Sustainability, Agri, Food and Environmental Research, (ISSN: 0719-3726), 11(X), 2023:
http://dx.doi.org/10.7770/safer-V11N1-art2899

Carbon sequestration and ecosystem analysis of semi-arid grazing lands at Sivagangai

Secuestro de carbono y análisis del ecosistema de los pastizales semiáridos en Sivagangai

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ABSTRACT

Present study is focused on biomass, net primary production and system transfer functions and carbon sequestration of grazing lands in the Semi-arid regions of Sivagangai. Climatic diagram was drawn based on the secondary data of Rainfall and Temperature collected from meteorological department, Sivagangai. Study area is dominated by *Heteropogon contortus* at site I and *Melochia corchorifolia* at site II. Dry matter dynamics reflected in carbon sequestration study at site I and II. Even though above ground carbon fixation and total carbon input to the system were high at site II, Carbon output from the grazing land to soil was low due to over grazing. Monthly soil organic carbon study at site I and II also conform the low carbon output from the system to soil. Grazing land ecosystem at site I shows its stability and grazing land ecosystem at site II shows its degradation nature.

Based on this study it is concluded that organic carbon is the major factor for soil nutrient bank and grazing land stability. It is very much affected at site II. Mild grazing is recommended at site I and over grazing should be controlled at site II to maintain productive grazing lands at site I and II of semi-arid grazing lands at Sivagangai.

Key words: Grazing land, Ecosystem, Climate, Decomposition, Productivity

RESUMEN

El presente estudio se centra en la biomasa, la producción primaria neta, las funciones de trasferencia y el secuestro de carbono de los pastizales en las regiones semiáridas de Sivagangai. El diagrama climático se extrajo conforme a los datos secundarios de lluvia y temperatura recopilados del departamento meteorológico de Sivagangai. Dentro del área de estudio, se predomina el *Heteropogon contortus* en el sitio I y la *Melochia corchorifolia* en el sitio II. Las dinámicas de materia seca en el estudio de secuestro de carbono se ven reflejadas en el sitio I y II. A pesar de que la fijación de carbono del suelo y el aporte de carbono total en el sistema fueron altos en el sitio II, la liberación de carbono en el suelo del pastizal fue bajo debido al sobrepastoreo. El estudio mensual de carbono orgánico del suelo en el sitio I y II igualmente concuerda con la baja liberación de carbono del sistema al suelo. El ecosistema del pastizal muestra estabilidad en el sitio I, mientras que en el sitio II presenta degradación de la naturaleza. A partir de este estudio, se concluye que el carbono orgánico es el factor principal en lo que respecta al banco de nutrientes del suelo y la estabilidad del pastizal, por ende, el sitio II se ve muy afectado. Se recomienda un pastoreo suave en el sitio I y se debe controlar el sobrepastoreo en el sitio II para mantener productividad en ambos sitios de los pastizales semiáridos en Sivagangai.

Palabras clave: pastizal, ecosistema, clima, descomposición, productividad.

INTRODUCTION

The global cover is 74% under water and perennial icefields, 9% under deserts, 11% under forests and 6% under grasslands (Shantz 1954). The 26% land area under these vegetation systems have undergone further change during evolution with several type of land use patterns as visible today. The rangeland covers nearly 40% of the land surface of the globe. Today there is evidence of rangelands degradation throughout the world. Most of the area under grasslands and forests has been converted into croplands to serve the growing food needs of the human population and some degraded into waste land due to mismanagement of grazing land.

In addition to the climatically determined grasslands, two other orders can be distinguished. Succession in grass lands result from removal of the original forest vegetation due to grazing, mowing or burning. Many of the grassland in India (Singh, 1968) and essentially all grasslands in Japan fall into this category. These grasslands are very productive largely because of high precipitation. The second type includes agricultural grasslands which have been planted and maintained by intensive agronomic practices. The vegetation is composed of a few species either of improved varieties of native grasses or introduced grasses. Management of agricultural grasslands usually includes irrigation and fertilization. These grasslands occur in areas that would support natural grasslands as well as where once forest or shrub vegetation thrived but subsequently destroyed.

Grazing lands can be important sinks of atmospheric CO2 and play a major part in the overall carbon cycle fluxes. This land use contains approximately 10%–30% of the world's soil carbon reserves (Eswaran *et al*. 1993). In grazing lands 90% of the carbon pools are located in the soil (Schuman *et al.* 2001), (Mekuria Argaw Denboba 2022) hence it can be readily transferred into more permanent storage in the soil. Because carbon stored below ground is more permanent than in plant biomass, soil carbon sequestration in grazing lands provides a long-term alternative to mitigate atmospheric greenhouse gas emissions.

Based on the available information, present study is focused on biomass, net primary production and system transfer functions and carbon sequestration study of the grazing lands in the Semi-arid regions of Sivagangai.

MATERIALS AND METHODS

Study Area

The study area is located at Sivagangai (9.9726˚N, 78.5661˚E) at an elevation of 102 M above mean sea level, Site I is dominated by *Heteropogon contortus* grass and has occasional grazing and site II showed over grazing. The annual rainfall was 836.5mm with a maximum rainfall in October and minimum in January. Mean maximum and minimum temperature were 37.49˚C and 19.03˚C in April and June respectively. The study was carried out from 2017-2019 for a period of 15 months.

Soil moisture:100g of soil from each pit was weighed accurately and kept in an oven and dried at 105°C for 48h and the dry weight was recorded after cooling in a desiccator. Percentage of soil moisture was calculated from the formula of Misra (1968).

$$\text{Percentage of soil moisture} = \frac{\text{Loss of weight on drying}}{\text{Dry weight of soil}} \times 100$$

Soil Texture: Soil texture was determined by the standard sieve method (International Society of Soil Science, 1927).

Soil pH: For routine survey work, pH determined in a soil / water suspension normally provided adequate information. Measurement of pH therefore was normally made on a 1:2:5 (Soil: Water) suspension, equilibrated for 12h and measured with a pH meter.

Biomass and productivity

Biomass was estimated by the harvest method (Milner and Hughes1968). The optimum quadrat size (50X50cm) was obtained through the species area curve method (Goodall 1952). Twenty four quadrats were sampled randomly at monthly intervals. Harvested samples were separated into live shoots and dead shoots and ground litter was collected separately. The below-ground biomass was sampled by a sub-sampling (25X25X30cm) within the harvested plot. The root mass was separated by washing thoroughly under running water using 2mm mesh screens. All plant samples collected were oven dried at 80˚C till a constant weight was obtained.

Data analysis

The system transfer functions were calculated using the compartment values following (Singh and Yadava 1974). The transfer of live shoots to dead shoots compartment was calculated by the summation of positive changes in the standing crop of dead shoot material on successive sampling months. Transfer of standing dead to litter compartment was calculated by positive changes in the standing crop of dead shoot material summed on successive sampling months. The decrease of standing dead material within sampling intervals represented transfer to litter compartment. The litter disappearance, root disappearance and total disappearance were calculated as shown below:

Litter disappearance (LD) = Litter production + Initial amount of litter - Final mass of litter

Root disappearance (RD) = Root production + Initial root mass - Final root mass

Total disappearance (TD) = LD + RD

Carbon analysis

Plant carbon analysis

Plant carbon for estimated following (Schlesinger 1991) using the formula C=0.475*B where C is the carbon content by mass and B is the over dry biomass.

Soil organic carbon analysis

Most routine organic carbon determination tests were made by the Walkley-Black dichromate methods. The results are usually quoted as percentage by weight of organic carbon in the soil.

RESULTS

Abiotic factors

(i) Climatic condition: Rain fall and Temperature

The study area is showed 28.20˚C as mean Temperature and 836.5mm annual Rainfall. Maximum rainfall was observed in the month of October (156.4mm) and Minimum in the month of January (5.63mm). Maximum temperature was observed in the month of April (30.48˚C) and Minimum temperature (25.91˚C) was observed in the month of December (Figure1).

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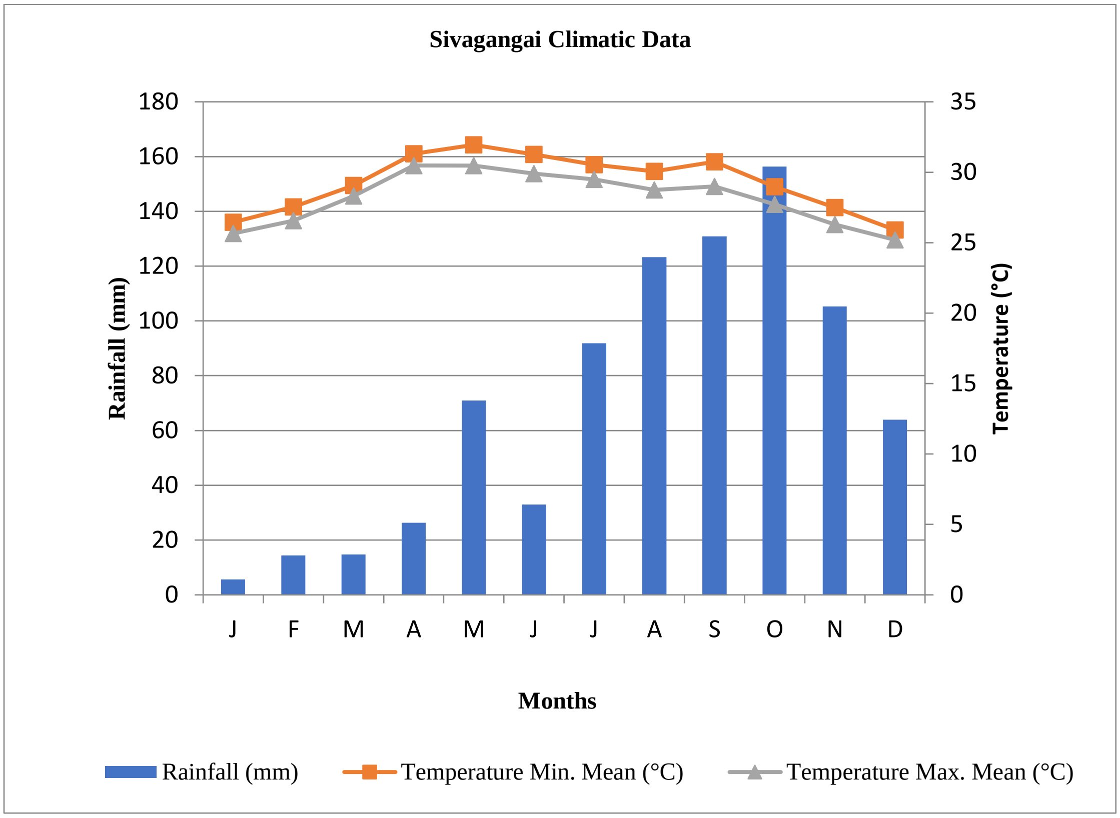
Figure.1. Mean Monthly Rainfall & Temperature.



Soil factor

Soil in the study area is sandy loam. Soil moisture, Water Holding Capacity (WHC), Soil Organic Carbon were higher at site I. Which showed 72%, 23%, 58% increase respectively than the site II. Whereas soil pH at site II showed 10% increase than the site I. (Table 1).

Table 1. Abiotic factors (Mean monthly value) at site I and site II

Abiotic factor	Site I	Site II
Soil	Sandy Loam	Sandy Loam
Soil pH	6.47	7.12
Soil Moisture	3.85	2.23
Water Holding Capacity (WHC)	34.87	28.29
Soil Organic Carbon	1.16	0.73

Biotic factors

Florestic composition

Florestic Composition present in site I and site II were showed in table 2. Compared to site I may plants were absent in site II *Heteropogon contortus* showed its dominance at site I and *Melochia corchorifolia* showed it dominance at site II. (Table 2).

Table 2. Vegetation analysis of Semi-arid grazing lands at Sivagangai.

PLANT NAME	SITE I	SITE II
Aristida funiculata	A	P
Apluda mutica	P	A
Heteropogon contortus	P	P
Dactyloctenium aegyptium	P	P
Cyperus rotundus	P	A
Chloris barabata	P	A
Megathyrsus maximus	A	P
Pennisetum setaceum	P	A
Chrysopogon-fulvus	P	A
Panicum-virgatum	P	P
Pennisetum-alopecuroides	P	A
Cynodon dactylon	P	P
Chrysopogon zizanioides	A	P
Indigofera linifolia	P	A
Hedyotis puberula	P	P
Evolvulus alsinoides	P	P
Acalypha indica	P	A
Gomphrena serrata	P	A
Leucas aspera	P	P
Cleome viscosa	P	P
Euphorbia hirta	P	A
Melochia corchorifolia	P	P
Phyllanthus amarus	P	A
Sida rhombifolia	A	P
Tridax procumbens	P	A
Pentanema indicum	P	P

P= Present, A=Absent

Biomass

Maximum above ground biomass was observed in site I in the month of December (393.43), minimum in the month of April (14.86) and site II was observed Maximum May

(252.71), Minimum June (144.96). Maximum Standing Dead was observed in site I March (124.43), minimum January (30.44) and site II was observed Maximum March (115.88), Minimum June (6.88). Maximum litter biomass was observed in site I May (484.25), Minimum Auguest (40.81) and site II was observed Maximum April (485.12), Minimum May (10.32). Maximum below ground biomass was observed in site I December (941.28), minimum February (26.08) and site II was observed Maximum October (259.36), Minimum December (12). (Table 3).

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http://dx.doi.org/10.7770/safer-V11N1-art2899

(Table 3). Monthly Biomass in site I and site II

	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb
AG	125.22 (75.66)	60.92 (104.97)	54.6 (-)	60.22 (114.06)	14.86 (-)	70.31 (252.71)	265.91 (26.16)	80.41 (87.39)	89.55 (144.96)	79.85 (91.56)	289.88 (89.36)	48.19 (101.69)	393.43 (165.60)	66.63 (82.57)	26.65 (87.84)
SD	30.44 (17.24)	- (94.88)	68.72 (87.11)	124.48 (115.88)	68.13 (33.76)	77.23 (-)	- (6.8)	- (-)	- (-)	- (-)	- (-)	70.84 (-)	- (-)	- (-)	95.30 (-)
LIT	129.14 (60.24)	94.61 (42.97)	244.4 (204.16)	166.71 (297.70)	301.91 (485.12)	484.25 (10.32)	131.00 (-)	- (-)	40.81 (-)	133.4 (-)	385.68 (-)	163.2 (-)	213.32 (-)	78.08 (-)	228.45 (-)
BG	144.53 (235.52)	90.24 (70.8)	- (30.24)	92.32 (112.4)	53.17 (48.64)	85.06 (166.48)	158.29 (87.76)	78.02 (49.28)	127.68 (72.48)	73.06 (68.48)	451.41 (259.36)	66.98 (65.6)	941.28 (12)	53.38 (50.08)	26.08 (70.32)

Biomass Productivity

Productivity of grazing land at site I and site were studied compared to site II. Site I showed maximum above ground live (820.95 g/m2/yr) standing dead (299.70 g/m2/yr) Litter (1053.45 g/m2/yr) and below ground (1499.70 g/m2/yr) respectively. Productivity in all compartment were low in grazed area. (Table 4).

Table 4. Biomass Productivity

Productivity g/m2/yr	Site I	Site II
AGL	820.95	596.25
SD	299.7	113.25
LIT	1053.45	442.05
BG	1499.70	472.35

Plant organic carbon

Carbon sequestration study

In *Heteropogon contortus* dominated grazing land (site I), the net carbon fixation of above ground live (AGL) and below ground (BG) compartment were 15.323 and total net carbon fixation was 1101.90 g/m2/yr. Here 35.3% of the fixed carbon was transferred to above ground live and 64.6 % below ground. Nearly 36.5% of the above ground fixed carbon was transferred to secondary dead (SD) and 6-fold increase to litter compartment. Annually about 914.05 g/m2/yr of fixed carbon was disappeared. In this litter disappearance contributes 90.5% and below ground disappearance contributes 107.89%. (Figure 2).

Figure 2. Plant organic carbon at Site I

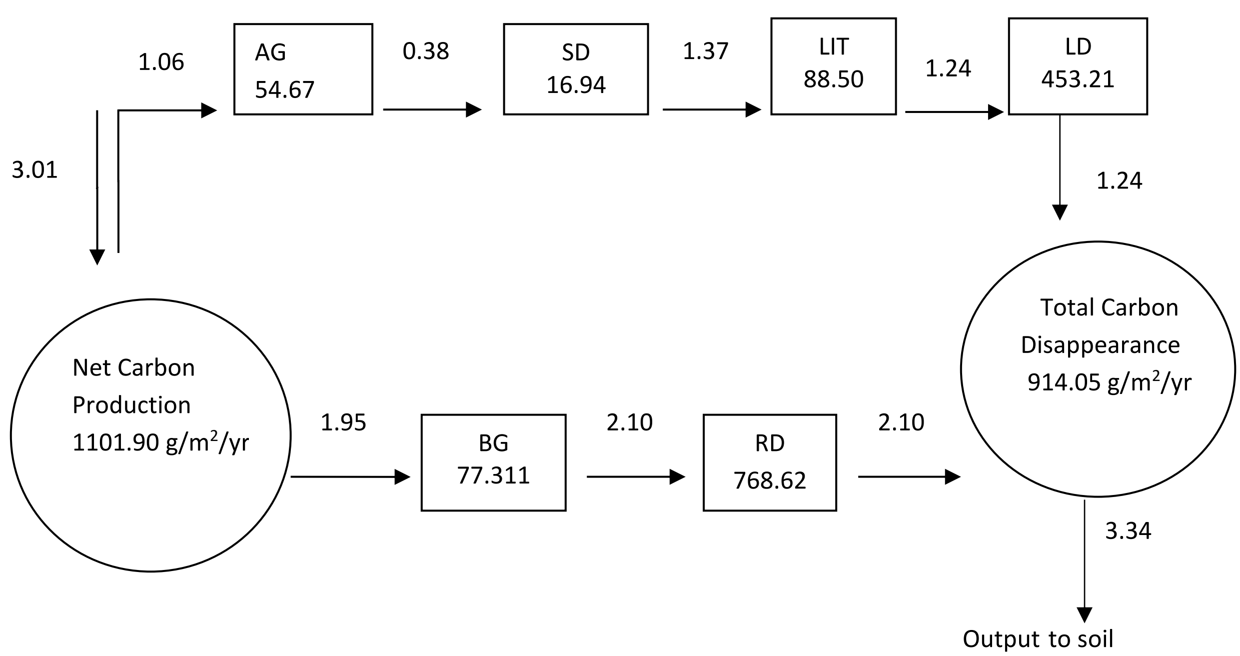


Figure 1. Net carbon Fixation and its flow at *Heteropogon contortus* grazing land at semi-arid region of Sivagangai (site I). Numbers in boxes are the mean carbon productions at standing crop (g/m2/yr). Number on the arrows are net carbon flux rates in g/m2/day

In site II, net carbon fixation of above ground live and below ground compartments were 163.88 and 302.83 g/m2/yr. respectively and totel net carbon fixation was 507.58 g/m2/yr. Here 55.8% of the fixed carbon were transferred to above ground live and 44.2% to below ground. Only 18.99% of the above ground fixed carbon was transferred to standing dead and 442.05% to litter compartment . Annualy about 541.42g/m2/yr of fixed carbon was disappeard. Litter disappearance and root disappearance contribute 113.62 and 134.97% respectively to the ecosystem. (Figure 3).

Figure 3. Plant organic carbon at Site II

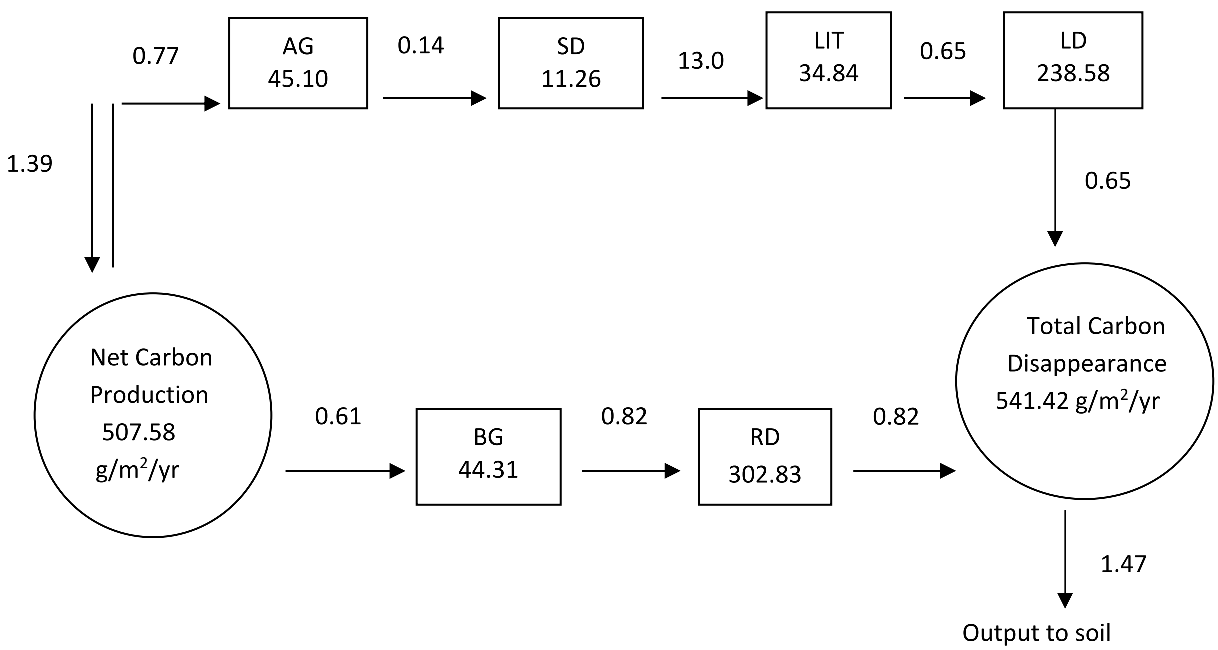
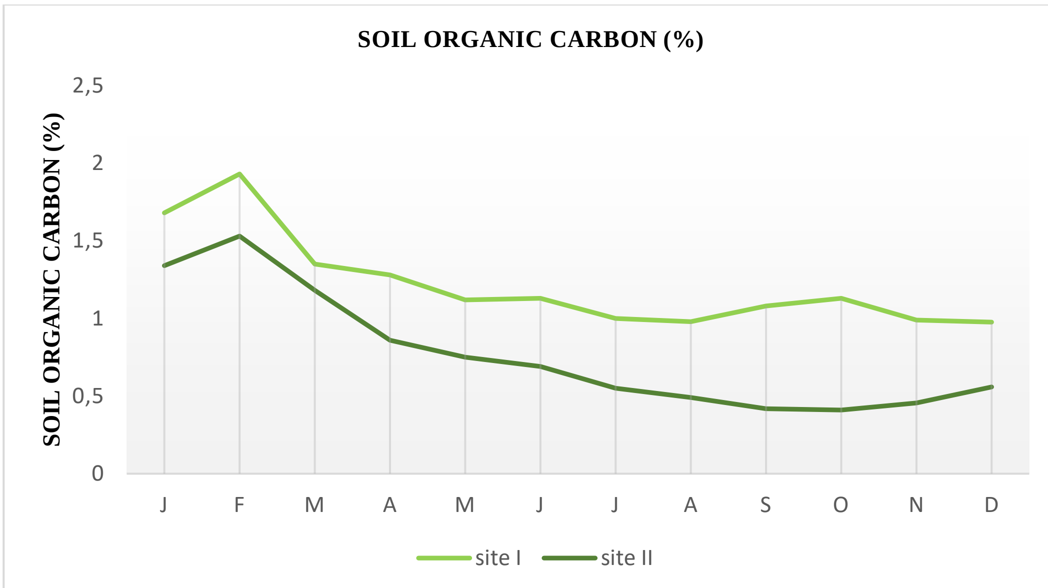


Figure 2.Net carbon fixation and its flow at *Heteropogon contortus* grazing land at semi-arid region of Sivagangai (site II). Numbers in boxes are the mean carbon production at standing crop (g/m2). Numbers on the arrows are net carbon flux rates in g/m2/day

Soil Organic Carbon

In the month of February maximum soil organic carbon (1.93%) and (1.53%) were observed at site I and site II respectively and in the month of August minimum organic carbon was observed at site I (0.97%) and site II (0.36%) respectively (Figure 4).

Figure 4. Soil Organic carbon site I and II



DISCUSSION

Temperature and Rainfall are the major deciding factor to find out the climatic condition of an area. Based on these data present study site consists of three climatic periods know as humid period, drought period and moderate drought period (Anusiya devi et al 2019) Mean monthly rainfall and temperature during these periods were compared with AG, SD, LIT and BG standing biomass. In this study rainfall showed positive correlations with AG (0.9) and BG (0.9). Likewise, temperature showed positive correlation with standing dead (0.6) and Litter (0.7). It indicated that higher rainfall increased the above ground and below ground biomass and temperature increased the standing dead and litter biomass at site I. In most parts of the subtropical areas the herbage available for grazing fluctuated with wet and dry periods. An excess of herbage available during rainy season and an extreme shortage in dry season was observed and higher productivity registered during rainy season. Similar observation also studied by (Haddad *et al*., 2002; Mukesh *et al*., 2012).

Other abiotic factors like soil moisture water holding capacity and soil organic carbon were more in site I due to higher organic production whereas soil pH was higher in site II. May be due to less organic production in that area. At site I soil moisture showed positive correlation with AG (0.8) and BG (0.9). Soil organic carbon showed negative correlation with AG (0.7) and BG (0.8). Soil pH showed positive correlation with standing dead (0.7) and litter (0.9). In site II soil organic carbon showed positive correlation with SD (0.9) and litter (0.5) and negative correlation with AG (-0.7) enhanced soil moisture AG and BG soil organic carbon showed negative correlation with

AG, BG and Soil pH showed positive correlation with SD and litter indicated that soil moisture enhanced standing biomass during that period standing dead and litter decreased.

Biotic factors like floristic composition, Biomass production, productivity were studied at site I and site II.

Floristic composition analysis table showed plant availability in site I and site II. Some plant species are not available at site II may be due to grazing pressure in that site. In semi protected area (site I) Heteropogon contortus showed its dominance, (Manoharan and Paliwal 2000). Melochia corchorifolia, showed its dominance at open grazed area (site II). Grazing enhanced changes in plant composition of plant community and carbon sequestration (Frank *et al.* 1995; Schuman *et al*. 1999; Derner *et a*l. 2006).

Site I showed maximum above ground biomass during humid period and maximum below ground biomass during drought period may be due to precipitation of that periods (Mukesh *et al*.2012). Low precipitation during drought period leads to water stress. So, the root biomass was increased to observe water from deeper layer of soil. Similar pattern of above ground and below ground biomass were observed at site II also.

Productivity increased during humid period was due to higher rainfall during that period. Increase in productivity at site II indicates that grazing enhanced productivity (Okaton and Resis 1999). Rabid regrowth of foliage was observed after grazing (Manoharan and Paliwal 2003). Productivity of standing dead increased during drought period was due to poor rain fall during that period. Good Correlation was observed between rainfall and above ground biomass productivity at site I (r = 0.9) and site II (r = 0.9) respectively. Similar observation was reported by (Rana and Rikhari 1994) and negative correlation was observed between litter fall and temperature in both sites.

It is reflected in carbon sequestration study at site I and II. Grazing land represent a large potential reservoir in storing carbon (C) in plant biomass and soil organic matter via Carbon sequestration, but the potential greatly depends on how grazing lands are managed, especially for livestock and grazing. Positive and negative grazing effect on soil organic carbon has been reported by (Xiaoyu Wang *et al*., 2014). Carbon Sequestration study in Semi-arid grazing lands of Tamil Nadu was studied by (Manoharan *et al*., 2016). Even though Above ground carbon fixation and total carbon input to the system were high in site II the carbon output from the grazing land to soil, was low due to over grazing. Conant and Paustein (2002) attempted an analysis of peer-required world literature on soil C is related to over grazing. They found soil carbon stocks decrease when grazing pressure is increased. Over grazing leads to land degradation (Manoharan *et al*. 2001). Grazing land Carbon sequestration can be influenced by many factors such as biomass composition, climate change (Conant *et al*. 2001) and grazing management (Jones and Donnelly 2004). Monthly soil organic carbon study at site I & site II also conform the low carbon output from the system to soil at site II. Increasing soil organic carbon (SOC) in grazing lands requires improved grazing management (Schuman *et al*. 1999). Heavy grazing affects dry matter output and species composition. It leads to land degradation. Grazing at light to moderate grazing intensity resulted in stably diverse plant communities (Gao *et al*. 2007) and stable ecosystem. It is believed that increased photosynthesis and above-ground biomass will increase carbon inputs and retention as SOM. Likewise, increases in primary production often result in increased removal of biomass by grazing or cutting (Mackay *et al*., 2018). At site I moderate grazing is recommended and site II should be protected from over grazing to maintain productive grazing land ecosystem at site I and II.

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Received: 14th June 2022; Accepted: 20th August 2022; First distribution: 29th October 2022.