The Effects of Abiotic Factors on Production of Livestock and Agricultural Plants in the Wa East District of Upper West Region-Ghana

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Abstract
The Wa East district is one of the 11 districts of Upper West region where livestock production and cultivation of food crops are practiced on commercial and subsistence bases. The effects of edaphic and climatic factors on livestock production and cultivation of food crops are underscored in the study. Programmes and projects have been implemented in the Wa East district in an attempt to promote agriculture. Some of the projects and programmes have been successful in achieving their objectives, whereas other projects and programmes have been futile in achieving their objectives. Recommendations have been forwarded for policy considerations.

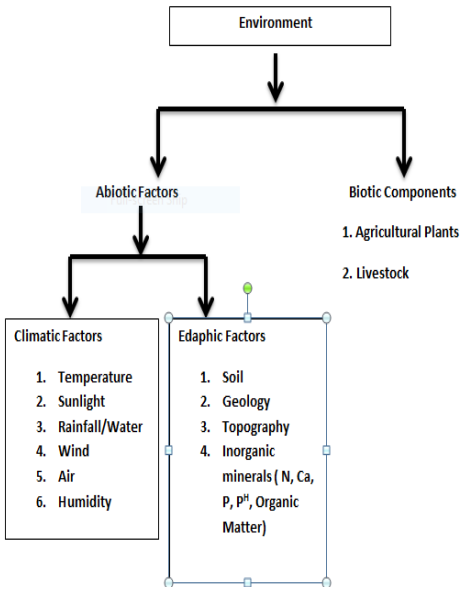
Key Words
Effects, Abiotic Factors, Production, Livestock, Agricultural Plants

I. INTRODUCTION

It is an undeniable fact that the function and structure of an ecosystem is controlled by a combination of biotic and abiotic factors. Whereas abiotic factors are non-living factors, biotic factors on the other hand refer to living things and their interaction. The role of multiplicity of factors in regulating ecosystem function has been widely investigated over the years, culminating to a characterization of the complexity of the abiotic and biotic relationships ([1], [2]). However, there is no experimental evaluation of the conceptual descriptions. In understanding ecosystem function and structure based on comparative approaches of Reichle (1981) [3], there is a provision of greater insights to broaden understanding and diversity of functional and structural relationship of systems [4]. Energy flow and material cycling have been given a clear articulation by continuous research over the years.

Plants and animals are interactive with their living environment. These environmental factors are abiotic factors (non-living factors) and biotic factors (living factors) [5]. Abiotic and biotic factors are essential in ensuring a continuous nutrient cycling and energy flow [5]. The distribution of organisms is influenced by abiotic environmental factors such as temperature, rainfall, sunlight, wind, relative humidity, inorganic nutrients, air, topography, geology, drainage and soil ([6],[7],[8]). Besides the abiotic factors, biotic factors such as living organisms and their interaction are also essential in species distribution [9] The study is informed by the conceptual framework in figure 1

Figure 1: Conceptual Framework of Study



From figure 1, it is obvious that the physical environment is divided into two components namely biotic (living) and abiotic (non-living) components. In the context of the study in question, biotic components are agricultural plants and livestock whereas abiotic factors are climatic factors such as temperature, rainfall, wind, humidity, sunlight, and air as well as edaphic factors such as geology (rocks), topography, inorganic minerals and soil. In effect, the physical

environment is interplay (mutual interaction) of abiotic and biotic factors.

II. MATERIALS AND METHODS

Materials and methods employed by the study are presented as follows:

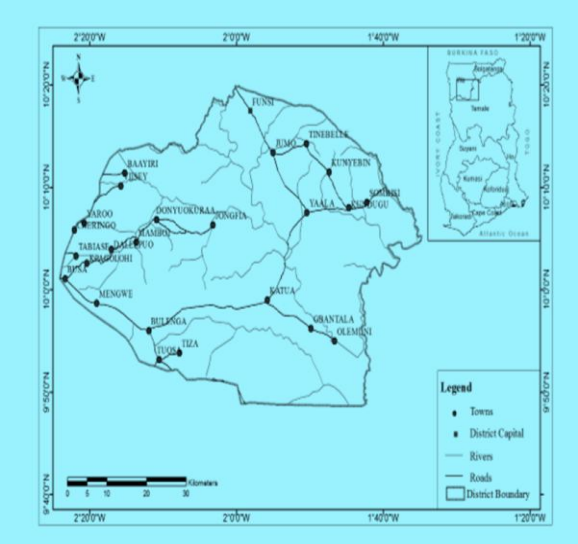
A) Materials

Location and size of the study area as well as a district map of Wa East are presented as follows:

1) Location and Size of Wa East District

The Wa East district became a full-fledged district in July 2004 under Legislative Instrument 1746 when there was the need for it to be carved out from the former Wa district. It is situated in the South Eastern part of Upper West region. It shares boundaries with Sissala East district to the north, West Gonja district to the south east, West Mamprusi district to the north west. It lies between latitude $9^0$55' N and $10^0$25'N and longitude $1^0$10' W and $2^0$5 W. It has a landmass of 3196 .4 $km^{2..}$ Figure 2 is a district map of Wa East.

Figure 2: District Map of Wa East



B) Methods

Methods employed in data collection on environmental abiotic and biotic factors are presented as follows:

A) Abiotic Factors

The following methods were resorted to in data collection on environmental abiotic factors:

1. Temperature

Data on annual temperature of Wa East district was obtained from the Upper West regional Meteorological Agency. Details of temperature records of Wa East district and its effects are presented in results and discussion.

2. Rainfall/Water

Data on annual rainfall of Wa East district was obtained from the Upper West regional Meteorological Agency. Details of rainfall records of Wa East district and its effects are presented in results and discussion.

3. Sunlight

Data on average daily solar intensity of Wa East district was obtained from the Upper West regional Meteorological Agency. Details on mean daily solar intensity of Wa East district and its effects are presented in results and discussion.

4. Mineral Nutrients (Nitrogen, Phosphorus, Organic Matter and P^H)

The P^H of soils in Wa East district as well as percentage of mineral nutrients such as nitrogen, phosphorus, and organic matter in the soil was disclosed by means of soil fertility analysis with the aid of a calibrated hydrometer with confirmation by a research conducted by the Council for Scientific and Industrial Research-Kumasi. Details of mineral nutrients in the soil of Wa East district and effects are discussed in results and discussion.

5. Wind

Data on types of wind of Wa East district was obtained from the Upper West regional Meteorological Agency. The data confirmed that there are two types of wind in the district. They are the South-West monsoon winds which is also known as the Tropical Maritime Air Mass and the North-East trade winds which is also known as Tropical Continental Air Mass. Details of the types of wind in the Wa East district are presented in results and discussion.

6. Humidity

Data on annual relative humidity of Wa East was obtained from the Upper West regional Meteorological Agency. Details of data on annual relative humidity of Wa East are presented in results and discussion.

7. Soils

Data on soil types and fertility was obtained by means of direct observation with a confirmation from records of the Upper West regional Directorate of Ministry of Food and Agriculture .Details on soil types of the Wa East district and their effects are presented in results and discussion.

8. Air Components (O_2, CO_2, N_2)

The components of air such as concentration of oxygen (O_2) in the atmosphere, concentration of carbon dioxide (CO_2) in the

atmosphere, and concentration of nitrogen (N_2) in the atmosphere on the basis of districts and their effects were disclosed by means of observation with a confirmation from the Upper West regional meteorological agency. Details of the components of air and their effects are presented in results and discussion.

9. Topography

Data on topography of Wa East district was obtained by means of direct observation with a confirmation from the Upper West regional survey department. Details of topography of Wa East district of Upper West region are presented in results and discussion.

10. Geology

Data on geology of Wa East districts in Upper West region was obtained by means of direct observation with confirmation from records of the Upper West regional survey department. Details on geology of the 11 districts are presented in results and discussion.

B) Biotic Factors

1. Agricultural Plants

The study reported 4 cereals, 3 legumes, and 2 roots and tubers as agricultural plants cultivated in the Wa East district. On the other hand, statistics on food crops in terms of total production (in Mt), performance (yield) (Mt/Ha), and cropped area (in Ha) of Wa East district were obtained from the Upper West regional directorate of the Ministry of Food and Agriculture. However, the details of agricultural plants cultivated in Wa East district and statistics are presented in results and discussion.

2. Domesticated Animals

The study reported 8 livestock in Wa East district comprising 5 poultry and 3 ruminants. On the other hand, statistics on animal production in the Wa East district were obtained from the Upper West regional Ministry of Food and Agriculture. Details of domesticated animals reared in Wa East district are presented in results and discussion.

III. RESULTS AND DISCUSSION

A) 3.1 ABIOTIC FACTORS

1. Topography

The Wa East district is characterized by an undulating topography with an elevation of 180mm-1300mm above sea level.

2. Geology

Major rocks in the district are metamorphic and igneous and are noted for deposits of iron, gold, and bauxite. Communities in the district namely, Duu, Bulenga, Donyukura and Johnfia are noted for illegal small scale mining activities. Booming of quarrying industry and tourist attraction are the opportunities offered by the rocks in the district.

3. Soils

The district is characterized by sandy loamy soils which are suitable for the cultivation of legumes, cereals and tubers due to their nature of fertility. Low yields are recorded on soils with low inherent fertility as a result of continuous cropping. Table 1 is an illustration of fertility status of soils in the Wa East district.

Table 1: Inorganic Minerals (Fertility Status) of Soils in Wa East District

District	% of Organic matter	% of Total Nitrogen	Available Calcium (mg/kg soil)	Available Phosphorus (mg/kg soil)	Soil pH
Wa East	0.5-1.3	0.01-0.07	52-151.5	2.0-7.4	6.0-6.8

(Confirmed by Council for Scientific and Industrial Research-Kumasi)

4. Climate

The district is characterized by tropical equatorial climate which is prevalent in the entire of northern Ghana. Annual temperature records are high especially in the month of March/April which is the peak period with maximum temperature of 42^0C. The lowest temperature of 22^0C is recorded in December/January. Harmattan is experienced in the period between November and April and characterized by dry, dusty and cold wind.

Single rainfall regime is a characteristic of the district. The rainy season spans from May to October. It is also noted that in some instances, rainfall is erratic, stormy and torrential in nature with an annual average of 1200mm. Buildings and farm lands are destroyed by the torrential and stormy rainfall. Farming in the district is seasonal due to single rainfall regime. There is redundancy of a considerable number of farmers during the long dry season which spans from November to May.

Annual relative humidity in the district ranges from 70% to 90% in the rainy season but reduces to 30% in the dry season.

It is also noted that, on the average, daily solar intensity is greater than 150 lux by virtue of its position. In other words, the district is part of the high thermal zones of Ghana.

5. Water Supply

The Wa East district is endowed with numerous sources of potable water. They are dams/dugouts, small water system, boreholes, and

Hand Dug Wells with pumps. The dams and dugouts are avenues for irrigation agriculture. Table 2 is an illustration of potable water facilities in the Wa East district.

Table 2: Status of Potable Water Facilities in the Wa East District

Facilities	Dams/Dugouts	Hand Dug Wells with Pump	Small Water System	Boreholes
Quantity	14	12	1	92

6. Air (CO_2, O_2 and N_2)

The proportion of carbon dioxide, oxygen, and nitrogen in the atmosphere is illustrated in table 3.

Table 3: Proportion of CO_2, O_2,and N_2 in the atmosphere

District	Percentage of O_2	Percentage of CO_2	Percentage of N_2
Wa East	20.8	0.03	79

It is revealed that emissions from the exhaust of vehicles in the district contribute to the concentration of carbon dioxide in the atmosphere. Part of the emitted carbon dioxide is absorbed by green plants whilst the remaining carbon dioxide increases the amount of atmospheric carbon dioxide which can cause the greenhouse effect as well as acid rain which is damaging to flora and fauna species.

Also, oxygen is released into the atmosphere by plants as well as photosynthetic cyanobacteria. Part of the oxygen released is used by human beings and animals in the process of respiration whereas the remaining oxygen increases the amount of greenhouse gasses in the atmosphere. When increasing concentration of greenhouse gases with the inclusion of excess oxygen traps solar radiation entering into the earth's atmosphere, it leads to the greenhouse effect which is not favorable for the growth of plants and animals.

Also, nitrogen gas is released into the atmosphere from application of chemical fertilizers such as N.P.K. This also increases the concentration of greenhouse gasses in the atmosphere and can consequently cause acid rain which is damaging to flora and fauna species.

B) Biotic Factors

1. Major Crops Produced

Major crops cultivated in the district are maize, millet, sorghum, groundnuts, rice, cowpea, yam, soybeans, and cassava. Table 4 is an illustration of major crops cultivated in Wa west district from 2008 to 2010.

Table 4: Major Crops Cultivated in Wa East District

S/NO	Crop	Achievable MT/HA	Actual (MT/HA)			ACTUAL LAND AREA (HA)			ACTUAL PRODUCTION (MT)		
			2008	2009	2010	2008	2009	2010	2008	2009	2010
1	Millet	1.3	0.6	0.7	0.7	6,025	6,400	6,800	3,434	4,160	4,583
2	Rice	3.5	1.5	1.8	2.3	482	600	750	735	1,080	1,360
3	Maize	2.5	1.4	1.6	1.8	5,295	6,300	7,500	7,479	10,310	11,296
4	Sorghum	1.5	0.6	0.7	0.7	3,310	4,100	5,080	3.383	3,690	4,033
5	Groundnut	1.0	1.0	1.4	1.6	11,792	11,900	12,010	11,792	19,040	19,080
6	Soybeans	-	-	-	1.5	4,115	4,300	4,490	390.9	6,020	6,390
7	Cowpea	1.3	0.9	0.9	0.93	4,262	4,900	4,410	3,836	4,410	4,557
8	Cassava	28.0	-	-	-	-	-	-	-	-	-
9	Yam	20.0	11.5	1.8	21.4	5,359	3,700	5,180	27,176	44,000	47,000

2. Livestock Production

The potential for poultry and livestock production is very high in the district. Apart from cultivation of food crops, farmers in the district resort to livestock and poultry production for home consumption and income. It is also noted that goats, sheep, cattle, rural poultry, swine, guinea fowls, ducks, turkey and pigeons are the major poultry and livestock reared in the district. Table 5 is an

illustration of total production of poultry and livestock from 2008-2010.

Table 5 : Production of Poultry and Livestock from 2008-2010

S/NO	Species	2008	2009	2010	Average
1	Goats	34,400	34,700	35,900	35,000
2	Cattle	37,000	39,000	40,700	38,900
3	Sheep	29,500	31,600	32,700	31,266.7
4	Rural Poultry	100,000	110,000	112000	107,333.3
5	Swine	5,200	5,900	6,050	5716.7

C) *Effects Of Abiotic Factors On Production Of Livestock And Agricultural Plants*

1) Effects of Rainfall

The study reveals that, favorable rainfall is supportive to the cultivation of agricultural plants in the Wa East district. Tisdell (1996) [10] argues that lower rainfall intensifies the level of environmental stress and consequently affects the productive levels of agro ecosystems with the inclusion of food crop production. It is also disclosed by the study that the growth, health and reproduction among domesticated animals is influenced by rainfall. It is argued by the World Bank (2010) [11] that, declining rainfall patterns leads to drought which serves as a threat to rearing of domesticated animals by means disease contraction emanating from unsafe drinking water.

2) Effects of Temperature

The study reveals that favorable temperature is a panacea for the promotion of yields of agricultural plants in the Wa East district. Alessandro et al (2012) [12] are of the view that, the yield of food crops is adversely affected by rising temperatures. It is also noted in the study that the growth, reproduction, and milk production of domesticated animals is influenced by temperature. Bouraoi et al (2002)[13] and Wheelock et al (2012)[14] are of the opinion that milk production and its composition is affected by high temperature in diary animals. On the other hand, Kadowoka et al (2012) [15] argue that high temperature leads to impairment of the reproductive organs of domesticated animals.

3) Effects of Soil

The study reveals that Savannah ochrosols (sandy loam) is very supportive to the cultivation of cereals, legumes, as well as roots and tubers in the Wa East district. Pimentel et al (1995) [16], Troe et al (2004) [17]. and Pimentel (2006) [18] are of the view that, loss of soil fertility at the world wide level has led a speculation that, global food supply will decrease by 30% in the next 50 years.

4) Effects of Carbon Dioxide

It is disclosed by the study that, carbon dioxide concentration in the atmosphere can lead acid rain which is damaging to plants. It is argued by Blanc (2011) [19] that an increase in global carbon dioxide by 1ppm contributes to an increase in the yield of millet by 4.75%. Garret et al (2006) [20] are of the opinion the structure of plants such as thickness, increased leaf area, greater number of leaves, as well as diameter of stem and branches may be influenced by elevated levels of carbon dioxide.

5) Effects of Sunlight

The study reveals that, sunlight is very instrumental in the provision of vitamin D3 to livestock. Hidroghou (1987) [21], argue that sunlight is a source of vitamin D3 to domesticated animals. This consequently leads to improvement in meat colour and tenderization. In the case of agricultural plants, it is also disclosed by the study that sunlight in combination with carbon dioxide, water, and chlorophyll is instrumental in photosynthesis of green plants. Anderson (1920) [22] argues that, fruits of domesticated plants affected by diseases can be given a natural cure by sunlight.

6) Effects of Geology

The study reveals that granite rocks undergo weathering under the influence of age and leaching in the formation of savannah ochrosols (sandy loam) which is very supportive to the cultivation of cereals, roots and tubers, and cereals. It is disclosed in a study conducted by Reiner (2002) [23] that, the influence of geology on flora and fauna species is segregated into direct and indirect. The indirect influence is by virtue of the fact that, rocks are pivotal in soil formation. In order words, rocks undergo weathering under the influence of age and leaching in the formation of soil. On the other hand, the direct influence of geology (rocks) on distribution of plants and animals is based on the facts that, congregation of species and organisms are directly attached to the face of rocks. Examples of such organisms are vascular plants and lichens. In this scenario, the attached congregated organisms to rock face derive mineral nutrients from rocks to ensure perpetuation of their lifecycle and decomposition of

organic matter to promote the yields of agricultural crops.

7) Effects of Topography

It is disclosed by the study that, the ability of soils of farm lands on undulating landscapes to retain water for the growth and yields of agricultural crops is minimal. This consequently affects the yields of agricultural crops. A study conducted by Ma et al (2010) [24] reveals that, productivity of agricultural plants and species diversity of vegetation are strongly influenced by micro-topographic factors such as slope, slope position and slope aspect. In a similar vein, studies conducted by Burke et al (1989) [25] and Li et al (2015) [26], reveals that there is a strong positive correlation between diversity in vegetation and agricultural plants of landscapes and topographic factors.

D) Programs Implemented In Wa East District In An Effort To Promote Agriculture

1) Fertilizer Subsidy Program

The district benefitted from a fertilizer subsidy program between 2008-2010. As part of the fertilizer subsidy program, various quantities of NPK 15:15:15, Sulphate of Amonia, NPK 23:10:05, and UREA were subsidized to farmers in the Wa East district. Table 6 is an illustration of quantities of fertilizers subsidized to farmers between 2008 and 2010.

Table 6: Fertilizer Subsidy between 2008-2010

S/NO	Fertilizer Type	Quantity Subsidized in 50Kg Bags			REMARKS
		2008	2009	2010	
1	Sulphate of Amonia	3,015	4,963	Nil	Purchased Directly by Farmers From Distributors in Wa
2	NPK 15:15:15	3,596	4,900	Nil	
3	UREA	Nil	988	Nil	
4	NPK 23:10:05	1,750	2,350	Nil	

In my opinon, the fertilizer subsidy program was a success. This is because , there was an improvement of production levels of food crops from 2008 to 2010 as indicated in table 6. For instance, maize production increased from 10,310 tonnes in 2009 to 11,296 tonnes in 2010, whereas yam production increased from 44,000 tonnes in 2009 to 47,000 tonnes in 2010. On the on the other hand, rice production increased from 1,080 tonnes in 2009 to 1,360 tonnes in 2010, whereas groundnuts production increased from 19,040 tonnes in 2009 to 19,080 tonnes in 2010.

2) Special Projects in the District in an Attempt to Promote Agriculture

With the aid of donor and NGO_S support, about 13 special projects were implemented in the district. Table 7, 8 and 9 are illustrations of special projects implemented in the district.

Table 7: Special Projects

S/NO	Type of Project	Sponsors	Intervention Areas	Year Started	Year Ended
1	Plan Ghana European Union Facility Project	European Commission/ Plan Ireland	• Expanded crops production of Maize and soybean in 10,000 households in 100 communities. • Inventory Credit Scheme	2010	2011
2	Plan Ghana Animal Protection Project		Support to 9 women groups in animal production and animal traction	2007	2010
3	ADRA-EC Northern Ghana Food Security Reliance Project	European Commission ADRA-UK	Expanded maize production and capacity building of farmers in 1,500 households	2010	2011
4	Concern Universal/UNDP Food Security Facility Project	EC/UNDP	• Expanded maize production and capacity in 200 households in 5 communities • Supply hermatic storage facility poly sacks to farmers	2010	2011

			• Supply of two maize shelters to two communities (Kunyebin and Yaala II)		

Table 8: Special Projects continued

S/NO	Type of Project	Sponsors	Intervention Areas	Year Started	Year End
5	Nerica 2 Africa Project	Bill gate Foundation	Enhancing Increased Legume Production through dissemination of best production packages on groundnuts, cowpea, and soybeans	2010	2012
6	Northern Rural Growth Programme	AfDP/GOG	Improving Agricultural Production through commodity value chain development	2009	
7	Livestock Development Project (LDP)	AfDP/GOG	• Capacity Building • Vaccination • Credit in cash/kind • Water Source Construction	2005	2010
8	Rice Sector Support	French Development Agency	Development of Lowlands for expanded rice production	2010	2015
9	Root and Tuber Improvement and Marketing Project	IFAD GOG	• Establishment of Secondary Production multiple farms • Establishment of tertiary field	2008	2016
10	AGRA Soil Health Project	Alliance for Green Revolution in Africa	Soil fertility improvement for cereal based production systems and evaluation of maize varieties for drought tolerant and hybrid maize production	2010	2011

Table 9: Special Projects- continued

S/NO	Type of Project	Sponsors	Intervention Areas	Year Started	Year End
11	Africa 2000 Networks/UNDP programme	UNDP	• Support to three groups with agro-processing machines and buildings. • Support to groups with animal traction equipment and bullocks. • Support to 4 communities with certified seeds and fencing wires for crops production. • Support to groups with small ruminant/poultry/guinea fowl for raring	**2008**	**2011**
12	Special Rice Initiation Project	CRS	Support to the vulnerable in rice production	2009	2010
13	Promoting Millet and Sorghum Production (PROMISO 2 PROJECT)	European Commission ADRA-UK	Improved sorghum and millet production in two communities (Loggu and Bulenga)	2011	2011

IV. CONCLUSION

The study concludes that, biotic factors such as agricultural plants and livestock are affected by climatic and edaphic factors. In response to the prevailing situation of Wa East district, projects and programmes have been formulated in an effort to promote agriculture and to also protect natural resources. Some of the implemented projects and programmes have been successful in achieving their objectives whereas others are a futile exercise. However, recommendations have been forwarded for policy considerations.

V. RECOMMENDATIONS

The following recommendations are forwarded for policy considerations:

1. Farmers in the Wa East district must be encouraged to effectively utilized the White Volta
2. separating Gbantala from Bielepong , as well as dams and dugouts in the district for the practice of irrigation agriculture in the dry season.
3. The Fertilizer Subsidy Programme must be enhanced by the Ministry of Food and Agriculture so as to facilitate desired results in yield improvement.

4. Indiscriminate bush burning in the district must be stopped by the Ministry of Food and Agriculture in order to protect soil microbes like bacteria and fungi, so that they can actively play their role as decomposers of organic matter.
5. Government agencies must be encouraged to formulate more projects and programmes in an effort to promote agriculture in the Wa East district.

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