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Socio-demographic and economic characteristics, crop-livestock production systems and issues for rearing improvement: A review

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ABSTRACT

This paper reviews some characteristics of crop-livestock production systems in Benin with a special focus on the issues for enhance pasture production and nutritive value which in turn will increase animal productivity. Benin is located in the Gulf of Guinea of the Atlantic Ocean in West Africa and covers 114,763 km^2. The population estimated in 2017 is 10,900,000 inhabitants with an annual population growth rate of 3.5%. The country is primarily an agro-based economy, characterized by subsistence agricultural production that employs more than 70%. The climate ranges from the bimodal rainfall equatorial type in the south to the tropical unimodal monsoon type in the north. The climatic limiting factor for plant growth is rainfall which is generally tending to diminish with increasing variation between years. There are two main soil types in Benin (ferruginous and ferralitic). Based on a national livestock survey in 2016 the national herd is estimated to be 2 339 000 cattle (*Bos taurus* or *B. indicus*), 915 000 sheep (*Ovis aries*), 1 836 000 goat (*Capra hircus*), 466 000 swine (*Sus scrofa*), 2 000 equines (*Equus caballus*), 800 donkeys (*E. asinus*), 20 camels (*Camelus dromedarius*) and 20 000 000 poultry (mainly *Numida meleagris*). The growth of the ruminant livestock improvement has been impeded by several constraints such as low feed supply in quantity and quality, low crop-livestock integration, low level of management practices, lack of improved breeding stock, disease, inadequate stock water, poor marketing and lack of capital. Zootechnical performances of animals are very low. In this context, the introduction of legume forage would be a sustainable way as it can enhance pasture production and nutritive value which in turn will increase animal productivity.

Keywords: Benin, agriculture, livestock, feed, grassland.

INTRODUCTION

In Benin, agriculture is characterized by the traditional predominance of a mixed farming system of crop production and livestock rearing. Agriculture is a major source of income providing employment and livelihoods for rural families. It is also the backbone in rural areas, providing a source of

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employment and the ultimate livelihood for 70% of the population of rural people and contributing 40% to National Gross Product (INSAE, 2015).

In the country, land cropping is practised by small-farmers according to the traditional method of slash-and-burn cultivation. Crop productions are commonly severely limited by a shortage of inputs, recurrent droughts and limited soil fertility (Adjolohoun, 2008). The evolution of this form of agriculture is classic in West Africa, as well as in other developing countries. It leads to an increase of cultivated lands to the detriment of the fallowed areas and the natural savannah's (Koura, 2015). The fields are cropped for 3 to 4 years and, afterwards, the land is left in a weed fallow with many unpalatable species for livestock (Adjolohoun, 2008). In this form of land use system, crop and livestock production are weakly interlinked (Koura, 2015). In the other hand, during 2016, Benin animal sector is around 5.09 million ruminants, 0.466 million swine and 20 million poultry which is expected to grow at a rate of between 2.20 and 2.78% for cattle and small ruminants respectively and 4.44% for swine (DSA, 2017).

Livestock production system is based on feeding grazing resources which is mainly composed of annual foraging on natural pasture and forest lands. Substantial amount of feeds are also derived increasingly from crop residues, agro industrial by-products and other farm products. The proportional contribution of these feeds however, varies with location and season.

Over the last decades, the crop and livestock system production of the country experienced rapid change in land use/land cover mainly due to increase in human population pressure and partly due to climate change (Koura, 2015). In some parts, over the last five decades, the area under crop cultivation has expanded considerably by about 25%, while that of grassland has contracted greatly by about 30% (Adjolohoun, 2008). This has resulted in to a considerable change both in the type and the amount of feed available to the livestock keepers.

This paper gives a review of the 1) socio and economic characteristics of Benin, 2) its climatic conditions and ecological zones, 3) summarize agriculture and livestock production systems and 4) propose actions to rehabilitate grass-land areas.

BENIN LOCATION

Benin is the name which replaced the former colonial Republic of Dahomey after the Revolution of October 26, 1972. Located in the Gulf of Guinea of the Atlantic Ocean, it lies within latitude 6^o 20' N and 12^o30' N and 1^o E and 4^o E with an altitude varying from 0 to 600 m. The country extends on 700 km from the north to the south and on 125 km from the East to the West on the coastline of the country. It is a landlocked country in the south of West Africa which borders Niger and Burkina Faso republics to the north, Atlantic Ocean to the south, republic of Nigeria to the east and republic of Togo to the west (Figures 1 and 2). The country covers 114,763 km^2, the capital is Porto-Novo and the official language is French.

SOCIO-DEMOGRAPHIC CHARACTERISTICS

According to the most recent census (INSAE, 2008) the population estimated in 2017 will be 10,900,000 inhabitants with an annual population growth rate of 3.5%, characteristic of most West African countries. Life expectancy at birth is 60 years. It has great ethnic diversity with more than twenty groups of which the main ones are: *Fɔn* (25%), *Aja* (10%), *Yuruba* (10%), *Gun* (8%), *Ayizɔ* (05%) and *Tɔli* (02%) in the south and the center of the country: *Batɔnu* (14%), *Dɛndi* (08%), *Mɔkɔle* (04%), *Fulbe* (3%), *Husa* (02%), *Otamari* (02%), *Natɛnba* (01%), *Wuama* (01%) and *Youm* (01%) in the north (Nonfon, 2015). The remaining 4% is made up of minor ethnic groups. Benin population is predominantly in traditional religion generally called Animism (48%), Christianity (35%), Islam (17%) (Nonfon, 2015).

Population density is highly variable according to the regions. It is highest in the south of the country (about 100-200 per km^2) and lowest in the north (about 15-60 per km^2). Average 70% of the population is rural (INSAE, 2008; Azuka et al., 2015).

SOCIO-ECONOMIC CHARACTERISTICS

For human development index, the country rank was 159 and 167 among the 173 countries in 2003 and 2016, respectively. The standard of living is very low; according to UNDP (PNUD, 2000), 75% of the people are below the poverty line and of which 30% in extreme poverty. Benin's Gross National Product (GNP) per inhabitant is 380 $ US. Agriculture contributes 54% of Benin's GNP and accounts for over 40% of export earnings while at the same time providing over 90% of the food needs of the country. Unemployment to population ratio is 32%. The country is primarily an agro-based economy, characterized by subsistence agricultural production that employs more than 70% of the population. About 65% of the labour forces are engaged in agriculture, 30% in services and 2% in industry. Approximately, 39% of farm labour forces are women (INSAE, 2015).

CLIMATE AND AGRO-ECOLOGICAL ZONES

Benin's climate is influenced by the hot, dry and dusty-laden air mass that moves from the north-east across the Sahara and by the tropical maritime air mass that moves from the south-west across the southern Atlantic Ocean. According to ASECNA (2010), the climate ranges from the bimodal rainfall equatorial type in the south to the tropical unimodal monsoon type in the north. The mean monthly temperature over most of the country never falls below 26 ^{o}C, a consequence of the low latitude position of Benin and the absence of high altitude areas. Mean annual temperature averages 27 ^{o}C. Absolute maxima approach 40 ^{o}C, especially in the north, with absolute minima descending to about 15 ^{o}C during *harmattan*. In the coastal areas, where the modifying influence of the sea breeze is felt the annual range of temperature is between 25 and 26 ^{o}C. In the interior on the other hand, the range is higher, about 27 ^{o} to 29 ^{o}C (ASECNA, 2010). The rainfall generally decreases from the south to the north. The wettest area is the extreme south-west where the rainfall is over 1300 mm per annum. In the extreme north, the annual rainfall is on average 900 mm. Much of the rain falls in intense storms of short duration, especially at the beginning of the season resulting in heavy runoff and erosion. The annual mean relative humidity is about 80% in the south and 55% in the north (ASECNA, 2010). The climatic limiting factor for plant growth is rainfall which is generally tending to diminish with increasing variation between years for most West African countries (Kagoné, 2000; Adjolohoun, 2008; Diarra et al., 2017). These characteristics have to be taken into account in research and development programs so as to anticipate food and forage crises.

Soils and Topography

According to Adam and Boko (1983), Youssouf and Lawani (2002), there are four soil types in Benin. These are: ferruginous soils; ferralitic soils; poorly evolved soils; hydromorphic soils and vertisols. The first two soils cover more than two thirds of the country. *Ferruginous soils* cover the greatest areas. These soils cover generally the center and the north of the country. They have sandy texture and are regularly associated with gravelly soils. *Ferralitic soils* are found in the south of the country. Their area is very limited. Their profile is related to that of ferruginous soils but their physical and chemical properties are clearly different. *Poorly evolved soils* are mostly found in the northern half of the country. They are found over the granites and migmatites from which they are derived. *Hydromorphic soils* are found on river alluviums or on fine weathered material. They have poor drainage and are regularly waterlogged in the rainy season. They are mostly developed in the west of the

country and are aligned with the drainage network of the main valleys. *Vertisols* have approximately the same textural parentage as the *Hydromorphic soils.* All of these types have a poor cation exchange capacity and therefore need appropriate soil management for plant mineral nutrition.

Soil chemical characteristics are variable. According to FAO (1965) and CPCS (1967) soil classification, ferruginous tropical soils in the north of the country are skeletal chromic-luvisoil or tropical concretionary soil (Youssouf and Lawani, 2002). Most lands have a slope varying from 1 to 10%, sometimes with a slightly undulating topography and granite or gneiss as parent material. Soil texture consists of friable gravely sand to gravely sand-loam and is highly leached in most of the region. Their deepness is highly variable (0.40-2 m) with reddish colour more pronounced in some sites and they increase in ferruginous gravel content with deep. Soils have a low water-holding capacity and are generally medium to well drained. The reaction is slightly acid to neutral (pH_{water} 6.0 – 6.7) in the surface layers (0-20 cm), decreasing slightly to acid in the lower layers. The chemical composition of these substrates shows an accumulation of ferric oxides and hydrates with low concentrations of aluminium oxide and low exchangeable cations capacity (2-8 $cmol^+/100g$), but with high base saturation (80-95%). Organic matter content is very low (0.5-1.5%) and soils are deficient in N (0.01-0.03%) and assimilable P (1-3 ppm Bray) (Youssouf and Lawani, 2002; Azuka et al., 2015).

The topography of the country is mainly a peneplain crystalline covers most area with numerous hills. This peneplain is deeply dissected by the valley of *Lama* which cut it into two blocks. Follow plateaus which are located mostly in the south of the country with altitude between 20-200 m. The highest region of the country is the mountain of *Atacora* (600 m).

VEGETATION AND CROP PRODUCTION SYSTEMS

According to the Ministry of Agriculture, Livestock and fisheries (MAEP, 2010), the country's land resources are approximately divided as follows: cultivable land 60% of which only 10% are under cultivation and 75% under grazing; protected areas (forests, reserves, national parks) 20%, other lands (buildings, homesteads, roads, river, etc.) 20%. It should be noted that this distribution of land is not static. Agricultural land is increasing at approximately 3% annually at the expense of the grazing land (MAEP, 2010). In fact, grazing lands are lands which are not under cultivation and include fallows, marginal lands and reserved lands. The ever increasing demand of farmland, fuel wood and charcoal production coupled with population growth has accelerated the rate of forest reduction in Benin as in most countries of West Africa (Kouelo et al., 2016; Gnikplepko, 2016; Zoumarou et al., 2016; Ye et al., 2017; Enbakom et al., 2017).

Benin's farming systems vary with agro-ecological zone. However, certain general features are discernible throughout the country. This agriculture is predominantly smallholder, traditional in rain-fed conditions with simple tools and, sometimes in the north of the country, animals drawn implements in cotton fields (DSA, 2017). Land is cropping according to slash-and-burn cultivation method for 2 to 3 years and, afterwards, the land is left in a weed fallow with many unpalatable species (Adjolohoun, 2008). Originally, the fallow duration ranged from 10 to 20 years in the country (Floret and Pontanier, 1999), while in other Soudanian zones of West Africa fallow periods up to 30 years are reported (Klein and César, 1999; Somé et al., 2007). Today, the increased population densities and the development of cash crops have drastically reduced land availability, leading to a net reduction of the fallow period with dramatic consequences on soil fertility (Koutika et al., 2002; Nikiema, 2005; Saidou, 2006; Kouelo et al., 2013;

Koura, 2015). Tables 1, 2, 3, 4, 5 and 6 present vegetable production for cereals, tubercules and roots, leguminous food crop, legumes food crop, horticultural crops and cash crops productions respectively (DSA, 2017). Cereal staple food crops are maize (*Zea mays*), sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum glaucum*) and legume crops are groundnut (*Arachis hypogaea*) and cowpea (*Vigna unguiculata*). Rice (*Oryza sativa*) is cultivated on limited areas corresponding to hydromorphic soils. Pepper (*Capsicum annuum)*, tomato (*Lycopersicon esculentum)* and bitter-leaf (*Vernonia amygdalina*) are sometimes grown around the houses. Tomato is one of the most important productions in Benin (Doussoh et al., 2017). Tuber and root crops are yam (*Dioscorea batatas*), cassava (*Manihot esculenta*) and sweet potatos (*Ipomoea batatas*). Clearing starts around January and February and tilling is done between March and April. Planting starts with the rains, between April and May, but installation of some later varieties of yam might take place already in December. Harvesting happens between August and December (Adjolohoun, 2008, Kouelo et al., 2016).

LIVESTOCK RESOURCES

Based on a national livestock survey in 2016, the national herd is estimated to be 2 339 000 cattle (*B. taurus* or *B. indicus*), 915 000 sheep (*O. aries*), 1 836 000 goat (*C. hircus*), 466 000 swine (*S. scrofa*), 2 000 equines (*E. caballus*), 800 donkeys (*E. asinus*), 20 camels (*C. bactrianus*) and 20 000 000 poultry (mainly *N. meleagris*). Over the last decade, annual increases are 2.7% for cattle, 15% for swine and 3% for small ruminants (DSA, 2017). Table 7 shows livestock number and production data for Benin from 1970 to 2016. During the last decade, total meat, milk and eggs production varied between 39500 and 71990 tons, 80089 and 115000 tons and 7445 and 16006 tons per year, respectively. Cattle, poultry, small ruminants and swine contribute about 57%, 20%, 13% and 8% to total meat production (DSA, 2017). According to FAO (2014), the requirement needs of meat for the population of the country would be 143000 tons in 2020 and only 50% of this will be produced in the country. Therefore, the import of more than 70000 tons of meat would be necessary to meet the requirement of the population.

Cattle

Many cattle breeds are reared in Benin. The most important in term of number is Zebu × Borgou accounts for 35% of the total country cattle livestock. It is a natural cross between Zebu and Borgou and is found mainly in the Center and North of Benin. Followed by Borgou breed (27%) of the livestock is encountered particularly in the South of Borgou and East of Atacora regions (DE, 2013). The breed Borgou × Somba accounts for 14% is found in Atacora region. Borgou × Lagunaire breed (11%) is found in the Center and South of the country. Zebu breed (8%) and Lagunaire breed (4%) are found in North and South of the country, respectively. Somba breed is the least represented (< 1%). The Borgou is a natural cross between the West African Short (Lagunaire) and the large humped Zebu cattle. It has developed a degree of tolerance to tsetse-borne trypanosomiasis (DE, 2013). The Zebu cattle are susceptible to trypanosomiasis and are found mainly in tsetse fly free areas. Zootechnical performances of these animals are presented in Table 8. The poor quality and instability of the native pasture lead to a low nutritive value of forages and increase calf mortality, the mortality rates from birth to weaning are about 35 to 45% (Table 8).

Sheep

The major sheep breed, the indigenous West African Dwarf (WAD) or Djallonké breed is distributed nation-wide. The breed is acknowledged for its hardiness, trypanotolerance, prolificacy and suitability for year-round breeding. Although it is a small animal, with an adult weight of 15-25 kg in males and 15-20 kg in females, the Djallonké does not exhibit traits associated with

dwarfism (DE, 2013). The larger and long-legged Sahelian sheep, and crosses between the Djallonké and the Sahelian sheep, are found mostly in the north of the country and peri-urban areas. The low feed supply in quantity and quality increases lamb mortality, the mortality rates from birth to weaning are about 15 to 40% (Table 8).

Goats

Most goats in Benin are of the indigenous WAD breed. The adult male weighs 15-22 kg and the female 15-20 kg. The breed is very prolific, precocious and trypanotolerant and are found throughout the country (DE, 2013). There are considerable numbers of the much larger and long-legged and exotic Sahelian as well as crosses between the WAD and the Sahelian goats in the north of the country and in the peri-urban areas. The productivity of the livestock is very low, the mortality rates from birth to weaning are about 15 to 40% (Table 8).

Ruminants

In Benin, ruminant livestock improvement has been impeded by several constraints such as low feed supply in quantity and quality, low crop-livestock integration, low level of management practices, lack of improved breeding stock, disease, inadequate stock water, poor marketing and lack of capital (Adjolohoun, 2008). Among these difficulties, the first is cited to be the most important. Livestock owners in their search for ruminant feeds intensively overexploit the natural vegetation as well as the weed fallows, and the availability of the natural forage has currently become the main constraint to ruminant production as in most West African countries (Peters and Lascano, 2003; Carr et al., 2005; Adjolohoun, 2008; Koura, 2015, Gimenes et al., 2017). This is especially the case during the dry season when the low nutritive value of forages induces loss of ruminants body weight, reduces milk production and increases calf mortality as well as nutritional anoestrus (McIntire et al., 1992; Gbamboché, 2005). The productivity of the livestock is very low, well below their potential and there is room for improvement (Table 8). There is an urgent need to adopt grassland improvement practices to maintain the quantity and quality of grasslands.

ANIMAL MANAGEMENT SYSTEMS

Although transhumant, pastoralists, nomadic and semi-nomadic tribes are crossed through Benin land, the main production system is based mainly agro-pastoralism system on extensive grazing or free range among smallholder farmers. After crop harvest, all members of the community have the right to graze their stock on any farmland, and grazing land (natural pasture) is generally communally owned (Lesse, 2016).

A**gro-pastoralism**

The smallholder agro-pastoralism, the main cattle production system in Benin, is geared towards beef production. It is linked with milk production system whereby milk is shared between the herdsman and the calf, with the surplus going to the market (Gnikplepko, 2016). In this system, settled farmers whose main occupation is crop cultivation own livestock. Ownership may be direct, personal and individual, or in the form of trusteeship for family group property held in trust. 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 (DE, 2013). The practice of herding under smallholder agro-pastoralism has not changed over decades. It has been described by Gnikplepko (2016) as a function of the type of settlement and distribution of the community, influenced by the availability of water and quantity of grazing areas.

Integrating livestock with tree crop plantations

There is a long history of integrating livestock into farming systems in Benin, the

major one being rearing of cattle and sheep under tree crop plantations. This is mainly found in coastal region of the country on oil palm, citrus and coconut plantations (DE, 2013). Introduced forage species of *Panicum maximum*, *Brachiaria deflexa*, *B. lata*, *Andropogon gayanus*, *Centrosema pubescens* and *Pueraria phaseloides* constitute the main diet of these animals in the plantations. However, a wide range of volunteer forbs and grasses, such as *Aspilia africana*, *Asystasia gangetica*, *Euphorbia hirta*, *P. laxum* and *Phyllanthus muellerianus* contribute significantly to the forage biomass. Farmers who have adopted the technology of integrating livestock with tree crops show lower standards of stock husbandry than the agro-pastoralists (DE, 2013).

Backyard small ruminant rearing

Backyard small ruminant rearing is popular in peri-urban areas. In this system, simple pens are usually provided for sheep and goats within or attached to the owner's house (DE, 2013). The pens are constructed from locally available materials such as timber offcuts, bamboo, tree branches and mud, and roofed with leaves, split bamboo or metal sheets. Children often undertake daily management, such as provision of water, feed and bedding as well as cleaning of pens. The system is based on cut and carry of forages, and the use of household wastes, mainly cassava and yam peels, crop residues and crop by-products. Breeding is normally not controlled and the animals are therefore open to conception as soon as puberty is attained (DE, 2013). Due to limited access to veterinary services, curative "self-medication" is commonly practised at times using various herbal concoctions (Olounladé, 2011). The backyard system supplies fattened rams and bucks for the expanding urban market, particularly during religious festivities.

Ranching

There are also four farms (Okpara, Bétécoucou, Samiondji and Kpinou) belonging to state institutions with herds ranging from 500 to 3 000 cattle (DE, 2013). In this system, cattle graze on sown pastures as well as natural pastures, which are sometimes improved with forage legumes. Introduced forage species of *P. maximum* local and *P. maximum C1*, *B. ruziziensis*, *A. gayanus*, *C. pubescens*, *Stylosanthes hamata*, *Leucaena leucocephala* and *Gliricidia sepium.* The system represents a comparatively safe, automatically incremental and readily realizable investment.

Poultry production system

In Benin, poultry is raised in traditional free-range system which accounts for about 97% of the poultry population of the country and are kept by smallholders (DE, 2013; DSA, 2017). In this system, different species are kept and the most important being chickens, guinea fowls, ducks and pigeons. Flock sizes vary from an average of 1-10 birds of indigenous poultry per rural household (Nonfon, 2015). The birds are owned mostly by women and children for home consumption, small cash income, social and cultural activities. These are left to scavenge around the homesteads during daytime feeding on household leftovers, waste products and environmental materials such as insects, worms, seeds and green forages. In addition, the birds are not regularly provided with water and other inputs such as supplementary feeds, houses, vaccination and medication. As a consequence, many birds die during pre-weaning periods due to starvation, diseases and predators. The level of productivity in terms of number of eggs produced (30-50 eggs hen^{-1} $year^{-1}$) and growth rate (5-10 g day^{-1}) (Smith, 1990; Guèye, 1998; DSA, 2017) is very low compared with semi-intensive or intensive systems.

FEED RESOURCES

In Benin, ruminants are maintained throughout the year on natural pastures comprised largely of grasses which nutritional value decreases very rapidly during the dry season (Adjolohoun, 2008; Adjolohoun et al.,

2013a; Gnikplekpo, 2016). Feeding animals remains the major constraint for productivities improvement in ruminant production (Adjolohoun, 2008; Koura, 2015). Natural fallows and savannahs constitute the basic feed for ruminants. Legume species are poorly represented in these grasslands, which are largely dominated by native grasses and weeds (Buldgen et al., 2001; Adjolohoun, 2008). Ligneous species available are *Afzelia africana, Khaya senegalensis, Pterocarpus erinaceus, Parkia biglobosa* and *Elaeis guineensis* (Houinato, 2001).

Natural pastures

The growth pattern of the forages follows the rainfall pattern within the different agro-ecological zones. In the Coastal Savannah area, there is a growing season of seven months and a "non-growing" period of five months while in the Northern Savannah area, the growing season lasts for six months and the "non-growing" period for equally length. The annual total dry matter yields reduced continuously over the years and vary between 0.3 and 2.5 tons dry matter per ha per year through the country (Sinsin et al., 1989; Adjolohoun, 2008; Lesse, 2016). On this basis of potential grazing land existing in the country reported above by MAEP (2010) and the grassland productivity of about 500 kg dry matter per ha and per year reported by many authors (Atchadé and Sidi 1990; Adjolohoun, 1992; Adandédjan, 1993; Adjolohoun, 1994; Houinato 2001; Adjolohoun 2008; Lesse 2016), edible annual grass forage available in Benin could be estimated to about 1,000,000 tons. Main dominant species are *Andropogon sp*, Panicum sp., *Brachiaria sp*., *Cymbopogon giganteus, Aframomum spp, Hyparhenia spp., Paspalum scrobiculatum, Loudetiopsis ambiens, Sorghastrum bipennatum, Fuirena ciliaris, Setaria sphacellata, Hyparrhenia rufa, Schizachyrium sanguineum, Schizachyrium schweinfurthuii,* etc. (Lesse, 2016).

In both zones, about 80 percent of the yields are achieved within the growing season. The ligneous species within the natural pastures are estimated to give forage dry matter (DM) yield of about 200-500 kg/ha/year (Adjolohoun, 1992). The nutritive value of the natural pasture herbage varies over the year according to the season. Protein content is high (8-12 percent DM) at the beginning of the rains but may drop to as low as 2 to 4 percent DM in the dry season (Adjolohoun et al. 2013a). Phosphorus levels are also low and rang between 0.06 and 0.16 percent DM (Buldgen et al., 2001; Adjolohoun, 2008; Adjolohoun et al. 2013a; Montcho et al., 2016).

Bush fires often occur as a result of illegal and uncontrolled burning of bush after harvest to remove rank vegetation, or for hunting or just for fun. The incidence of bush fires can be correlated with human presence, as indeed can cattle density, since fires occur most frequently in areas with very high cattle populations. Damage done by fire to the natural pastures is very significant and is a major contributing factor in the decline in the condition of both natural and sown pastures as well as the greatest constraint to the success of over-sowing natural pasture with forage legumes. Uncontrolled bush fire destroys standing hay and crop residues lying in the field. Although there have been efforts at educating the farming communities against bush burning, the impact has not been very effective, particularly in the Coastal Savannah zone. This may be due partly to lack of collaboration among the sectors in anti-bush fire campaign and inadequate logistic support to fire-fighting volunteers. Whereas a group of anti-bush fire campaigners place emphasis on "early-burning" as a solution to the wanton incidence and the devastating effect of bush fire, others preach "no-burning" concept, which tend to confuse the farmers.

Crop residue

Crop residues and also tree fodder are commonly used in the dry season (Koura, 2015). However, regarding tree fodders, the legumes trees used are threated and their population decreased. Indeed, exploitation of branches of these trees with even reproduction

organs limits the regeneration of the species. About 300,000 tons of legumes (groundnut and cowpea) residues are produced in Benin (FAO, 2014).

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. In general, cereal and legume residue represents approximately 30-35% of grain production (Adjolohoun, 1992). On this basis and according to cereal grain production in Benin (Table 1), cereal crop residues can be estimated at about 500,000 tons of cereal stalks and 900,000 tons of residues from roots and tubers are potentially available as animal feed in each year. However, quantities of these that are actually fed to livestock form a very small fraction (< 10%) of the available crop residues. Large scale systematic feeding of crop residues is hindered by alternative uses such as fuel source (e.g. sorghum and millet stalks), thatching (hut roof), and by the problem of collection in view of the bulkiness of the residue and in some cases distance from settlements. In some cases, many possibilities for using crop residues are ignored by farmers and do not made any attempt to recover from the field, store and improve the quality of these valuable resources. In spite of this, crop residues, such as groundnut and cowpea haulms, bean vines, maize, sorghum and millet stover, cassava or yam peelings constitute the bulk of ruminant feed during the dry season (Koura, 2015; Ojokoh and Odesanya, 2016). Tables 9 and 10 present dry matter content and chemical composition of main crop residues produced in the country. According to Koura (2015), crude protein contents of cereal residues are between 2.44 and 5.84% and are very below the critical level of 7 to 8% needed to maintain efficient rumen function (Minson, 1981; Babatounde et al., 2010). Indeed, despite their low nutritive value, crop residues supply feed for livestock in West Africa (Savadogo, 1999; Ayantunde et al., 2007; Attoh-Kotoku, 2011; Akinfemi et al., 2012).

PASTURE IMPROVEMENT: INTRODUCTION OF LEGUMES SPECIES IN PASTURES

Sustainable models of animal production constantly seek for ways to pasture production with inputs reduction. In this context, the introduction of forage legumes in the pasture system is fundamental to fix nitrogen from the atmosphere and supply it to grasses, increasing its production and persistence, enhancing animal nutrition (Adjolohoun et al., 2013c; Flávia et al., 2017). In tropical areas such as Benin, forage grasses grow rapidly and plentiful biomass is produced after the onset of the rains, but protein concentration declines as grasses grow and mature. During the dry season, the crude protein concentration in the native grasses can drop below 3% DM (Adjolohoun 2008, Koura, 2015). To solve this problem, livestock farmers can supplement their livestock with agro industrial by-products such as cottonseed and groundnut cake, but this solution is costly. As an alternative, cultivated forage legumes can provide cheap high-quality feed, which can greatly enhance the productivity of traditional agricultural systems. Owing to their higher N content compared with grasses, legumes improve intake of forage by ruminants and digestion of fiber and reduce CO_2 and methane emissions from the rumen, through a more efficient use of the energy content of the ingested forage (Mannetje, 2000). Tables 11, 12, 13 and 14 report a number of forage legumes which can be used to improve pasture productivity and nutritive values. Their integration in crop rotations may also increase grain yields of the subsequent food crops (25–136%) and potentially save 50–300 kg/ha N of artificial fertilizer (Cook et al., 2005).

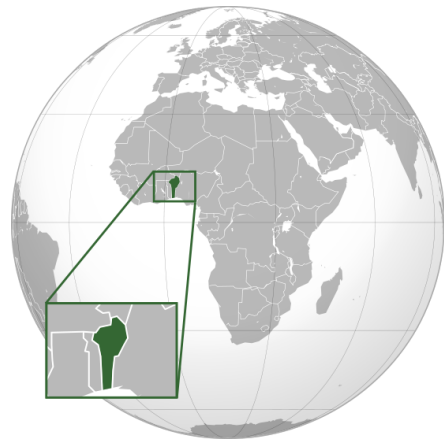

Figure 1: Location of Benin in West Africa.

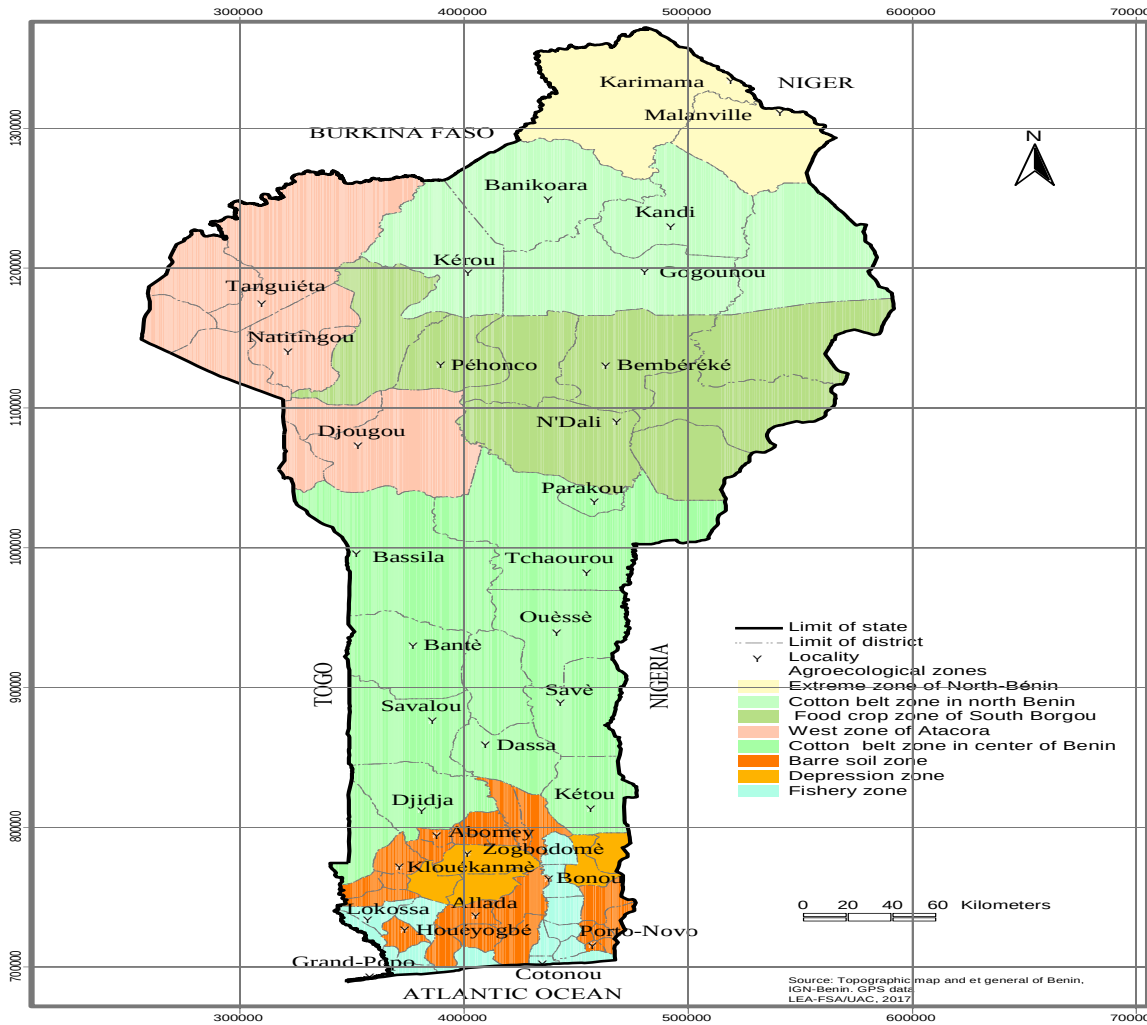

Figure 2: Benin map and agro-ecological zones (IGN, 2017).

Table 1: Benin cereal food crop production.

Crop	Year									
	2000		2005		2010		2015		2016	
	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)
Maize	644989	1210	726016	1202	924764	1152	968030	1399	1003715	1281
Rice	17476	2112	24749	2627	40834	2760	74586	3139	65305	3129
Millet	37950	785	44761	823	33998	807	27724	854	26670	811
Sorghum	154564	812	181253	905	119880	1099	101513	988	131553	986

Source: (DSA, 2017).

Table 2: Tuber and root food crop production.

Crop	2000		2005		2010		2015		2016	
	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)
Cassava	202117	10432	237916	13187	256615	14761	296641	13709	284033	12044
Yam	145366	9571	171746	12775	167919	14135	214054	14909	202605	13082
Sweet potato	10880	6327	11163	4479	11442	5585	10938	5987	10016	5532
Potato	3	533	12	667	11	768	13	1290	6	1386
Taro	518	4548	612	4144	974	2671	519	3913	559	2921

Source: (DSA, 2017).

Table 3: Benin leguminous food crop production.

Crop	2000		2005		2010		2015		2016	
	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)
Bean	112218	664	122558	767	106764	826	116559	822	120612	822
Groundnut	125538	813	160217	966	147798	894	163009	869	15812009	850
Soybean	3234	835	10173	544	58225	949	97783	1013	152138	920
"*Voandzou*"	12747	1141	18581	813	14862	757	13250	949	12619	825

Source: (DSA, 2017).

Table 4: Benin legume food crop production.

Crop	2000		2005		2010		2015		2016	
	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)
Tomato	20953	5435	24526	5884	28078	5558	45630	8779	303893	7786
Pepper	17830	1302	20378	2058	18235	1415	28070	2706	25861	2928
Onion	726	15952	386	10238	2418	14893	2652	16155	4156	17120
“Gumbo”	12003	2662	4086	4847	12945	3310	14397	3397	12751	3258
“Leaf legume”	819	8873	1242	9047	4403	5279	10613	8593	13824	13971

Source: (DSA, 2017).

Table 5: Benin horticultural crop production.

Crop	2000		2005		2010		2015		2016	
	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)
Lettuce	2167	4356	5004	6543	3289	7619	4271	7614	3564	8618
Cabbage	355	18760	389	12896	509	13666	398	16867	444	18125
Carrot	378	13902	429	16754	690	14901	651	14882	717	15847
Watermelon	12467	15698	1544	16770	967	19843	1432	18753	1596	17748
Cucumber	187	14699	190	13581	210	11631	267	12098	250	10643

Source: (DSA, 2017).

Table 6: Benin cash crop production.

Crop	2000		2005		2010		2015		2016	
	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)	Area (ha)	Yield (kg/ha)
Cotton	305236	1234	156350	1046	137086	999	405400	970	313535	859
Cashew nut	38966	1843	40988	1765	49087	2109	56398	1542	68166	2056
Sugar cane	553	21899	505	20150	437	20058	460	21790	810	33679
Oil palm	7007	7560	7843	9005	8082	8830	6584	10700	12129	5950
Pineapple	1492	47233	2065	58689	4208	51210	6512	57592	6682	53531
Tabaco	707	651	874	678	183	508	20	749	28	530

Table 7: Benin statistics for livestock numbers, meat and milk production (1970 – 2016).

Species	Year								
	1970	**1980**	**1990**	**2000**	**2010**	**2012**	**2014**	**2015**	**2016**
Cattle	500 000	750 000	1 080 000	1 879 000	2 005 000	2 111 000	2 222 000	2 280 000	2 339 000
Sheep	656 000	691 000	726 000	767 000	808 000	842 000	878 000	896 000	915 000
Goats	1 216 000	1 286 000	1 360 000	1 434 000	1 605 000	1 678 000	1 755 000	1 795 000	1 836 000
Swine	166 000	192 000	222 000	254 000	368 000	398 000	431 000	448 000	466 000
Equine	950	1 100	1 250	1 400	1 560	1 700	1750	1 900	2 000
Donkey	500	545	560	610	629	650	680	730	800
Camels	5	8	10	13	15	15	17	20	20
Poultry	10 000 000	12 000 000	12 900 000	15 600 000	17 200 000	17 820 000	19 500 000	19 512 000	20 000 000
Aulacode	90 000	110 000	150 000	200 000	230 000	250 000	300 000	320 000	350 000
Rabbits	20 000	25 000	36 000	45 000	58 000	60 000	70 000	74 000	75 000
Meat (tons)	39 500	47 000	53 900	58358	61 646	64 969	68 492	70 327	71 990
Milk (tons)	80089	84 560	89 200	94 110	99 334	107 254	110 066	112 958	115 000
Egg (tons)	7745	8 175	8 623	9 348	9 850	11 551	13 585	14 746	16 006

Source: (DSA, 2017).

Table 8: Zootechnical parameters of cattle, sheep and goat.

Parameters	Species			
	Cattle	**Sheep**	**Goat**	**Swine**
Age at first oestrus (months)	24-27	16-20	14-21	4-6
Age at first parturition (months)	30-50	21-25	20-26	8-11
Parturition frequency (months)	15-20	7-10	7-10	5-8
Fertility (%)	80-90	80-95	80-95	90-94
Sterility (%)	10-20	5-20	5-20	6-10
Reproduction rate (%)	70-80	70-85	70-85	85-90
Abortion rate (%)	10-20	10-15	10-15	5
Number of animal per parturition (units)	1	1-1.2	1.2-2.0	4-8
Mortality rate from birth to weaning (%)	35-45	15-40	15-40	30-50
Adult mortality (%)	15-30	15	15	5
Weight at birthday (kg)	8-12	0.8-1.5	0.7-1.5	0.6-1.0
Age of weaning (months)*	9-15	4-6	4-7	8 (weeks)
Weight at weaning (kg)	40-80	5-7	4-7	1.5-3.0
Weight at 1 year age (kg)	40-80	10-12	8-12	15-20
Adult weight (kg)	180-200	15-25	15-20	30-40
Numeric productivity (unit/female/year)	0.55-0.65	0.9-1.5	1.1-2.6	4-11
Weight productivity (kg/female/year)	22-55	9-18	9-20	60-200

* Week for swine age of weaning; Source: (Adjolohoun, 1994 ; Gbanboché, 2005 ; DE, 2013 ; DSA, 2017).

Table 9: Dry matter composition and nutritive values of crop residues in Central regions of Benin.

	DM (%)	**Ash (%)**	**CP (%)**	**NDF (%)**	**ME *(KJ/kgDM)***
Cereal					
Maize cob	94.2	3.62	4.99	84.9	6.48
Maize husks	94.4	2.52	3.31	87.4	6.31
Maize stalks	92.9	3.25	4.40	88.1	6.38
Sorghum offal	93.2	4.53	2.44	83.8	4.54
Legume					
Cowpea haulms	91.2	8.56	15.6	43.2	14.51
Cowpea pod shell	90.7	8.95	9.20	65.5	9.07
Groundnut haulms	90.5	13.4	18.1	54.0	16.30
Soybean haulms	91.1	12.6	9.63	52.8	8.10
Soybean pod shell	91.1	8.03	8.50	58.3	8.51

DM = dry matter, CP = crude protein, NDF = neutral detergent fiber, ME = metabolizable energy; Source: (Koura, 2015)

Table 10: Dry matter composition and nutritive values of crop residues in Northern regions of Benin.

	DM (%)	Ash (%)	CP (%)	NDF (%)	ME (*KJ/kgDM*)
Cereal					
Maize cob	92.90	2.68	4.36	86.6	5.69
Maize husks	92.50	6.88	5.84	79.9	6.90
Maize stalks	92.20	6.79	4.07	87.7	5.26
Sorghum offal	92.00	5.64	3.89	81.5	5.26
Legume					
Cowpea haulms	90.50	11.70	18.8	39.20	17.0
Cowpea pod shell	93.60	4.060	8.84	68.70	8.63
Groundnut haulms	90.40	10.10	13.90	51.70	12.6
Soybean haulms	91.20	12.90	8.90	57.20	7.61
Soybean pod shell	91.10	6.16	6.23	70.62	6.62

DM = dry matter, CP = crude protein, NDF = neutral detergent fiber, ME = metabolizable energy; Source: (Koura, 2015).

Table 11: Agronomic characteristics of some grass forages adapted to Benin environment.

Species	Dry matter yield (tons/ha)	Feeding values	Drought and defoliation tolerance	Compatibility with legumes	Source
Panicum maximum	3-15	5-13% CP, 51-65% digestibility, 0,17% P, high palatability before flowering and LWG* = 100-400 kg/ha/year	Good tolerance to drought and very high tolerance to defoliation	Very good	(1), (2), (3), (4), (5)
Andropogon gayanus	4-30	7-15% CP, 63% digestibility, high palatability and LWG + 100-200 kg/ha/year	Very high tolerance to drought and good tolerance to defoliation	Medium to good	(1), (3), (6), (7)
Brachiaria ruziziensis	3-25	5-15% CP, 55-75% digestibility, very high palatability and LWG* > 200 kg/ha/year	Low tolerance to drought and defoliation	low	(1), (8), (9)

* LWG = Live weight gain with approximately 2 animal units per ha per year; (1) Cook et al. (2005), (2) Bodgan (1977), (3) Adjolohoun (2008), (4) Adjolohoun et al. (2013a), (5) Adjolohoun et al. (2013b), (6) Buldgen and Dieng (1997), (7) Toledo et al. (1990), (8) Adjolohoun et al. (2013d), (9) Milles et al. (1996).

Table 12: Agronomic characteristics of some erect herbaceous legumes adapted to Benin environment.

Species	Dry matter yield (tons/ha)	Feeding values	Drought and defoliation tolerance	Compatibility with grasses and nitrogen fixation	Source
Aeschynomene histrix	2-8	20% CP, 53-66% digestibility, very high palatability and LWG* > 200 kg/ha/year	Medium for drought and defoliation tolerance	Good and 150 kg/ha/year	(1), (2), (3), (4), (5), (6), (7)
A. americanum	3-5	10-28% CP, 60-70% digestibility, very high palatability and LWG > 200 kg/ha/year	Moderate for drought and defoliation tolerance	Good and 112 kg N/ha/year	(1), (8), (9), (10)
A. indica	-	Not sufficiently evaluated but may be acceptable	Low for drought and defoliation tolerance	Very good with 100 kg N/ha/year	(1), (10), (12), (14)
Stylosanthes fruticosa	3-5	8% CP, 66% digestibility, high palatability	Highly good but medium defoliation tolerance	Very good with more than 80 kg N/ha/year	(1), (2), (3), (4), (5)
S. hamata	1-6	CP > 17-24%, 66-72% digestibility, very good palatability	Good for drought but low defoliation tolerance	Good	(1), (15), (16), (17), (18), (19), (20)

* LWG = Live weight gain with approximately 2 animal units per ha per year; (1) Cook et al. (2005), (2) Tarawali and Mohamed-Saleem (1995), (3) Merkel et al. (2000), (4) Adjei and Fianu (1985), (5) Olanite et al. (2004), (6) Barnes and Addo-Kwafo (1996), (7) Muhr et al. (1999), (8) Bishop (1992), (9) Bishop et al. (1985), (10) Bishop et al. (1988), (11) Hodges et al. (1982), (12) Kretschmer and Bullock (1980), (14) Bielig (1997), (15) Roberge and Toutain (1999), (16) Cameron (1985), (17) English (1999), (18) Jones and Bunch (2003), (19) Jones and Jones (2003), (20) Loch and Ferguson (1999).

Table 13: Agronomic characteristics of some climbing legumes adapted to Benin environment.

Species	Dry matter yield (tons/ha)	Feeding values	Drought and defoliation tolerance	Compatibility with grasses and nitrogen fixation	Source
Centrosema pubescens	2-7	13-26% CP, 54-65%digestibility, 0.15-0.21% P, 0.5-0.8% Ca, 0.32% Mg, 1.5% K, high palatability and LWG > 100-650 kg/ha/year	Medium to good for drought and defoliation tolerance	Very good and more than 100 kg N/ha/year	(1), (23), (8), (9), (10), (11)
Pueraria phaseoloides	1-6	10-20% CP, more than 65% palatability and LWG > 200 kg/ha/year	Medium and moderately tolerant to defoliation	Medium compatibility and more than 250 kg N/ha/year	(1) (22)
Mucuna pruriens	2-10	11-26% CP, 60-65% digestibility, high mineral content, medium to high palatability and LWG is good.	Annual plant	Very good and more than300 kg N/ha/year	(1), (13), (14), (15), (16), (17)

* LWG = Live weight gain with approximately 2 animal units per ha per year; (1) Cook et al. (2005), (23) Muhr (1998), (8) Bishop (1992), (9) Bishop et al. (1985), (10) Bishop et al. (1988), (11) Hodges et al. (1982), (13) Buckles et al. (1998), (14) Bielig (1997), (15) Roberge and Toutain (1999), (16) Cameron (1985), (17) English (1999).

Table 14: Agronomic characteristics of some ligneous forage legumes adapted to Benin environment.

Species	Dry matter yield (tons/ha)	Feeding values	Drought and defoliation tolerance	Compatibility with grasses and nitrogen fixation	Source
Cajanus cajan	2-25	10-25% CP, palatability increases with plant age, and LWG 200-500 kg/ha/year.	Very good for drought but low defoliation tolerance	Very good with more than 250 kg N/ha/year	(1), (24), (8), (9), (10)
Leucaena leucocephala	1-33	25-30% CP, 55-70%, very high palatability, 0.2-0.3% P, 0.8-1.9% Ca, 0.01-0.02% Na and LWG : 200-1700 kg/ha/year	Very good for drought and defoliation tolerance	Very good with more than 200 kg N/ha/year	(1), (11), (12), (13), (14), (15), (16)
Gliricidia sepium	2-20	18-30% CP, 60-65% digestibility, low palatability and high toxicity, increases 25% LWG.	Very good for drought and defoliation tolerance	Very good with more than 100 kg N/ha/year	(1), (17), (18), (19), (20), (21)

* LWG = Live weight gain with approximately 2 animal units per ha per year; (1) Cook et al. (2005), (24) Vandenbeldt (1988), (8) Bishop (1992), (9) Bishop et al. (1985), (10) Bishop et al. (1988), (11) Hodges et al. (1982), (13) Buckles et al. (1998), (14) Bielig (1997), (15) Roberge and Toutain (1999), (16) Cameron (1985), (17) English (1999), (18) Jones and Bunch (2003), (19) Jones and Jones (2003), (20) Loch and Ferguson (1999), Ella et al. (1989).

Conclusion

In tropical areas such as Benin the growth of the ruminant livestock improvement has been impeded by several constraints such as low feed supply in quantity and quality, low crop-livestock integration, low level of management practices, lack of improved breeding stock, disease, inadequate stock water, poor marketing and lack of capital. Zootechnical performances of animals are very low. To solve this problem cultivated forage legumes can provide cheap high-quality feed, which can greatly enhance the productivity of traditional agricultural systems.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between all authors. DDMH designed the study, performed documentation research, was involved in data collection, and wrote the first draft of the manuscript. SA and others managed on data collection, evaluation and interpretations. All authors read and approved the final manuscript.

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