomfortable.

5.1.5 Biomass

Biomass estimates showed an increasing order from early rains to the dry season. These results are directly opposite the findings in Sudan by Fatur (2009), where the rainy season rather had the higher amounts of biomass and the dry season having lower levels. These differences could be due to the fact that the fields in the Sudan study were strictly for grazing purposes, whiles those in the current study include farm lands where harvesting always coincides with the dry season, and farm residue such as rice straw are left in the field after harvesting. These constitute a huge portion of the biomass yield recorded during this season. Also, differences in management of graze lands could account for these differences. The low levels of biomass in the early rainy season could be due to residual effects of the previous dry season, bush burning and to some extent heavy grazing. The higher dry season yields, however, does not translate into good feed for animals since these plants are all mature with inadequate reserved energy, considering the fact that the carbohydrate in them would have been used up for flower, fruit and seed production, leaving highly lignified straw. This feed resource may be improved through urea treatment, enhancing feed availability during this period.

5.1.6: Carrying capacity

Carrying capacity may vary from season to season considering the erratic rainfall pattern. The result shows that Tropical Livestock Unit (TLU) requires more hectares of land during the early rainy season as compared to the peak rainy season. Also, according to this study, the dry season is the season in which TLU requires less hectares of land, but this could be misleading. This is because a lot of these dry pasture and farm left over could easily be lost to bush fires aside the fact that the standing straw does not really meet the feed requirements of the animal in terms of nutrient availability following the fact that, pasture at that time of the year will be highly lignified.

5.1.7: Stocking density

The higher stocking density recorded in the intermediate season could be due to the absence of crop farming which gives farmers free access to the grazing lands.

5.1.8: Bush fires

During the period of this study, only 2.67% of the graze fields had been burnt, which is highly impressive. Burning occurred mostly for two main reasons; firstly, by Fulani men with the hope of stimulating plant re-growth for animals to have fresh forage to feed on. Secondly, by children, and occasionally, grownups for hunting purposes. This is in line with the assertion made by Nsiah-Gyabaah (1996). The herders believe bush burning improves the acceptability and nutritional value of trees and other species (e.g., grasses) for grazing and browsing. The worry in this is that animals end up losing more feed than gains because most of these lands are always too dry for any plant re growth Nsiah-Gyabaah (1996). Burning can also be done in order to control dangerous animals, insects and pests, including grasshoppers, ticks, locusts, anthrax and tsetse flies, which live and thrive on the vegetation Nsiah-Gyabaah (1996). There have been several attempts by both governmental and nongovernmental organizations to stop bush fires in Ghana, especially, the northern sector, but not much has been achieved because bush burning is now an integral part of the people, and fighting it is like asking the people to stop their way of life (culture) Nsiah-Gyabaah (1996).

5.2 Seasonal effects on grazing behaviour

5.2.1 Feeding

Cattle in the study area spent on average, 66% of the time in the field feeding, this was followed by walking (24%), resting (7%), social interaction (2%) and watering (1%). The average proportion of time spent feeding and walking in the present study were similar to those reported by Feldt and Schlecht (2016) in a Madagascan study. The proportion of time spent resting in the present study was, however, lower than those reported by Feldt and Schlecht (2016). These differences are attributable to the fact that these authors captured water intake and social interaction as part of resting period. This would have over-estimated the period spent resting in their study. The fact that feeding took a greater proportion of the time spent by the animals at grazing is not surprising, as animals are more likely to concentrate on meeting their energy requirements first before engaging in any other activity (Stafford Smith, 1988).

Cattle require about 7.5 Kg DM/day (Mustafa *et al.,* 2000), which will require a longer time to attain in the field, considering that animals move about selecting plant Species of interest (Thorne *et al.*, 2007).

The fact that animals spent more (69%) of their time feeding during the intermediate season than any other season is expected, as fresh plants were just beginning to emerge, and longer time may be required for feeding to enable the animal meet its energy requirement, and also, smaller but more bites are made when pasture is short and scattered (Gibb and Orr, 1997). . Additionally, the favourable temperatures during this time of the year may have increased the feeding period as animals are said to feed more when ambient temperatures are favourable (Stafford Smith, 1988). The relatively less time spent feeding in the dry season may be related to the higher ambient temperatures associated with this period of the year. Additionally, the higher feed resources recorded at this time of the year may have contributed to the reduced grazing time. Reduced availability of water during this time of the year is also a factor, as cattle are not likely to graze beyond 1 mile away from water sources (Thorne, 2009) and a distance of 2 miles away from water source reduces grazing capacity by 50%. Since herdsmen move the herd irrespective of sources of water relative to the grazing site, it is likely the animals will reduce grazing time in order to cope with inadequacy of drinking water.

5.2.2 Walking

Animals walked the most during the dry season when they spent about 34% of their time walking. The dry season comes with its own problems of feed and water scarcity, this thereby forces animals to walk more in search of pasture and to reach water sources (Little and McPeak, 2014). Grazing behaviour among other factors is determined by pasture quality/ availability and level of supplementation (SDSU, 2007). Cattle mostly select different parts of plants based on palatability (Narjisse, 1991). It is, therefore, not surprising that cattle in the current study spent extra time walking during the dry season when pasture conditions were poor, presumably, selecting palatable plants. Cowboys also influenced the amount of time spent walking. On days cowboys do not feel like moving round for a longer period, less walking would be done, also younger cowboys mostly soon get tired and return home earlier than their older counterparts.

The problem, however, with this proportion of time spent walking is that, animals will expend a lot of energy in search of feed and water for which they might not be able to replace because available feed during this season is simply inadequate. The result is weight loss and general down ward trend in productivity which characterizes the dry season. A similar observation was made by Osuji (1974). Loss of energy or emaciation is not the only problem that comes with walking more and not replacing the lost energy, but even more worrying is the fact that the animal's immunity to diseases and other environmental hazards is greatly reduced, thereby making it prone to pest and disease attacks.

The least percentage of walking time was found in the peak rainy season. This looks quite understandable because the rainy season comes with a lot of feed resource for grazing animals, hence there will be no need walking longer distances in search of feed. Additionally, animals may not have to walk longer distances in search of water since there is water available all over during this period of the year.

5.2.3 Resting

Resting proportion was significantly higher in the peak rainy season (13%) than the intermediate (6%) which was also higher than the dry season (2%). This could have been as a result of the fact that during the peak rainy season, animals had abundant feed and water available and could, therefore, afford to spend more time resting as against the intermediate when there was less feed. Animals probably rested the least in the dry season because they had to continuously move about in search of feed and water, and could therefore not afford to spend plenty time resting as in the intermediate and peak rainy seasons.

5.2.4: Social interaction

Season statistically had no influence on social interaction as it was generally insignificant. Meanwhile, more time was spent in social interaction during the peak rainy season as compared to the other seasons. This could be due the fact that it is in this same season animals rested more, most of these interactions took place during resting periods. It is also possible animals had enough to feed on during this season and could therefore afford to take time off for other activities such as social interaction. A number of these interactions were also between mother and child, which came in the form of suckling. The dry season on the other hand had the least proportion of time for social interaction within an average daily portion of 1%. As observed in walking for the dry season, animals spent a great deal of time walking in search of feed and water hence affecting all other activities including social interaction.

5.2.5. Watering

Season had no effect on the portion of time spent on water intake since it was one percent in all three seasons. This is quite surprising as the expectation was that animals would have spent more time at water places in the dry season because feed material in this season is always very dry with minimal moisture content. The dry season also comes with increased temperatures and dry wind; hence animals may want to take in more water to maintain a good temperature balance. However, the turnout of events may be attributable to the fact that cowboys mostly decided when and how long animals should stay at the water source and water intake under natural circumstances may not, therefore, have been accurately captured.

5.3 Effects of management on behaviour

Time spent feeding on grazing land was significantly higher in the Non-Fulani than Fulani managed animals, this could be as a result of the fact that the Fulani managed herds had to spend a greater part of their time walking in search of feed. In any case the Fulani managed cattle also belonged to locals (non-Fulani) who do not have access to good pasture and therefore hired the services of the Fulani who are mostly willing to move far distances in search of feed and water.

Time spent walking during grazing unlike feeding was higher in Fulani than non-Fulani managed cattle. This is probably because Fulani herdsmen mostly kept moving with their animals in search of better pasture during the dry season, there by doing more walking than the local cowboys. Also, local cowboys were kids below 14 years of age, as compared to their Fulani counterparts who were grown (30years and above), and this could have accounted for the less walking among the local cowboys since they prefer to play more instead of continuously walking.

The proportion of time spent resting was slightly higher in the non-Fulani managed cattle and could be due to the fact that, non-Fulani managed cattle had enough to feed and could, therefore, afford to rest more, whiles the Fulani managed ones had to keep moving in search of feed. Plus the local cowboys who were mostly children generally liked to take some rest themselves (Feldt and Schlecht, 2016)

Management had no effect on social interaction and drinking of water, however, all three non-Fulani farms (Fuo, Dalogyili and Natua Yipala) had no water problems as they all have dams which both humans and animals drink from, with distances from the dams to farmers' houses being 0.27 Km, 1.6 Km and 1.2 Km, respectively. Two other Fulani managed farms (Kpalung and Gbanyamni) also had water ways running through the grazing fields, usually, with water during the rainy season but soon dry out when the rains are gone, and animals now have to trek long distances in search of water, just like the Kalariga farm which does so all year round.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusions

Based on the study, it can be concluded that

Grasses formed the most dominant species group of plants on natural grazing lands in the study area all year round. Biomass availability was highest in the dry season as a result of the availability of crop residue (mostly rice straw and maize stalks) in high quantities and least in the early rains where plants were just beginning to grow.

Carrying capacity was also highest in the dry season (0.55 TLU/ha) owing to the high amounts of biomass in that season and least in the early rainy season (0.21 TLU/ha) which also had the least amount of biomass.

Grazing lands had higher vegetation cover in the peak rainy season owing to the high level of rains while the dry season has the least cover.

Longer time was spent on feeding and resting in the peak rainy season than the intermediate and dry season whiles, the proportion of time spent walking was also higher in the dry season than the intermediate and peak rainy seasons. Proportion of time spent on social interaction and water intake stayed same for all seasons.

Non-Fulani managed herds spend more time feeding than Fulani managed herds. Conversely, more time was spent walking in the Fulani managed herds than non-Fulani herds.

6.2 Recommendation

The study recommends that:

Farmers should learn to do feed supplementation using legumes or create some legume pastures to augment the high grasses levels on natural grazing lands.

Crop residues during the dry season should be harvested and treated with urea in order to improve upon their nutritional quality as feed for animals. This will help reduce the long walking distances recorded during the dry season.

Grazing lands can be over sown in order to improve upon the biomass yield and carrying capacity of these lands.

Nutrient composition of forages on the various grazing lands should be determined.

Herdsmen should herd their animals mostly considering availability of water within range, to minimize animals underfeeding in order to cope with unavailability of water that characterizes the dry season.

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